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Aesthetic choices: Defining the range of aesthetic views in interactive digital media including games and 3D virtual environments (3D VEs)

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Aesthetic Choices: Defining the Range of Aesthetic Views in Interactive Digital Media Including Games and 3D Virtual Environments (3D VEs)

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Dedicated to,

All my family and friends, especially my parents and my husband for helping and supporting me throughout this journey

Thesis Declaration

I, Hira Maqbool, certify that

This thesis has been accomplished during the enrolment in the degree.

This thesis does not contain material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution.

This thesis does not contain any material previously published or written by another person, except where due reference has been made in the text.

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List of Publications

Maqbool, H., & Masek, M. (2021, December). Image Aesthetics Classification using Deep Features and Image Category. In *2021 36th International Conference on Image and Vision Computing New Zealand (IVCNZ)* (pp. 1-5). IEEE.

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Abstract

Defining aesthetic choices for interactive digital media such as games is a challenging task. Objective and subjective factors such as colour, symmetry, order and complexity, and statistical features among others play an important role for defining the aesthetic properties of interactive digital artifacts. Computational approaches developed in this regard also consider objective factors such as statistical image features for the assessment of aesthetic qualities. However, aesthetics for interactive digital media, such as games, requires more nuanced consideration than simple objective and subjective factors, for choosing a range of aesthetic features.

From the study it was found that the there is no one single optimum position or viewpoint with a corresponding relationship to the aesthetic considerations that influence interactive digital media. Instead, the incorporation of aesthetic features demonstrates the need to consider each component within interactive digital media as part of a range of possible features, and therefore within a range of possible camera positions. A framework, named as PCAWF, emphasized that combination of features and factors demonstrated the need to define a range of aesthetic viewpoints. This is important for improved user experience. From the framework it has been found that factors including the storyline, user state, gameplay, and application type are critical to defining the reasons associated with making aesthetic choices. The selection of a range of aesthetic features and characteristics is influenced by four main factors and sub-factors associated with the main factors.

This study informs the future of interactive digital media interaction by providing clarity and reasoning behind the aesthetic decision-making inclusions that are integrated into automatically generated vision by providing a framework for choosing a range of aesthetic viewpoints in a 3D virtual environment of a game. The study identifies critical juxtapositions between photographic and cinema-based media aesthetics by incorporating qualitative rationales from experts within the interactive digital media field. This research will change the way Artificial Intelligence (AI) generated interactive digital media in the way that it chooses visual outputs in terms of camera positions, field-view, orientation, contextual considerations, and user experiences. It will impact across all automated systems to ensure that human-values, rich variations, and extensive complexity are integrated in the AI-dominated development and design of future interactive digital media production.

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List of Important Terms

3D Virtual Environment (3D VE)	A hugely user-populated computer-based 3D simulation platform that allows for interaction and content creation (Saleeb et al., 2016)
Interactive digital media	An interactive digital media is defined as “Computer-driven experiences, mostly screen based, that facilitates the interaction between the device and a user” (Griffey, 2019).
Other digital media forms/ digital media	Other digital media forms do not respond to the user, and the user does not interact with it. The other digital media forms such as audio, text or video are experienced by the user in a sequential order with a distinct start and ending.
Game Systems/ Games	Game systems are composed of various important components required for game design working together (Nash, 2015), such as physics simulation, graphical user interface, and Artificial Intelligence (AI).
Camera System	The camera system is responsible for view generation of the 3D Virtual Environments (VEs) for display.
Aesthetics	A science of what is perceived and imagined.
Digital Media Aesthetics/ Interactive Digital Media Aesthetics	An interaction that results in invoking feelings often like pleasure.
Subjective Aesthetics	Aesthetics is focused on the interaction between the visual stimuli and the perceiver of the stimuli while observing a particular object.
Objective Aesthetics	Aesthetics is focused on intrinsic properties of an object that is perceived by a human eye. Objective predictors include properties such as symmetry, shape, composition, colour, order, complexity, and statistical image properties.
Aesthetics for Human Computer Interaction (HCI)	Aesthetics is not within the object but occurs in the interaction between the stimuli and perceiver. In this approach both subjective and objective perspectives are combined.
Edutainment	The mixed state of education and entertainment is described as “Edutainment”. The main purpose of these applications is to assist education through entertainment.
Aesthetics of Edutainment	A resemblance to the aesthetics of games that are used for entertainment purposes.
A digital game aesthetics	A sensory phenomenon encountered in a game by a player is called game aesthetics, such as visual, aural, or embodied features.
Camera Constraints	Cameras in a virtual environment are placed with certain orientations and positions and are known as camera constraints.
Game camera behaviours	Define the game perspective such as interactive or cinematic games.
Game Camera Aesthetics/ Virtual Camera Aesthetics	The aesthetics associated with a camera include defining acceleration and velocity limits, handling passing through geometry, and the position of the target object relative to the character.
Interactive Camera system	A camera system that changes response motivated, by the player’s action or any other element in a game, to real time events in a game.
Cinematic Camera system	A camera system that is unaffected by the player or any other object in a virtual environment in presenting a view.
Hybrid Camera system	A camera system that has been developed, mixing up both interactive and cinematic camera effects, in a 3DVE.
In-game cinematic camera	Such camera systems emphasis on applying cinematography principles to camera design.
First Person (FP) perspective	Viewpoints are the eyes of the player with a limited view, usually demonstrated when used in shooting games.
Third Person (FP) perspective	Viewpoints are part character and part of a surroundings of a character. This perspective is usually used in role playing games.
Virtual Cinematography	An art, composed of many cinematography rules, developed over centuries for defining the structuring of visual elements on the screen.

List of Abbreviations

GA	Genetic Algorithm
2D	Two dimensional
3D	Three dimensional
3D VE	Three-dimensional Virtual Environment
FoV	Field of View
VE	Virtual Environment
HCI	Human Computer Interaction
IIS	Integrated Industry Standard
RoT	Rule of Thirds
RoV	Rules of Visibility
DoF	Degrees of Freedom
PSO	Particle Swarm Optimization
SA	Simulating Annealing
PCG	Procedural Content Generation
IEA	Interactive Evolutionary Algorithm
UE	Unity Engine
CNN	Convolutional Neural Network
FP	First Person
TP	Third Person
AI	Artificial Intelligence
VR	Virtual Reality
MS	Medium Shot
CS	Closeup Shot
LS	Long Shot
FS	Full Shot
PCAWF	Player Centric Aesthetically Weighted Framework

List of All Variables and Symbols

p	Point on a Target Object
x	Coordinates of camera (x, y and z) x-axis points towards right y-axis points towards down z-axis points towards forward
x_{low}	Lowest bound of the frame
x_{high}	Highest bound of the frame
Π	Conversion of world coordinates to screen coordinates
f	Input
g	Output
Σ	Symbol for Sum
c	Origin or a Camera Point (Coordinates)
a	Top Point on Target Object for Shotsize
b	Bottom Point on Target Object for Shotsize
θ	Vertical Field of View (FoV) of camera
x_0	Constant (1/3)
$\propto$	Tunning Parameter

Chapter 1
Introduction

1.1 Overview

Aesthetic choices for presenting a range of views in interactive digital media such as games is a challenging task. Interactive digital media such as games includes entertainment games, walking simulators, and virtual educational tools (Benvegnù et al., 2021; Araiza-Alba et al., 2021; Uppot et al., 2019; Ranon et al., 2015). Aesthetics plays an important role on its user for such interactive digital media using various factors (Atkinson & Parsayi, 2021a; Niedenthal, 2009; Andersen et al., 2011). Current approaches for aesthetic assessment for interactive digital media typically focus on objective and subjective elements such as complexity, symmetry, and colours (Chamberlain, 2022; Nayak & Karmakar, 2018; Van Geert & Wagemans, 2020), all of which have some relation to aesthetics. However, aesthetics for interactive digital media involves more considerations than just colour and shape, such as usability, and interactivity (Griffey, 2019).

For an aesthetic assessment of interactive digital media there are many rules which need to be considered for analysis. It is not an easy task for people without professional training to objectively categorize images based on their aesthetic qualities. Hence, analysis of aesthetics from a computational perspective is a difficult task. This study explores this field by integrating both qualitative and computational approaches for defining aesthetics for interactive digital media such as games and 3D Virtual Environment (VE) using expert opinions. This introductory chapter of the thesis discusses the background, aims and objectives, research questions, contribution of the study, significance of the study, and provides the brief outline of the thesis chapters. This thesis focuses on camera placement and optimised views.

1.1.1 Introduction to Interactive Digital Media

An interactive digital media is defined as "Computer-driven experiences, mostly screen based, that facilitates the interaction between the device and a user" (Griffey, 2019). An interactive digital media includes experiences related to mediums like websites (Vijay et al., 2019; Tsao et al., 2016; Erkan & Evans, 2018), a mobile application (Stocchi et al., 2021; McLean & Wilson, 2019; Elmurodov, 2020), a video game (Filipović & Bjelajac, 2021; Doherty et al., 2018; Chursin & Semenov, 2020), and virtual reality applications (W. Huang & Roscoe, 2021; Chandra et al., 2019; Earnshaw, 2014). These experiences are driven by computer sensors installed in computational devices. All these mediums are developed using different programming languages. They may require different types of hardware required for running different types of applications that have been developed for serving different purposes. What they have in common among such mediums is two way communications between a device and a user (Griffey, 2019; Y. Liu et al., 2022).

Interactive digital media is different from other digital media forms. This is because when other digital media forms are experienced by the user such as a photo, a text, or a video, the media does not respond to the user, and the user does not interact with it. The other digital media forms such as audio, text or video are experienced by the user in a sequential order with a distinct start and ending. However, for interactive digital media the user experience is dynamic and unique based on the purpose it has been used for (Bowman et al., 2021; Griffey, 2019) such as a mobile application for e-commerce which can be used for either grocery shopping by one user or it can be used for fast-food delivery by another user.

Interactive digital media is a visual medium (Griffey, 2019). The goal of such media is to enhance the efficient and enjoyable experience of a user. This can be achieved if aesthetics developed for such media work in favour of enhancing the user experience rather than spoiling it. Important aesthetic elements that contribute in defining the overall look and feel of interactive digital media are colour, layout and typography (Chamberlain, 2022; Griffey, 2019). Along with these factors there are other elements that need consideration such as placing a camera in a 3D VE to find the range of optimised views to support game narratives.

1.1.2 Camera Placement in a 3D Virtual Environment (3D VE)

Virtual camera control in interactive digital media applications such as games and 3D VE applications is becoming increasingly useful in generating an aesthetically engaging user experience. A 3D VE is a hugely user-populated computer-based 3D simulation platform that allows for interaction and content creation (Saleeb et al., 2016). The aesthetic benefits of interactive digital media applications can be considered in terms of heightened emotional experiences and those experiences that engage the user. These qualities are important because they allow the designers of interactive digital media applications to create software that will draw users to either play more often or engage with greater connectivity with game software.

For interactive digital media applications (such as game aesthetics) can be defined in three different ways (Niedenthal, 2009; B. Kim, 2015; Bateman, 2015). Firstly, game aesthetics can be considered as sensory phenomena encountered by a user (Alexiou et al., 2020, Goethe, 2019). Sensory phenomena such as looks, sounds and visual perceptions are important for motivating a user to play a certain game. Secondly, game aesthetics can be seen as artifacts that give rise to experiences that are 'fun' and 'pleasant' (Niedenthal, 2009, Nadal & Skov, 2018, de Aguiar et al., 2018, Juul, 2018). Sensation, fantasy, narratives, challenges, and expression are useful descriptors for game aesthetics (Hunicke et al., 2004). Thirdly, we can consider the aesthetic engagement of computer graphics in terms of its ability to engage the user and in so doing increase the level of immersion with the experience (Eber, 2001; Y.-H. Hung & Parsons, 2017; Abbasi et al., 2017; Atkinson & Parsayi, 2021a). The importance of camera placement in games and 3D VEs play an important role in defining aesthetics for such applications.

Interactive digital media applications such as game systems are composed of various important components required for game design working together (Nash, 2015), such as physics simulation, graphical user interface, and Artificial Intelligence (AI) (Gregory, 2018; Haigh-Hutchinson, 2009; Eberly, 2006). One of the important components of game systems is the camera and viewpoint management (Haigh-Hutchinson, 2009; Yannakakis et al., 2010; C. Xu et al., 2018). Careful planning of the camera system is required to present a 3D VE in an appropriate context to the user in order to lead to an aesthetically enhanced experience (C. Xu et al., 2018). The camera system is responsible for view generation of the 3D VE for display. If the camera in a 3D VE is poorly defined, the user experience will deteriorate to such an extent that it cannot be improved through excellent graphics or mechanics. Quality implementation and designing of a camera system provides for the success of a 3D VE such as in the application of games.

Cameras in a 3D VE of a game are placed with certain orientations and positions known as camera constraints (Bares & Kim, 2001; Amerson et al., 2005; Christie et al., 2005; Ranon & Urli, 2014; Burelli, 2015; PRIMA et al., 2016) to provide the best view possible of a 3D VE game. Basic aesthetic quality is defined by means of an appropriate distance of a camera from 3D VE elements and game objects. They can also include a ledge or a column avoidance for the player or character, occlusion avoidance, and geometric avoidance (Nash, 2015; Burelli, 2015; Christie et al., 2008). The aesthetic properties defined for any VE game is dependent upon the game genre and presentation style. This could include 2D environments (Kelly, 2012) or 3D VEs (Kanev & Sugiyama, 1998). In addition, the aesthetics and its camera/VE, are dependent upon the type of game genre. This can include the camera behaviour chosen to represent a viewpoint to a player (Kanev & Sugiyama, 1998).

There is a need for understanding aesthetics in general from the perspective of experts, and aesthetics of different presentation styles and behaviours of interactive games. Game camera behaviours mostly define the game perspective such as interactive or cinematic games. This knowledge is important for two reasons. Firstly, we need to have better game camera designs and visualisation from both designers' and users' perspectives. Secondly, for improving user experience of a VE for any genre. There is a range of presentation styles starting with simple 2D, for example, Kickstart 2, to complex 3D, for example, Call of Duty and Hybrid 2.5D, for example, Brutal Legend (O'Hailey, 2012). Understanding aesthetics is important to produce games that can improve gameplay for any type of 3D VE or game genre.

In the case of improved aesthetics, computer graphics contribute to benefits in the form of increased immersion in safety training applications such as presented in (Benvegnù et al., 2021; Ranon et al., 2015; Prima, 2019) military training (Dam et al., 2019; Maxwell et al., 2018), and in the use of education through virtual experiences (Konakondla et al., 2017; Best et al., 2018; Olszewski & Wolbrink, 2017). Additionally, there are benefits in terms of an increased immersion in virtual constructs that although based in fantasy environments, allow for increased engagement and higher levels of realism in the game play. Such developments promote the likelihood of higher levels of repeat usage, and greater numbers of game users as discussed in S.-L. Wu & Hsu (2018).

1.1.2.1 Optimization using Genetic Algorithm (GA)

Optimum parameters for manually positioning a camera is a complex task when there is a need to satisfy both the technical and cinematography principles of game design (Nathan, 2020). Such complexity is further accentuated in a 3D VE (H.-Y. Wu et al., 2018; Ronfard, 2021; Badler, 2011). Some optimisation based approaches have been developed for finding an optimum solution for a 3D VE camera parameter, as developed by (Litteneker & Terzopoulos, 2017), (Prima et al., 2016), and (Ranon & Urli, 2014), and in these approaches they have started by considering a single optimum solution. Whilst technical aspects are often integrated into the established principles of cinematography, they relate to elements such as lighting and staging (Badler, 2011).

In this study, a Genetic Algorithm (GA) based optimisation was developed to test the quantified camera properties given in Litteneker & Terzopoulos (2017). This test was based on the application of principles of cinematography. This was done in order to focus on aesthetic elements in preference to a focus on technical aspects. Using the automatic control of a camera in a 3D VE, the user is freed from the restrictive practice of adjusting low-level camera parameters. GAs are useful in finding a single optimum and robust solution where there is a wide range of possible solutions (Forrest, 1996 ; Alam et al., 2020). Specifically, GAs are suitable for complex non-linear models (Lam et al., 2019) such as the optimisation of camera parameters. GAs are population based algorithms developed on Darwin's theory of evolution (Goldberg & Holland, 1988; Holland, 1992; Mirjalili et al., 2020).

Optimum high quality solutions can create a genetic algorithm using a process of selection, crossover and mutation (Mirjalili, 2019). This study offers an evaluation of the cinematographic principles such as frame bounds, occlusion, shotsize, and the rule of Thirds (Litteneker & Terzopoulos, 2017). This was specifically used to evaluate VEs camera parameters using GA. Based on this research, the proposed method can assist in automatic optimisation of camera parameters using a genetic algorithm.

A significant benefit of this research is the development of a time-saving system for game developers and designers, by developing a framework for making a range of aesthetic choices. Further benefits relate to the complex decisions that are employed in the standard "Rules of Cinematography". Currently such users rely on their expertise and experience to manually critique and refine their designs, which takes time, both in terms of training a professional in this area and in the actual creation process (Badler, 2011; H. Jiang et al., 2020). This proposed technique can be used to assist such designers by automatically evaluating their designs and suggesting more aesthetic alternatives.

1.2 Aims and Objectives of the Study

The overall aims and objectives of this research was to develop an understanding of aesthetics for interactive digital media. The importance of determining the optimal placement of a virtual camera in a 3D VE based on aesthetic criteria has been emphasized. This work focuses on expert opinions that have been collated to define aesthetics more clearly. The research considers the criterion for defining a richly diverse range of aesthetic viewpoints in a 3D VE. This thesis focuses on a four-part solution.

Aim 1: The first aim is to analyse and understand the aesthetic criteria in design and development of interactive digital media. This includes games, and digital photography. This approach included the aim to set a number of baselines for aesthetics.

Aim 2: The second aim is to define the way that measurable constraints can determine optimum camera placement based on aesthetics through the use of positioning, orientation, and Field of View (FoV) considerations.

Aim 3: The third aim is to combine these measurables to determine optimum camera parameters from a computational approach and analysis of aesthetic values.

Aim 4: The fourth aim is to create a framework for defining a range of aesthetic views that can form the basis for development of human based computerized systems that show a range of aesthetic views.

1.3 Problem Statement

A view of a 3D VE, for any real-time game environment or any other real-time applications, is represented through a camera. View of the 3D VE provided should be contextually appropriate and also aesthetically pleasing (Haigh-Hutchinson, 2009) for a viewer. A camera system that is poorly implemented will result in a poor application, whereas a quality design is important for a successful application (Haigh-Hutchinson, 2009). There is an implicit effect of real time camera systems on the viewers perception of the control of VE required for interaction. Therefore, a good camera system needs to be developed for such 3D VEs. In this study, a qualitative analysis and algorithmic approach has been carried out to determine the set of principles, guidelines, and rules for implementation for an aesthetically placement of a camera in a 3D VE of an interactive digital media including games.

1.4 Research Questions

This study was driven by a principal research question. The main research question was as follows: ***RQ: "How can a range of aesthetically optimised views be obtained for a 3D VE of an interactive digital media including games?"***

The main research question is further divided into sub-questions to address the various aspects of the research problem.

SQ1: How can aesthetics be defined for interactive digital media and what standards can be followed for applying these aesthetics across such media? This research question will be investigated using two methods. It will include a scoping literature review and a qualitative data analysis.

SQ2: What measurable constraints can be developed for the camera positioning in 3D VEs? This research question will consider the aesthetics of an image, taken from a viewpoint in a VE. It will examine constraints such as the target object visibility within a camera frame, the shot size, and composition rules such as the Rule of Thirds (RoT).

SQ3: How can an approach incorporating aesthetic measurements be developed for finding an optimised range of camera parameters in a 3D VE? This research question will consider various options to demonstrate the inclusion of a broad and richly diverse understanding of aesthetic features.

1.5 Contributions of the Research

This research focuses on solving the problem of defining the range of aesthetic views and viewpoints using the perspectives of experts and users of interactive digital media applications. Existing methods use subjective and objective factors that describe aesthetics. These include the application of the rules of photography and cinematography, and have been developed over a long period of time (Chamberlain, 2022; Kamps, 2013; Mascelli, 1965; Heiderich, 2012). This study considers the development of a framework for defining the range of aesthetic choices for views or viewpoints based on the characteristics reflected from the combination of the quantitative and qualitative parts of this study. In addition, the effect of the application of rules and guidelines such as frame bounds, occlusion, shotsize, and the Rule of Thirds (RoT) have also been included in these contributions. These research outputs have emerged based on the development and implementation of this study.

Contribution 1: Qualitative analysis for aesthetic criteria from the perspective of industry experts, academic experts, and game usage experts, to lay the foundation for an aesthetic range of viewpoints for a camera in a 3D VE.

Contribution 2: Development and testing of an algorithmic approach for measurable constraints for camera parameters (position, orientation, and field of view (FoV) based on rules-based approach.

Contribution 3: A novel approach to defining a broad range of aesthetic features that can be included in interactive digital media decisions relating to optimum camera positions and viewpoints.

Overall Solution

This research helps to explain the importance of determining the range for optimal placement of a camera in a 3D VE. The research puts forward a four-part solution for the investigation of this sub-domain. The first part explores literature through a scoping review to understand how aesthetic values have been set in the past for interactive digital media usage. The second part uses a qualitative study approach based on focus groups that include users, gamers, developers, designers, and academics. All of the participants in this study had a professional involvement in interactive digital media and held an understanding of the importance of aesthetic perspectives in the field. The third part focuses on algorithmic approaches that can be used to define the way that measurement constraints can determine optimum placement using positioning, orientation, and Field of View (FoV) considerations.

The fourth part integrates the results of both the qualitative and computational methods to define a framework for finding a range of aesthetic views and viewpoints in 3D VEs.

1.6 Significance of the Research

This research will assist in improving the quality of the experience in interactive digital media such as games and virtual reality-based applications. This study is significant because existing approaches for 3D VE creation are limited to the presentation of an environment that shows a natural appearance to users. For example, VE is unsuitable because it does not allow for the full range of creative and virtual freedoms that underpin the emerging features of interactive digital media and contemporary VEs. This research will provide an important toolset for designers and interactive digital media users to apply a full range of aesthetic judgements and tailored user experiences. The framework proposed in this research can serve as the foundation for automatic aesthetic assessment of camera views in a game based on human preferences. This research will reduce time and cost-prohibitive choices and guide the automated requirements of future interactive digital media.

This research will result in the development of a study that will benefit users whose job it is to design and develop environments in a virtual setting. This includes professionals in interactive digital media including game developers, digital landscape designers, and animators. Currently such users rely on their expertise and manually critique and refine their designs. This process takes time, both in terms of training a professional in this area and in the actual creation process. This proposed study can be used to assist such designers in implementing designs that will benefit from a range of aesthetic features and attributes. These aesthetic features will be demonstrated through a framework which will direct interactive digital media professionals to follow a comprehensive set of guiding aesthetic options. These guidelines have economic and productivity benefits. They also provide guidance aimed to increase user engagement and satisfaction.

This study lays the foundations for the development of automated aesthetics-based assessment. Virtual Cinematography rules have been historically used as a criterion for optimisation of camera viewpoints. However, in 3D VE there is an urgent need for a set of aesthetic features that matches a wider construct of interactive digital media in 3D VEs.

1.7 Scope of the Study

Virtual cinematography rules have been used as a criterion for optimisation of camera viewpoints in 3D VEs since beginning of the 20th Century. Their value as standalone criteria are greatly diminished in the context of modern 3D VEs. The scope of this study includes the following elements.

- Analysis of GAs used for optimisation of rules of cinematography including frame bounds, occlusion, shotsize, and the Rule of Thirds (RoT).
- Scoping review of aesthetic features in interactive digital media and other digital media.
- Round table discussions with industry and academic experts.
- Creation of a framework showing the wide range of aesthetic features and attributes.

The scope of previous studies in this field have been limited by the adherence to historically established rules such as the rules of cinematography and photography. However, the scope of this study looks beyond these historic conditions and takes an inclusive approach to the discovery of the aesthetic attributes of modern interactive digital media and 3D VEs. This study provides a future approach for the comparison of variable camera positions that are unconstrained through interactive digital media extension. This study will redefine the aesthetic considerations for the VE challenges of the future.

1.8 Organization of the Thesis

This thesis comprises of seven sequential steps that are explained across nine chapters. The flow chart representing the steps followed for this study is given in Figure 1.1. The first step for this study consisted of a scoping literature review in order to have an understanding of the important differences between traditional and modern conceptualizations of aesthetics for interactive digital media and other media. The second step was to gather the information from a cross-section of experts in the field of interactive digital media. This step involved the gathering of data and information that provided a rich understanding of the contemporary values that relate to aesthetics for interactive digital media. The third step consisted of an analysis of the roundtable data to define themes and codes that inform the contemporary values from step 2. The fourth step involved drawing upon the rules of composition in order to test and develop an algorithm for optimum camera views and viewpoints in a 3D VE. The fifth step consisted of comparing the findings of qualitative and quantitative elements from steps 2, 3 and 4. Lastly the conclusion where the findings, discussions, impact, and future work for this study has been described and completed.

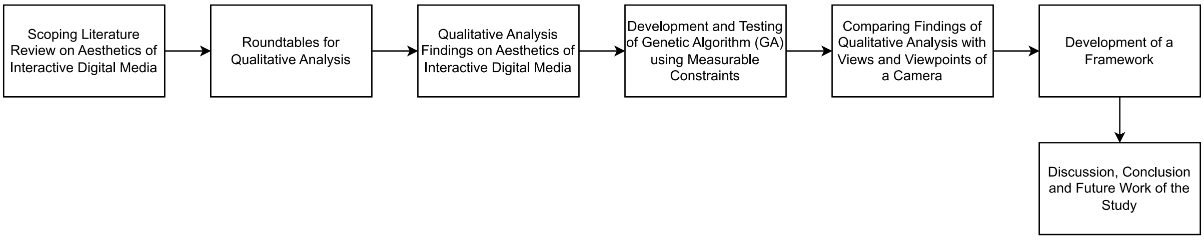


Figure 1. 1 Flow chart to represent steps followed for this study

The individual components that make up the content for this thesis have been organized as given below.

Chapter 2 consists of a scoping literature review on aesthetics of interactive digital media and other digital media. In addition, this chapter also consists of the state of the art in image aesthetics analysis and optimisation methods, and a technical review of the concepts used in the study.

Chapter 3 describes the methodology used for this thesis. It includes the qualitative and quantitative elements of this study.

Chapter 4 consists of an analysis and discussion of the results from the qualitative data that was collected by means of roundtable discussions with industry experts. This chapter developed the themes, nodes and codes that inform the aesthetic attributes required for contemporary interactive digital media and 3D VEs.

Chapter 5 states the details of the quantitative comparative analysis of an optimisation algorithm that is restricted to the four elements of *Frame Bounds, Occlusion, Shotsize* and the *Rule of Thirds (RoT).*

Chapter 6 discusses optimisation and visualization using rules of cinematography to test for optimum camera positions and viewpoints.

Chapter 7 reorganizes the view of aesthetics to include a broad range of characteristics, parameters and definitions. It explains the formation of a framework that satisfies the full spectrum of consideration for aesthetic features in interactive digital media and the 3D VEs.

Chapter 8 is a discussion of a major findings and analysis of the research study.

Chapter 9 provides a conclusion to the thesis. It answers the research questions, discusses limitations, and provides an indication of the impact of the study and the expected future work that will emerge from this thesis.

References, this is a list of the references that support the information provided in this thesis.

Appendix A states the preliminary experiments for the aesthetic analysis of 2D images of real time photography.

Appendix B contains the details of the file formats supported by Unity Engine (UE).

Appendix C contains the information letter and the consent form used for qualitative part of the study. It provides direction regarding the ethics approval for this study.

Appendix D consists of a list of the roundtable constructs used for collection of data during qualitative part of the study.

Appendix E consists of a compilation of all visual and graphical results obtained as a result of optimisation testing.

Chapter 2
Literature Review

Chapter 2 provides details of the review of literature that supports the information, direction and explanation of factual data that has been selected, annotated, and synthesized in order to provide peer review quality information in this thesis.

Section 2.1 describes a scoping review. It consists of an overview of aesthetics as an interdisciplinary approach. This section summarises details of subjective and objective predictors, which is the part of a scoping literature review, used for aesthetics measurement in other digital media. Section 2.2 consists of subjective and objective predictors for computational approaches. This section encapsulates the state-of-the-art computational models for aesthetics assessment of images. Section 2.3 and Section 2.4 consists of the aesthetics assessment in Human Computer Interaction (HCI), and game Virtual Environments (VEs). In the last section, Section 2.5 describes a technical review of the algorithm implemented, and the technical review of the qualitative analysis method used for this study.

2.1 The Reasoning supporting the need for Conducting a Scoping Literature Review

At the beginning of this study a literature review was used to establish the early information and data on how aesthetics has been defined for different art medias such as photography, cinematography, games, and 3D VEs Designs. These different areas form the basis for an investigation into optimum camera placement in VEs. This review accessed information on peer reviewed material in the form of peer reviewed journal articles and conference papers. The initial review of literature identified specific rules, principles, and guidelines for defining and establishing aesthetics for different arts and artifacts. This further led to study on methods for creating optimisation solutions by using the rules of cinematography and the rules of photography. This literature provided a firm background to the problem statement, research gap and research questions of this thesis. This information was used to achieve a confirmation of candidature and to progress the research beyond its initial directions. On the basis of the paucity of initial information that informed both aesthetic qualities and their application with genetic algorithms, it became apparent that there was a need for a scoping review in order to establish the areas where different aesthetic characteristics held a connectable linkage with Genetic Algorithms (GAs).

In the course of applying these previously identified rules of cinematography and rules of photography, it became clear that optimisation that was based on the inclusion of aesthetics involved a deeper understanding of the principles and guidelines for the use of aesthetics in other digital media, and interactive digital media that includes 3D VEs. This literature review then returned to gather a more informed selection of literature in order to satisfy the greater needs of the proposed investigations into optimised camera positions. Consequently, a further review in the form of a scoping review was undertaken to more formally describe aesthetic features in a contemporary sense that was appropriate for application to interactive digital media including games and 3D VEs.

2.2 Details of Scoping Literature Review

This section states the details of the scoping literature review conducted for this study. Details of various important methods such literature selection, inclusion and exclusion criteria, along with details of the databases, used for searching literature, has been included in this section.

2.2.1 Method for Literature Selection

One of the sub-research questions for this study was, SQ1: "**How can aesthetics be defined for the interactive digital media and what standards can be followed for applying aesthetics for such media?**". To answer this research question, a scoping literature review was carried out. This method of literature review was selected to understand what rules, standards, guidelines, and principles for aesthetics that has been defined for other digital media and interactive digital media. The main purpose of reviewing literature was to discover information about the existing standards, rules and guidelines that have been established in the design and development of other digital and interactive digital media. For this purpose, different databases were searched, and relevant literature was chosen to answer the given research question.

2.2.1.1 Databases and Keywords used for a Scoping Review

A scoping review methodology was carried out to understand the standards, rules and guidelines that describe the method for collecting sufficient information to a scope an area of research. This scoping review is specifically purposed with defining the aesthetics for interactive digital media and other digital media. Numerous steps were carried out during the scoping review such as the identification of the aim for the review, identification of relevant literature, and selection of the literature to be included in the review. The last step consisted of gathering, summarizing, and reporting the results. All these steps were followed in a systematic way using a scoping review to identify the set of relevant literature defining the standard, rules and guidelines for aesthetics of interactive digital media and other digital media (Peters, Godfrey, et al., 2020; Tricco et al., 2018; Peterson et al., 2017).

The first step of the scoping review consisted of the identification of the aim of this study. The aim was identified by the research question as stated in Section 2.1.1. The research question for the scoping literature review was SQ1: "***How can aesthetics be defined for the interactive digital media and what criteria can be followed for applying aesthetics across such media?"*** This main research question was further divided into sub questions to extract the relevant literature. Sub questions used for identification of relevant literature as follows.

SQ-a of Scoping Literature Review: *"**How aesthetics has been defined and measured in other digital media such as digital photography, computer games, websites and computer user interfaces?"***

SQ-b of Scoping Literature Review: "***What was common among the measured aesthetic criteria between such digital media?"***

The aim for searching the literature included both understanding the philosophical concepts as well as standards, rules and guidelines used in the design and development of aesthetics in other digital media and interactive digital media. This was especially directed towards interactive digital media like games. A variety of databases were used for searching relevant articles on interactive digital media aesthetics. Grey literature was also included as part of the review. This focus was taken because this literature consisted of establishing the guidelines and rules used for developing aesthetics for games like interactive digital media.

2.2.1.2 Search String for the Scoping Review

Studies which were relevant to aesthetic features within other digital media and interactive digital media were identified using initial research queries targeted at a specific set of databases. This was achieved by accessing Science Direct, Sage, IEEE Xplore, Art & Architecture source, ACM digital library, and Google Scholar. A summary of keywords used for searching data is given in Table 2.1. Keywords such as "Aesthetics of Video Games", "Media Art Aesthetics", and "Aesthetic composition + Computer games" were used for initial searching. The keywords used for search were initially not beneficial for these databases. Therefore, searching keywords were changed for other databases. To further scope the topic a multidisciplinary search was conducted. Subsequently, after further discussion, new databases were added for search purposes. The addition of new databases such as Web of Science (WoS) was also included. A whole query was executed along for keywords like “ALL = (Computational Aesthetics)”, “ALL = (Film Aesthetics)”, and “ALL = (Game Aesthetics)” to individually investigate topics in detail. Topics searched for literature revealed a large number of review papers written on them. This resulted in inclusion of references that were mentioned in a range of review papers. The papers which cited review articles were also included as part of this scoping review.

Based on the keywords recognised for this literature review a detailed search string was built. The search strings used were (~Aesthetics~ or ~Computer science~), (~Aesthetics~) AND (~Digital Media~), and (~computer media~ OR ~computer games~ OR ~Digital media~) AND (~Aesthetics~ OR ~Aesthetic experience~ OR (~aesthetic pleasure~ OR ~aesthetic emotions~ OR ~applied aesthetics~ OR ~aesthetic measurement~ OR ~computational aesthetics~). The number of Boolean operators used were decreased, as given in the search string, because some databases do not support more than 8 Boolean operators (such as Science Direct).

Table 2. 1 Summary of Databases searched, and keywords used

Database	**Keywords**	**Number of Articles Last 5 Years (2017-2021)**
Science Direct	Empirical Aesthetics	326 (Review Articles Only)
	Aesthetics in Arts	81 (Review Articles only)
	Aesthetics of Digital Media	1,357 (Includes all types)
Sage	Aesthetic Emotions	93 (Review Articles Only)
	Aesthetics of Digital Media	28 (Review Articles only)
Springer	Aesthetic Emotions	18,643 (Includes all types)
	Measuring Aesthetic in digital media	867 (All types in discipline of computer science only)
IEEE	Aesthetics in Arts	193 (All types)
	Empirical Aesthetics,	25 (All types)
	Scientific Aesthetics	17 (All types)
	Aesthetic Experience	106 (All types)
	Aesthetic Quality Assessment	67 (All types)
	“Aesthetic Quality Assessment” AND “3D virtual environment” OR “Games” OR “Digital Media”	81,882 (Journal and Conferences)
Web of Science	Aesthetics	18,095
	(((((((((ALL=(computer media)) OR ALL=(computer games)) OR ALL=(Digital media)) AND ALL=(Aesthetics)) OR ALL=(Aesthetic experience)) OR ALL=(aesthetic pleasure)) OR ALL=(aesthetic emotions))	58 (Review Articles in the field of computer vision and Graphics)

	OR ALL=(applied aesthetics)) OR ALL=(aesthetic measurement)) OR ALL=(computational aesthetics)	
Google Scholar	Aesthetics of Arts	33,380
	Aesthetics of digital media	3,460
	Visual Media Aesthetics	3,420
	Aesthetic perception in Art	4,320
	Aesthetic Significance in digital games	16,900
	Computer game Aesthetics	20,300

2.2.1.3 Inclusion Criteria

The following inclusion criteria has been used for the scoping literature review for this study.

Criteria 1: Papers from the last 5 years from 2017 to 2021 were selected. Last 5-year articles were included in a review to understand the modern and contemporary perspectives of aesthetics for digital media and interactive digital media.

Criteria 2: The search criteria were further narrowed down by selecting articles relevant to disciplines such as Arts, human computer interaction (HCI), computer science, Artificial Intelligence (AI), and entertainment.

Criteria 3: Articles in English were the only selected articles. Any repeated articles were screened out from the search. Review articles were also included in the search criteria.

Criteria 4: The review included reference articles, if found relevant to the study, stated in the reference section of the selected articles were also included in a review. In addition, articles which have cited the particular articles were also included in the study.

Criteria 5: Grey literature was also included as part of the review. The grey literature included YouTube videos on positioning cameras in games and other digital media.

2.2.1.4 Exclusion Criteria

The following exclusion criteria was used for the scoping literature review.

Criteria 1: Articles that have not been peer-reviewed

Criteria 2: Articles not published in English

Criteria 3: Articles older other than the last five years

Criteria 4: Articles on aesthetics other than digital media

The databases searched resulted in finding review articles on different aspects of aesthetics such as Empirical Aesthetics, Computational Aesthetics, Aesthetics of Human Computer Interaction (HCI) and Aesthetic emotions. All the articles selected for the review were between

2017 and 2021, and some relevant articles published at the start of 2022 were also included in the review for digital media. All articles selected were written in English. Articles from other languages were not selected or included in the review.

2.3 Aesthetics as an Interdisciplinary Approach

"Aesthetics" is a broad concept that has been defined in various ways in accordance with the field it has been studied for, such as, Brielmann & Pelli (2018) focused on empirical aesthetics for arts, Skov & Nadal (2020) studied aesthetics of arts from psychological and neurological perspectives, and the count of aesthetics used in scientific disciplines was conducted by Anglada-Tort & Skov (2020). An investigation and understanding of the keyword "Aesthetics" revealed that it was first invented by Alexander Baumgarten (1714-1762), who was a German philosopher. According to Alexander Baumgarten "Aesthetics" is a science of what is perceived and imagined (Baumgarten, 1763; Ogden, 1933; Radman, 2004; Brielmann & Pelli, 2018). The definition for aesthetics was later modified to the admiration of beauty in an art form (Datta et al., 2006; Brielmann & Pelli, 2018).

With the emergence of a new disciplinary inclusion in digital media, interactive digital media and Virtual Environments (VEs). The term "Aesthetics" is defined and described as something more than just an appreciation of beauty. According to Chatterjee, "Aesthetics" is not only an appreciation of beauty but it is also an interaction with that characteristic that results in invoking feelings often like pleasure" (Fenner, 2003; A. Chatterjee, 2011; Brielmann & Pelli, 2018). The word "Aesthetics" is not used alone but combined with other words providing a broader level of comprehension and interpretation of the context in which it is used. Words such as "Aesthetic experience", "Aesthetic pleasure", "Aesthetic emotions" (Wassiliwizky & Menninghaus, 2021), "Applied media Aesthetics" (Zettl, 2016), "Computational Aesthetics" (Bo et al., 2018) have been used to explain the different concepts of aesthetics in reference to digital media interaction.

Figure 2.1, adapted from Nadal & Vartanian (2021), represents various disciplines for which aesthetics have been associated. This table emphasizes that aesthetics has also been used as an important part in the contextualisation of these disciplines to define the impact of aesthetic experiences in such fields of study. There is a field of empirical aesthetics (Leder & Nadal, 2014; Che et al., 2018; Chamberlain, 2022), environmental aesthetics (Sadeghi et al., 2014; Andermann et al., 2018; Brady & Prior, 2020), evolutionary aesthetics (Rusch & Voland, 2013; Moura et al., 2018; Shaub, 2021), neuro aesthetics (Iigaya et al., 2020; R. Li & Zhang, 2020; A. Chatterjee et al., 2021), psychological aesthetics (Mastandrea et al., 2019; Hoegg & Alba, 2018; Haney, 2020), computational aesthetics (Bo et al., 2018; Bodily & Ventura, 2018; Suzuki, 2019), medical aesthetics (Xiong et al., 2021; Valiga et al., 2022; Senior, 2019) and digital game aesthetics (Schaffer & Fang, 2019; Schwarz et al., 2020; Gintere, 2020; Atkinson & Parsayi, 2021a). The field of digital game aesthetics is an emerging field of study.

In the 19th century, aesthetics was studied as part of experimental psychology leading to the emergence of the field of Empirical aesthetics (Augustin & Wagemans, 2012; Wassiliwizky & Menninghaus, 2021; Nadal & Vartanian, 2022). In the current era there is a large volume of research in the field of neuro aesthetics (A. Chatterjee & Vartanian, 2014; Iigaya et al., 2020; R. Li & Zhang, 2020). Other fields in which aesthetics have been studied are music, poetry, and films (Vessel et al., 2018, Anglada-Tort & Skov, 2020). With the emergence of a new field of studies there is still a need to develop methods and frameworks to define aesthetics to measure its impact on human behaviour and experience and define models and frameworks for enhancing user experience.

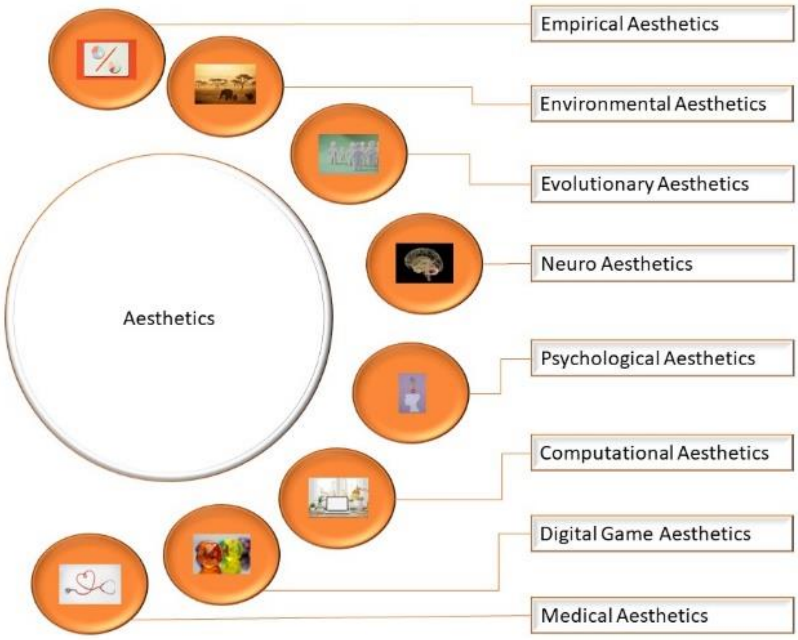


Figure 2. 1 Aesthetics and different associated facets of associated aesthetics adopted from (Nadal & Vartanian, 2021)

The next section summarises various definitions and associated attributes, stated in literature with connection to "Aesthetics". In the first section, the general view of aesthetics in terms of its subjective and objective factors was uniformly described. In the second section, aesthetic attributes from the perspective of computational aesthetic approach are more broadly characterised. In the third section, an approach to visual aesthetics in the field of Human Computer Interaction (HCI) has been summarised. In the final section, aesthetic assessment attributes have been given for digital games in terms of overall game design, and game camera design the perspective of visuals.

2.3.1 Objective and Subjective Factors in Aesthetics

The eyes are one of the major sources of input for humans and that supports the perception that through visual representation many aesthetic features act as powerful stimuli. Therefore, this begs the question as to how aesthetics can be measured or defined from the perspective of human visual stimulus. Two approaches are considered for the purposes of defining aesthetics from the perspective of human visual stimuli. They are shown in Table 2.2. This table provides the various attributes of the two perspectives mentioned that are described in the literature as objective and subjective approaches (Nayak & Karmakar, 2018; Chamberlain, 2022).

Subjective and objective predictors have previously been studied for their aesthetic qualities by philosophers, designers, and scientists in different fields (Lazard & King, 2020; Van Geert & Wagemans, 2020; Mayer & Landwehr, 2018). The objective evaluation of aesthetics was carried out by Fencher (1876), who posited that, “Aesthetic assessments are driven by dynamic forces”. Similarly, the term “Aesthetic Measure” was introduced by American Mathematician Birkhoff to describe the objective components of aesthetic features. Birkhoff used symmetry, complexity, and balance as values in order to measure aesthetic qualities of different art works using variables from polygons, poetry and other feature-based criteria (Garabedian, 1934). Along analogous aesthetic vectors Daniel Berlyne (1974) coined the term “Experimental Aesthetics” in his attempt to objectively measure aesthetic qualities. Berlyne’s work developed the relationship between an object’s aesthetic variables through an understanding of non-verbal aesthetic responses from different participants. Objective parameters such as complexity, contrast, and composition were used to explore the patterns affecting the aesthetics of visual perception. It was postulated that there would be a richer and more descriptive set of results from the evaluation of both objective and subjective attributes. This was specifically noted for the combination of visually perceived artifacts. (Sidhu et al., 2018) analysed both subjective and objective predictors to determine aesthetic preferences that could be derived from the abstract and representational features of paintings.

The subjective theory of aesthetics famously states that “Beauty is in the eyes of a beholder”. Based on this theory aesthetics does hold any inherently uniform qualities in connection with an object under observation. Instead, the subjective theory of aesthetics is focused on the interaction between the visual stimuli and the perceiver of the stimuli while observing a particular object (Silvennoinen, 2021). One part of this theory considers that the way aesthetic preferences are shaped can also be determined by subjective properties (Chamberlain, 2022). Some of these properties directly relate to the context, the artist and the process of creating an artistic object, with some measures trying to measure and describe the stability of an object's contextual influence.

In contrast, objective aesthetics declare that the law of aesthetics is in fact inherently connected within objects (Silvennoinen, 2021). This theory suggests that it depends what object is actually under observation and defined by the object's intrinsic properties. These intrinsic properties define the way that an object is perceived by a human eye. Objective predictors include properties such as symmetry, shape, composition, colour, order, complexity and statistical image properties. Details of these objective predictors are described below

Table 2. 2 Subjective and objective aesthetics predictors adopted from (Sidhu et al., 2018) and (W.-H. Kim et al., 2018)

Subjective Predictors	Context
	Information About the Artist and Artistic Process
Objective Predictors	Symmetry
	Shape and Composition
	Colour, brightness, and textures
	Order, Complexity
	statistical Image properties

2.3.1.1 Subjective Predictors

A range of subjective aesthetic predictors are visually represented in Table 2.1. These subjective predictors include predictors like the context, the artist and the process used by the artist to create an artistic object. They include the evaluation of the permanency of any contextual influence (Chamberlain, 2022). Subjective aesthetic predictors are highly idiosyncratic as they depend upon individual persons observing artifacts. An individual's perspectives can be affected by the context in which they are observed. A subjective ranking was put forward for the initial aesthetic scoring of digital or non-digital photographs and has been broadly applied (Amirshahi et al., 2016; Murray et al., 2012; Jin et al., 2020). Computational approaches have been developed and investigated on aesthetic rankings that have been developed using subjective predictors. Relevant feature extraction from visual images or artifacts has previously been used for the construction of aesthetic values for these artifacts. Computational aesthetic approaches have been established using similar principles and guidelines (Sidhu et al., 2018). There are two predictive elements that inform and influence these aesthetic judgements.

Predictor 1: (Context)

The effect of context on the development and investigation of aesthetic preferences is an enormous consideration in terms of the categorisation and consideration of visually perceived objects (Chamberlain, 2022). This is demonstrated through large variability on user aesthetic preferences (Sammartino & Palmer, 2012). For any given piece of art or media that is under observation, the meaning and interpretation of that piece is enhanced by a range of representations and contextual descriptions (Chamberlain, 2022). Context is regarded as the key driver that makes a perceiver aware of the reasons for which that piece of art was created. The background and story related to an art is clearer when an individual has the ability to relate to their personal aesthetic preferences. This capability leads to an increase in the sensory awareness of a user regarding the object in question. In creative contexts, the relationship between perceived beauty and positive emotions is more direct.

The degree and force of aesthetic judgments can also be influenced by the presence of an artistic context around a stimulus. Such analysis was carried out by (Sidhu et al., 2018) for abstract vs. representational images. Sidhu (2018) measured both subjective and objective measures in making aesthetic preferences for these types of images. This study used two descriptors to identify beauty ratings and aesthetic ratings. Beauty ratings were based on people who liked the images themselves, whereas the aesthetic ratings were based on what respondents thought other people would like. Sidhu (2018) concluded that there are other subjective and objective factors that can influence an aesthetic judgement but contextual factors on aesthetic judgments is an important research area.

Predictor 2: (Information About the Artist and Artistic Process)

Aesthetic perspectives are also affected by the information about the artist as well as the process used by the artist to create the particular piece of art (Chamberlain, 2022). If a person is aware that a piece of art was created by a professional instead of a novice, then this generates a huge perception-based difference in developing aesthetic preferences for a given image (Kirk et al., 2009). Similar types of preferences are observed in different types of digital media such as paintings (Sidhu et al., 2018), photography (Jokeit & Blochwitz, 2020), and video games (Junaedi123 et al., 2018). Jokeit and Blochwitz (2020) describe an aesthetically driven case study on photography images. In such media the ideas, styles and characteristics of famous artists are replicated to increase its aesthetic value (Mastandrea & Crano, 2019).

The literature describes various factors that determine the aesthetic values of the artworks and images. These include the process to create images, the relationship of each image to scenarios, and the perceived contact level with the image. Studies have shown that the preferences towards an image was reduced when created through computational processes (Chamberlain et al., 2018). The same studies also revealed that graffiti tags, if linked to crimes and criminals, were devalued as compared to a similar art forms when presented more formally as calligraphy (Chamberlain et al., 2022). The aesthetic value of artwork was also perceived lower when it was presented as a duplicate of some other art work (Reymond et al., 2020). The perceived value of the works of art and digital images are more strongly influenced by the level of contact between the creator/developer and the object. The literature demonstrated that evidence of aesthetic influences were derived from the personal choices made by individual percievers of digital media (Chamberlain et al., 2018). In this sense these perceptions hold a strong connection in terms of serving as a subjective predictor for an aesthetics of an artwork.

2.3.1.2 Human Subjective Predictors

Humans have been used as subjective predictors for assessment of aesthetic ratings for various artwork images (Murray et al., 2012; Vessel et al., 2018; Jin et al., 2020; Min et al., 2020; Gutierrez et al., 2022). The process of perception of visual and audio artwork has been studied from the perspective of human aesthetics judgements. Once human aesthetics judgements were obtained, these studies have been used in the development of computational models for evaluation of similar types of artworks. Details of computational approaches developed for aesthetic assessment are given in the following section.

2.3.1.3 Objective Predictors

Fechner (1876) pioneered “objective” aesthetic predictors that involve measuring the statistical image properties of paintings. These statistical image properties have also been used for the development of computational approaches (Sidhu et al., 2018). Several measures have been developed for recording objective aesthetic measurements (See Table 2.1). Objective measures have also been used for describing the aesthetic characteristics of photographic images (Murray et al., 2012; Jin et al., 2020). This was also used for the development of computational models for the aesthetic assessment of photographic images. The same measurements have also been used for predicting people’s preferences between urban and natural scenes (Sidhu et al., 2018; L. Li et al., 2019). Details of the objective predictors, as stated in Table 2.1, are given below.

Predictor 1: (Symmetry)

The term "Symmetry" is also described as "aesthetic primitive" as this predictor holds a unique place in the human visual system (Makin et al., 2018). It was found that the stronger predictor for beauty was symmetry (Sidhu et al., 2018). This is because strong and fluent visual processing is affected by the regularities in patterns such as dots or geometric patterns (Sidhu et al., 2018). The effect of symmetry on aesthetic assessment in details was studied by Höfel & Jacobsen (2003), and Makin, (2012). Symmetry is also useful for the aesthetic assessment of complex and naturally occurring stimuli for things like faces, flowers and landscapes (Hůla & Flegr, 2016; Bertamini et al., 2019; Pombo & Velasco, 2021).

Neuroscience and behavioral studies have provided evidence that symmetrical stimuli are easy to process as compared to non-symmetrical stimuli. A range of symmetrical features are described here. In addition, this ease of processing regular patterns is described as a phenomenon leaded to the feeling of pleasure and satisfaction (Makin et al., 2018). These studies have emphasized the value of recognising symmetry as an important visual factor for aesthetic preferences (Huang et al., 2018). Symmetry has been involved as an important part of web-based interfaces design (Purchase et al., 2011; Hanif, 2020; Lima & Gresse von Wangenheim, 2022).

Predictor 2: (Shape and Composition)

A second predictor using shade and composition is described in the literature. One of the major elements for defining aesthetics based on shape and composition is the golden ratio. The golden Ratio has a significance in the recognition of perceptual goodness in artwork (Chamberlain, 2022). The golden ratio (Yalta et al., 2016; Iosa et al., 2018; Santos et al., 2020) was the first objective predictor that was investigated in empirical aesthetics by Fencher in 1876 (Fechner, 1876). The golden ratio is a ratio with a numeric value of 1.618 and is denoted by a Greek letter phi (φ). This ratio has been accepted universally from deepest structures to the colossal galaxies, making it an important predictor for aesthetic assessment (Yalta et al., 2016; Chamberlain, 2022). Although the golden ratio was considered as an important factor for the aesthetic assessment of artwork or image-based objects one consideration is that preferences varied based on the context and observer's preferences (Palmer et al., 2013).

Spatial composition is also an important aspect in aesthetic considerations besides object shapes (Palmer et al., 2013). In spatial composition the objects are placed within a frame relative to one another. An important part is to balance the objects around the centre of the frame. The centre was considered as an essential part of any artwork by Arnheim (1988) and

Alexander (2002). This idea has been illustrated through many examples, but no experimental proofs are on record. Later on, experiments were carried out that proved the importance of centre in rectangular frames (Palmer et al., 2013).

Predictor 3: (Colours)

This colour predictor presents various colour properties for any piece of art or image such as white balance, colour contrast (or contrast between colours), and the colour palette (Kim et al., 2018). Colour choices and preferences can vary from person to person however recent studies that have included the use of standard colours and statistical analysis techniques. These techniques have clearly demonstrated that in spite of large variations among individuals, a reliable and systematic pattern exists for colour selection between three primary dimensions of colour (Palmer et al., 2013; Albers et al., 2018; Shamoi et al., 2020; Nakauchi & Tamura, 2022). These three primary dimensions are hue (basic colour), saturation (purity), and lightness (brightness) (Palmer et al., 2013).

There are many colour choices available that can be selected during development. The use of colour predictors recommends that it is better to choose colours at the beginning to narrow down the options (Griffey, 2019). This restrictive practice prevents the challenge for viewers by showing them what is of importance and showing where to look on a screen. Colour contrasts with strong colours can be helpful for drawing attention of the user to important screen elements. Poor colour contrast has a negative effect on the ability of a user to notice important information. The choice of colour is important for branding a company, but of greater significance is that it defines the intended meaning to people in from culturally diverse origins (Griffey, 2019).

Predictor 3: (Order and Complexity)

Birkhoff (1933) first highlighted the relationship between order and complexity. A mathematical formula was developed that proposed that aesthetic preferences should directly vary with the number of objects (O) and inversely with the complexity (C). The formula proposed was $M = O/C$ (Palmer et al., 2013). This equation was tested experimentally. In these testing phases it yielded low correlations. This then led to work from others who published work along similar lines their own formulas (Boselie & Leeuwenberg 1985; Eysenck 1941; Eysenck & Castle 1971). One of the early aesthetic features centred on the significance of familiarization. This was an important factor which demonstrated a strong alignment with the preference for complexity. It was confirmed that once people were familiar with simple stimuli, they preferred complexity in terms of their choices around artwork and images (Tinio & Leder, 2009). Recently, the significance of order in Berlyne's psychobiological theory was upgraded. This was because it showed that the balance between order and complexity determined the rank of fascination for structured objects in images (Van Geert & Wagemans, 2021).

Predictor 5: (Statistical Image properties)

Statistical image properties are also known as Global image properties in aesthetic assessment. These properties have been analyzed using image statistical approaches for automatic computation of image preferences (Sidhu et al., 2018; Letsch & Hayn-Leichsenring, 2020). Different measurements can be developed using statistical image properties. These measurement methods include fractality (D. Chatterjee, 2019; D. Chatterjee, 2019; Viengkham et al., 2019), self-similarity (Amirshahi & Stella, 2018), complexity (Papadimitriou, 2020; Van Geert & Wagemans, 2021) and anisotropy using image global properties (Sidhu et al., 2018). The global image properties that are extracted from the images are typically recognized as an interpretation of verbal descriptions. These properties are used to capture aesthetic features which in turn make sense in human visual terms. Various computational aesthetics assessment approaches have been developed using global image properties and descriptors (Tang et al., 2013; X. Fu et al., 2018; Kucer et al., 2018; X. Zhang et al., 2019; Jin et al., 2019; L. Li et al., 2020; Maqbool & Masek, 2021)

2.4 Subjective and Objective Measures in Computational Aesthetics

The previous description above provided a summary of subjective and objective properties used for determining aesthetic aspects of different artworks, images, and artifacts. The section summarized the effects of both objective and subjective predictors of aesthetics in different field of studies such as computational aesthetics, human computer interaction, and computer games.

Computational aesthetics is an emergent field that connects science and arts (Bo et al., 2018). With the advancement of digital technology, a pivotal role has been supported by computers in making aesthetic assessments, and has enabled humans to understand aesthetics by developing computational approaches (Neumann et al., 2005; Galanter, 2012; Brachmann & Redies, 2017). Recent scientific approaches are increasingly being used to understand aesthetics (Bo et al., 2018), and more comprehensive methods are being developed for aesthetic evaluation.

Computational aesthetics and aesthetic computing are two areas of research in the field of digital photography and digital art (Neumann et al., 2005). Computational aesthetics deals with methods of computation that can apply or take aesthetic decisions in a manner that is analogous to human behaviour (R. Li & Zhang, 2020; Debnath & Changder, 2020; W.-H. Kim et al., 2018). It is a subfield of image processing and computer vision (W.-H. Kim et al., 2018) and is regarded as an important research area of empirical aesthetics (Nadal & Vartanian, 2021; W.-H. Kim et al., 2018) linking different fields such as psychology, cognitive science, and computer science (Neumann et al., 2005).

Most of the computational approaches developed for the assessment of aesthetic perception and appreciation of digital images are summarised here by describing and synthesizing a set of review articles chosen for this study. The articles on computational aesthetics (W.-H. Kim et al., 2018), (Kucer et al., 2018), (R. Li & Zhang, 2020), and (Debnath & Changder, 2020) provide summary material about almost all of the computational methods developed for the assessment of digital photography and paintings. These review articles are significant to this study because they inform the dialogue about the computational methods developed for aesthetic assessments.

The automatic evaluation of photo aesthetics has been an active area of research for the past decade as given in (W.-H. Kim et al., 2018), (Kucer et al., 2018), (R. Li & Zhang, 2020), (Debnath & Changder, 2020), and (Maqbool & Masek, 2021). Two types of approaches have been developed for aesthetic assessment. In the first approach a discrete value for aesthetic prediction was formulated, whereas, in the second approach a continuous ranking for aesthetic prediction was deployed (Xiao et al., 2013; Jang & Lee, 2021; Biswas et al., 2022; Y. Wang et al., 2022). The initial aesthetic ranking of photographs for each of the datasets was obtained by the judgment carried out by human participant viewers, as described in the previous information about human subjective aesthetics. The mean ranking of the digital photos was used as a ground truth to test the systems developed for the aesthetic classification of digital images.

2.4.1 Subjective Measures Used in Computational Aesthetics

Aesthetic criteria have evolved for photographs over decades of image studies. Previously, accurate recording of scenes or objects was the only focus of photography. Current practices with photographs demonstrate a high level perception-based approach that describes the story, emotion, message, and thoughts of a photographer (W.-H. Kim et al., 2018). Aesthetically appealing photos are created by the practice of photographers repeatedly taking photos using varying guidelines defined in the field of digital photography.

There are two factors that classify photo aesthetic assessment, described as technical and semantic factors (W.-H. Kim et al., 2018). These technical factors are associated with objective elements such as light, colour or textures, whereas semantic factors are associated with subjective elements like emotions, stories or artists. Human aesthetic ratings are based on semantic factors in most cases (W.-H. Kim et al., 2018). Aesthetic judgment is affected by the pre, and post experiences of each user as recorded against a certain type of image. In many cases it is expected at there could be a degree of discrepancy between any two observers. The disagreement can be described as being due to the difference of criteria for an aesthetic evaluation (Chang et al., 2017).

Digital Photos can also be edited to increase their aesthetic values by changing various properties like brightness, saturation or enhancement of contrast (W.-H. Kim et al., 2018; Manovich, 2018; Binalrimal, 2019). The uniform features that influence the human interpretation of selecting a photographic image are derived from aesthetic values. Viewers and/or audiences have a natural and intrinsic understanding of image aesthetics. This occurs both consciously and unconsciously across both actively and passively engaged audiences irrespective of the onlookers of the images (W.-H. Kim et al., 2018).

The human aesthetic ratings of a photograph can demonstrate highly subjective variations. The normative human mindset is subject to a wide range of variable ideas and criteria with respect to aesthetics. The photographic image venerated by one person may not be liked by the other. To achieve an aesthetic evaluation of an image, a general opinion of the viewers, audience or users is a purposeful method of achieving an order of rank for images in terms of their aesthetic values (W.-H. Kim et al., 2018).

Computational methods have been developed for the subjective ranking of photographs such as PIAA (personalized image aesthetic assessment) (H. Zhu et al., 2021; Lv et al., 2021). The purpose of this model is to develop each user's aesthetic preferences based on the subjective factors stated previously. The literature shows alternative but similarly featured models including FLICKR-AES (Ren et al., 2017), and the adoption of deep meta-learning frameworks (H. Zhu et al., 2020; W. Wang et al., 2019). These can also be applied to ascertain personalised image aesthetic assessments of images.

Aesthetics is subjective in nature, but methods have been developed to understand the objective factors associated with the aesthetic ranking of digital images. Both factors have been used in aesthetic assessment of images (H. Zhu et al., 2021). A major finding of this collection of literature on aesthetics is to note the collective conclusion that subjective aesthetic measures are developed based on the subjective characteristics of an image. These characteristics are associated across a broad spectrum of engagement with images and remain consistent irrespective of whether the engaged person is a photographer, a developer, a user and a viewer. When looking at established models it is not easy to develop the computational models without the understanding of objective measures, that have been developed and used in computational aesthetic measures.

2.4.2 Objective Measures Used in Computational Aesthetics

From the perspective of objective measurements, the aesthetics of an image, photograph or the application of computational aesthetics can all be defined using the "rules of thumb" which have evolved from the rules of photography (Debnath & Changder, 2020). In this case, the literature points to the Rules of Photography which highlight the importance of several characteristics including Out of Focus, the Background, Balancing, Golden ratio, Lines, and the Rule of Thirds. Some other objective attributes used for aesthetic assessment include sharpness, depth, clarity, colourfulness, and the tone of a photo. The composition of an image or set of images is an important factor in the consideration of aesthetic features. The positional composition such as diagonal lines, leading lines, golden triangle rule, spiral structure, symmetry, patterns, frame within frame, cantered composition, and the shape and size of object are influential factors for the aesthetic ranking of images (Debnath & Changder, 2020). Various Machine learning and Deep learning techniques have been developed for image aesthetic assessment. They are further described below.

One of the branches of computational algorithms is Machine Learning (ML) where is designed to mirror human intelligence (El Naqa & Murphy, 2015; Kucer et al., 2018). Machine learning techniques have been used in diverse fields such as pattern recognition, computer visions problems, engineering, entertainment, and medical applications. These techniques proved to be successful in all these fields (El Naqa & Murphy, 2015). Various types of machine learning algorithms have been developed such as supervised, unsupervised, and reinforcement learning techniques (Debnath & Changder, 2020). Many of these algorithms along with their variations have been used in image aesthetic assessment treatments (Debnath & Changder, 2020). These results are over-shadowed by the inclusion of deep learning models which show more promising results.

Deep learning follows a different path and is composed of computational models using multiple processing layers (LeCun et al., 2015). These multiple processing layers in deep models provide multiple levels of abstraction to learn data representations (LeCun et al., 2015). Deep learning has significantly improved as a state-of-the-art method in visual object recognition, object detection, speech recognition, and other areas. The key difference and aspect of deep learning is that the human engineered features are not used by the models, instead general-purpose learning procedures are used for learning from the data (LeCun et al., 2015). The literature points strongly to the conclusion that deep learning is better than machine learning models.

Debnath & Changder (2020) demonstrate that objective predictors are robust options for the aesthetic assessment of images. The objective aesthetic predictors mentioned in (Debnath & Changder, 2020) are based on compositional rules and generic photograph features. These generic image features include colour features, bag-of-visual-words, descriptors like Bag of Features (BOV), Fish Vectors (FV), SIFT, GIST and Gaussian Mixture Models (GMM). The compositional rules used for photo quality and image assessment are Depth-of-field, Diagonal lines, leading lines, Golden Triangle rule, spiral structure, and a centred position.

2.4.2.1 State of the Art in Computational Aesthetics Assessment of Images

Image aesthetic analysis can be performed either through conventional machine learning approaches (Luo et al., 2011) or via deep learning algorithms (Suchecki & Trzciski, 2017). In both approaches, certain numerical values that are useful for the analysis of aesthetics are extracted from images. These values are known as features (Brachmann & Redies, 2017). The type of features used for image aesthetics assessment range from hand-crafted features that have been proposed based on some previously described understanding of images through to deep learning features which are automatically learned.

Hand-crafted features for the classification of images based on their aesthetics have been used in previous work. (Luo et al., 2011), (Kucer et al., 2018), and (Fu, Shao, Jiang, Fu, & Ho, 2018) have tried to assess image aesthetics using hand-crafted features. According to the study by Kucer et al. (2018), an accuracy of about 61% can be obtained through hand-crafted features, and there is a need to use almost all the available 300 sets of features, for analysis. In addition, some sets of features work better for some categories where others do not. For example, it is difficult to classify images consisting of landscapes using hand-crafted features optimized for the images of human portraits (Kucer et al., 2018).

Based on the current literature, automatically learned deep features are more powerful for the analysis of tasks like object classification for an image, scene recognition, or feature extraction. (Sharif Razavian et al., 2014). Deep neural networks can automatically learn the image features as compared to hand-crafted features (Brachmann & Redies, 2017), which are designed manually. These hand-crafted features include elements such as the hue, the hue-complexity, and the Depth of Field (DOF) (Kucer et al., 2018). This suggests that deep neural networks can learn properties of images which might not otherwise be considered by humans. These properties are difficult to be explained by conventional machine learning approaches (Brachmann & Redies, 2017). Image aesthetics assessment using deep learning features has been conducted by many researchers (Maleš et al., 2013; Tian et al., 2015; Suchecki & Trzciski, 2017; Tian et al., 2018) to test the set of deep features for an aesthetic analysis of images.

Dong et al. (2015) used an eight-layer Convolutional Neural Network (CNN) trained on ImageNet database (Deng et al., 2009) for feature extraction. A feature vector of 4096 in length was extracted and used in a Support Vector Machine (SVM) classification for a single image. The network was tested on a CUHK-PQ dataset (Luo et al., 2011) and an AVA dataset (Murray et al., 2012). The SVM classifier successfully classified the images with 93% accuracy. Training of the SVM was made on an entire database irrespective of their respective image category.

Suchecki and Trzciski (2017) and Tian et al. (2018) have used AlexNet (Krizhevsky et al., 2012) trained on the ImageNet dataset (Deng et al., 2009) for of deep learning features of images. Suchecki and Trzciski (2017) used SVM classifier and Random Forest (RF) classifier for classification of extracted features of images. Tian et al. (2018), on the other hand, only used SVM classifier. Results obtained by (Suchecki & Trzciski, 2017) were 71%, and the results obtained for (Tian et al., 2018) were 70%. Image type and image categories were not the matter of interest in this research.

A summary of the research articles consisting of image aesthetic analysis using deep learning features is given in Table 2.3. Two research studies, Fu et al. (2018) and Kucer et al. (2018) both used VGG-16 and ResNet-50 deep neural networks, trained on 1.5 million images of ImageNet dataset (Deng et al., 2009), for feature extraction. The features were classified using an SVM classifier. Their performance was analysed using an CUHK-PQ dataset (Luo et al., 2011) and an AVA dataset (Murray et al., 2012). In terms of measurable results, Fu et al. (2018) obtained an accuracy of 87,1%, for the CUHK-PQ dataset, and for the AVA dataset it was 82.1% whereas the accuracy obtained through ResNet-50 was 90.3% for the CUHK-PQ dataset and 87.7% accurate for AVA dataset (Murray et al., 2012). Through a Comparison of the classification accuracy of deep learning features against hand designed features by Kucer et al. (2018), it was found that the pre-trained CNN deep learning features gave better performance in the aesthetics analysis of images. The pre-trained CNN as compared to hand designed features, (H. Zhu et al., 2021) used pretrained networks, and RAPID for the aesthetic classification of images (Zhu et al., 2021; Lu et al., 2014). The results were compared with their classification accuracies with VGG16. They found that the features like colour, harmony and textures play an important role in aesthetic classification of images.

Table 2. 3 Summary of previous work for aesthetic classification using deep learning

Previous Work	Deep Neural Networks Used
Dong et al. 2015	Convolutional Neural Network (CNN)
Suchecki & Trzciski, 2017	AlexNet (Krizhevsky et al., 2012)
Kucer et al., 2018	VGG16
	ResNet50
X. Fu et al., 2018	AlexNet (Krizhevsky et al., 2012)
	VGG16
	ResNet-50
Jang & Lee, 2021	RAPID (Lu et al., 2014)
	VGG16
Maqbool & Masek, 2021	VGG16

A summary of the above-mentioned articles showed the importance of objective features for aesthetic classification of images. The subsequent selection includes the details of how aesthetic classifications have been carried out for visual perspectives of VEs. VEs are an important part of the digital medias like games. The factors affecting this aesthetics are collected with respect to the visual perception of VEs and are explained below.

2.4.2.2 State-of-the-Art Methods for Aesthetic Analysis of Virtual Environments (VEs)

A study of VEs based on aesthetic analysis shows a paucity of information. In specific terms, it was noted that the quality assessment of VEs was based on distortion, blurriness, and compression. Research by (B. Jiang et al., 2018), (Zhibo Chen et al., 2019), (Yang et al., 2018), and (M. Xu et al., 2018) revealed a body of research work completed from the perspective of quality assessment of VEs.

(Wang, Rehman, Zeng, Wang, & Wang, 2015) and (Zhibo Chen et al., 2019) have analysed the assessment of the perceptual quality of distorted stereoscopic images. Stereoscopic images are used for the generation of virtual content consisting of images captured from more than one viewpoint and combined together to create the 3D effect of a captured scene. Wang et al. (2015) have tried to estimate the quality of the asymmetrically distorted images using the original image as a reference image and by splitting the images into two viewpoints, the left and right view of the separated 2D images. Similarly, Chen et al. (2019) proposed the Stereoscopic Omnidirectional Image Quality Evaluator (SOIQE) which applied a similar approach to that of Wang et al. (2015), but instead of using only two viewpoints the original images were separated into N number of stereo images into multiple viewpoints. The quality of multiple viewpoints was analysed using reference images, and the main focus of the study was on the natural appearance of the images within the VE rather than aesthetics.

In a similar way, the quality assessment of virtual videos has also been studied by numerous research teams (Xu et al., 2018), (Yang et al., 2018), and (H. G. Kim et al., 2018). The work of Xu et al. (2018) demonstrated an analysis of the quality of omnidirectional videos by dividing the videos into eight different categories. These were "Computer Animation (CA)", "Driving", "Action sports", "Movie", "Video Games", "Scenery", "Show", and "others", based on the contents of videos. The contents inside the field of view (FOV) were considered for analysis, whereas FOV is an area which is perceived by the user during the VE experience. In contrast to this, Yang et al. (2018) tried to analyse the video quality of 3D panoramic virtual reality videos using a 3D convolutional neural network. Yang et al. (2018) studied distortions caused due to compressions like JPEG2000 during the analysis in VR videos.

Other related work has been carried out by (H. G. Kim et al., 2018) who tried to measure the VE sickness for 360-degree videos using the difference between the original virtual videos with non-exceptional motion and generated virtual videos with exceptional motion such as a roller coaster ride. The difference in motion of the two videos is calculated and compared with the VE sickness score, which was previously evaluated through subjective evaluation of the videos. The quality assessment of VEs was based on factors like blurring, and compression. This formed part of the above-mentioned research, where an aesthetic quality assessment had previously not been discussed in the literature.

One study considered an aesthetic evaluation by measuring the fractal complexity of the VE (Della-Bosca et al., 2017). This study analysed the fact that the variation in the complexity of the scene is helpful in the creation of positive and negative experiences for users. Fractal analysis was conducted during the study, where the fractal analysis refers to the analysis of geometric shapes, which are not easily analysed by simple geometrical rules. For the fractal analysis study, in-game screenshots of the VR environments were selected. Most of the scenes were from various adventure puzzles and Myst games (a series of adventure video games). Through analysis, it was concluded that fractal analysis is one tool that can be used to measure the aesthetic analysis of scene complexity where other methods may include neural net-based approaches (Bo et al., 2018).

Visual aesthetic analysis for the camera direction of video games was carried out by (Erdem & Halici, 2016) using machine learning. The camera direction was adjusted during the study for the user based on the aesthetic analysis of the captured scenes using hand-designed features. A third-person view was captured with the movement of the player where 55 hand-designed features, grouped into nine categories, were extracted. The nine categories of features used were: composition features; line composition features; texture features; hue distribution features; colour features; saturation features; brightness related features; sharpness features; and general features. The extracted features were then classified using an SVM classification algorithm for ranking captured viewpoints. Ranking the current viewpoint was compared with the ranking of previous viewpoints, where the camera view of the player was updated based on this comparison, and a new point was captured for further analysis. There were many limitations to this study such as the fact that only hand-designed features were tested during the study, and the original model for aesthetic analysis was trained on natural images whereas tested images were extracted from artificially designed VEs.

Aesthetic analysis has become an important topic for the study of evolutionary-based processes. It has also been carried out using Interactive Evolutionary Algorithms (IEA) (Easton et al., 2019). Methods of optimization for IEA consist of human evaluation (Takagi, 1998), where the fitness function of evolutionary algorithms are replaced by the human evaluation. Humans do evaluations based on their emotions, intuitions, preferences, and psychological aspects, for the system under analysis. Accordingly, IEA has been used by Raffe et al. (2014), Liapis et al. (2013), Zhang et al. (2015), Liapis & Yannakakis (2016) and Alobaidi & Sandgren (2021) for the development, and improvement of personalized Procedural Content Generation (PCG). User preference aesthetic analysis has also been applied for the evaluation and generation of visual content for VEs.

In this research direction, quantifiable visual properties for aesthetic analysis have been used, and optimization methods have been used to find an optimal viewpoint. The last step in such a process consists of the incorporation of a qualitative analysis for aesthetic assessment of optimal viewpoints captured in a VE.

2.5 Visual Aesthetics in Human Computer Interaction (HCI)

Human Computer Interaction (HCI) research is based on visual aesthetics and has increasingly gained popularity in recent years (Silvennionen, 2021). The statement “What is beautiful is usable” was coined by Tractinsky (2000) who emphasised the importance of the relationship between aesthetics and perceived usability for interactions in technology. An experience that is observed as a result of an interaction is titled as "Aesthetic-Usability" (J. M. Silvennoinen & Jokinen, 2016; Musdi, 2018; Kujala & Silvennoinen, 2022) in the literature. It involves the study of usability for the developed technological artifact.

Aesthetics in HCI has been studied from both subjective and objective perspectives but HCI features suggest that there is an additional factor associated with aesthetic assessment in HCI. From a subjective perspective "beauty lies in the eyes of a beholder", whereas from an objective perspective "aesthetic is a property of an object under observation". Details of subjective and objective aesthetics are given in Section 2.2. A third perspective is from the user's perspective and defines the effect of aesthetics on the usability of the digital media products. This perspective is known as the interactionist approach (Campagnolo, 2020; J. Silvennoinen, 2021; Héron et al., 2021).

In HCI the objective approach is usually described as a screen-based design approach. In this approach various design elements and structures are studied that effect user experience in technological artifacts such as websites (Bauerly & Liu, 2006; Moshagen & Thielsch, 2010; Tuch et al., 2010; Seckler et al., 2015; King et al., 2020; Wan et al., 2021). Objective factors can be adopted in the designing for usability for technological artifacts. This approach has proved to be useful in defining the usability guidelines for such artifacts (Moran et al., 2018; Wan et al., 2021; King et al., 2020). The use of objective factors emphasizes addressing a large number of design combinations to solve the problem for wider population of individual preferences.

Subjective approaches in HCI are recorded through self-reporting using a questionnaire (Seckler et al., 2015; Baraković & Skorin-Kapov, 2017). User experiences in HCI are mostly studied from subjective perspectives (J. Silvennoinen, 2021). Different questionnaires have been developed to understand and examine the aesthetic experiences from subjective perspectives. Examples of such questionnaires include Seckler et al. (2015), Baraković & Skorin-Kapov (2017) and Kocabalil et al. (2018).

The third perspective, which is the interactionist approach, follows a definition that "aesthetics is not within the object but occurs in the interaction between the stimuli and perceiver". In simple words, the physical properties of an object may not hold aesthetics, but aesthetics are provided as information to a perceiver's mind through object properties that are under observation (Silvennoinen, 2021). In this approach both subjective and objective perspectives are combined. This perspective defines the visual experience that occurs when there is an interaction between object and subject.

In HCI, objective and subjective factors affect the way that any technological artifact or digital media is experienced. An interactionist perspective explains that this experience emerges as the result of interaction between an object and a subject. Together all three of these perspectives define the effect of experience on the emotions of a user (J. Silvennoinen, 2021). This can also be related to the visual aesthetics of interactive digital medias like games. Games are regarded as the technological artifacts of this era as they have been stated as art (Tavinor, 2011). The aesthetic perspective of these digital medias is explained in the next section.

2.6 Aesthetics of Edutainment Applications

The mixed state of education and entertainment is described as "Edutainment" (Aksakal, 2015; Putra & Setyaningrum, 2018; Lutfi et al., 2019). The main purpose of these applications is to assist education through entertainment. The concept of edutainment was first suggested by Robert Heyman (Aksakal, 2015) by way of the American National Geography Academic Union. Later David Buckingham, an expert in mass education in England, elaborated on the concept of edutainment as a teaching style that is mixed with games and including a range of visual material (Aksakal, 2015). In addition to these different definitions of Edutainment, applications were created by a range of researchers as summarised by Aksakal (2015).

In the same way that games have users, similarly, in education the main consumers are students. It is assumed that the involvement of students can be increased if entertainment is included as part of the a course content and learning material (Aksakal, 2015). If edutainment is used as a teaching method, then students could be included in active discussions, and they can also be involved within the events of a class using simulations and narration. Any edutainment that is descried as having mixed computational access is regarded as having a format along similar lines to games with similar types of stories and visual materials. The term "technological entertainment" has been used for such games (McKenzie, 2003).

The aesthetics of edutainment applications can resemble the aesthetics of games that are only used for entertainment purposes. The same standards, rules and guidelines for aesthetics are used for edutainment as that for general games. This is because the edutainment applications have the characteristics of game applications (Charsky, 2010; Lameras et al., 2017) by motivating a user to complete learning activities to get entertainment.

2.7 Visual Aesthetics of Games

Video games are included in the category of interactive digital media (Griffey, 2019), but are different from other interactive digital medias applications like digital photographs, websites, or a traditional standalone kiosk. Video games require computer systems, mobile devices, or dedicated game consoles to run. A user interacts with a video game using a physical controller, or a sensor such as touch screen. The first video game was released in 1972 and named Pong (Wolf, 2008). Pong consisted of a virtual ball that was hit by a bat back and forth on a screen. It was a game with simple black and white graphics that was quite easy to understand. It was popularised as a fun game to interact with and often included an advancement in computational hardware that related to the evolution of video games. There are games in augmented reality (P. Chen et al., 2017; Y. Chen et al., 2019; Parekh et al., 2020), and virtual reality (Cruz-Neira et al., 2018; Checa & Bustillo, 2020; Oyelere et al., 2020). Currently, games are not exclusionary for entertainment but are also used in education, and for the training of students. They have also been used for training professionals. Games are regarded as the background of a growing industry with lots of opportunities (Griffey, 2019).

The visual aesthetics of games such as interactive VEs (Dozio et al., 2021) provides a structure that aims to show game attributes that provide aesthetic values to gameplay and games. In addition, it is responsible for highlighting the combination of visual elements and game design elements such as the story, the narrative, and their inherent properties for game development (Goethe, 2019). According to Ole Goethe (2019), a sensory phenomenon encountered in a game by a player is called game aesthetics, such as visual, aural, or embodied features. Game aesthetics can be valued in the form of pleasure, emotion, sociability and can be encountered during game experiences. A digital game environment is a complex combination of many different elements, predominately because of the aesthetic needs to examine many different elements (Nash, 2015). One of them is virtual camera placement in a game environment.

Virtual Camera (VC) placement (Bares et al., 2000; Keogh, 2018; Wolf, 2021) in computer graphics applications such as animations, games and visual simulations are becoming increasingly useful in generating an aesthetically engaging user experience. The aesthetic benefits of computer graphics can be considered in terms of heightened emotional experiences, and those experiences that engage the user. These qualities are important because they allow game designers to create software that will draw users to either play more frequently or engage with greater connectivity with game software. Game aesthetics can be defined in three different ways (Niedenthal, 2009; B. Kim, 2015; Bateman, 2015). Firstly, game aesthetics can be considered as sensory phenomena encountered by a user (Alexiou et al., 2020). Sensory phenomena such as looks, sounds and visual perceptions are important for motivating a user to play a certain game. Secondly, game aesthetics can be seen as artifacts that give rise to experiences that are ‘fun’ and ‘pleasant’ (Niedenthal, 2009; Nadal & Skov, 2018; de Aguiar et al., 2018, Juul, 2018). Sensation, fantasy, narratives, challenges, and expression are useful descriptors for game aesthetics (Hunicke et al., 2004). Thirdly, we can consider the aesthetic engagement of computer graphics in terms of its ability to engage the user, and in so doing, increase the level of immersion with the experience (Eber, 2001; Hung & Parsons, 2017; Abbasi et al., 2017; Atkinson & Parsayi, 2021; M. T. Brown, 2019).

2.7.1 Aesthetic qualities for Game Cameras

Game systems are composed of various important components required for game design working together (Nash, 2015), such as physics simulation, graphical user interface and artificial intelligence (AI) (Haigh-Hutchinson, 2009; Gregory, 2018; Eberly, 2006). One of the important components of game systems is the camera and viewpoint management (Haigh-Hutchinson, 2009; Yannakakis et al., 2010; C. Xu et al., 2018). Careful planning of a camera system is required so that it can present a VE in an appropriate context to the user that can lead to an aesthetically pleasant experience (C. Xu et al., 2018). The camera system is responsible for the generation of a view in the VE. If the camera in a VE is poorly defined, the user experience will be compromised and will prevent access to high quality graphics or mechanics. Quality implementation and the designing of a camera system is critical to the success of an interactive VEs such as games.

Cameras in a VE are placed with certain orientations and positions and are known as camera constraints (Amerson et al., 2005; Bares & Kim, 2001; Ranon & Urli, 2014; Christie et al., 2005; Burelli, 2015). They provide the best view of a VE. Basic aesthetic qualities are defined for placing a camera. These include items such as “an appropriate distance of a camera from VE elements”, as well as a range of features including game objects, ledges or columns avoidance. They also include: occlusion avoidance, and geometry avoidance (Nash, 2015; Burelli, 2015; Christie et al., 2008). The aesthetic properties defined for any game are dependent upon the game genre and presentation style such as 2D games (Kelly, 2012) or 3D (Kanev & Sugiyama, 1998). In addition, the aesthetics of a game camera/VE are dependent upon the type of game genre. This is sometimes discussed as the “camera behaviour chosen to represent a viewpoint to a player” (Kanev & Sugiyama, 1998).

In this part of the literature review for aesthetics the inclusion of 3D principles has been mentioned so that 3D games have been proposed based on the definition of the design principles of camera design in a VE of a game (Haigh-Hutchinson, 2009). There are two ways to think about virtual camera aesthetics. The first is to look at aesthetics from the designer’s view, and the second is to show aesthetics from a player's view (C. Xu et al., 2018; Mangeli & Xexéo). They are given in Figure 2.2. If we think from the designer's perspective, the designer would like to provide a view of a VE to the user. That view can help in navigating the VE even with the fixed camera control such as in Resident Evil 2 (Keller). The fixed viewpoint camera for Resident Evil is given in Figure 2.2. For a player it is regarded as simple fun (despite being able to die) in a simple, easy to use, format. However, for a designer, a good camera design is important. The prediction of the actual experience of game interaction is challenging since it is influenced by the different styles of playing, possibilities, and choices available for interactions (de Wit, 2021). Aesthetic properties defined for games depends on the game style and game genre (Cho et al., 2018, Hamlen, 2018, Bontchev et al., 2018), especially for game camera placement.

Figure 2. 2 Fixed third person camera in Resident Evil 2 (fixed cameras in Resident Evil 2 remake - SA Gamer). Adapted from (Venter, 2019)

There is a need for understanding the aesthetics of different presentation styles and behaviours of games for camera placement in a 3D VE of a game. Game camera behaviours mostly define the game perspective such as interactive or cinematic games. This knowledge is important for two reasons. Firstly, it is important to have better game camera designs and visualisation from both the designers' and users' perspective, as given in Figure 2.3. Secondly, it is important in improving user experience of a VE (any genre). Examples can be seen from: Starting with a simple 2D (Example: Kickstart 2) to complex 3D (Example: Call of Duty) and hybrid (2.5D) (O'Hailey, 2012) (Example: Brutal Legend) presentation styles. The key aesthetics understanding is important to produce games that can improve gameplay for a given VE.

Camera aesthetics in a game-based VE, and the theoretical foundations have been extracted from two main sources. Firstly, it is important to include material properties (of the object or geometry) from the details of a complete camera system. This is described in in "Real-time Cameras: A guide for game developers and designer" by Haigh-Hutchson (Haigh-Hutchinson, 2009). Secondly, based on a GDC 2014 talk by John Nesky, there are 50 poor choices taken by camera designers of a VE (Nesky, 2015).

This aesthetic criteria begins with a general criterion required to satisfy an aesthetic viewpoint in a VE (Haigh-Hutchinson, 2009) and the need to discuss the aesthetic criteria based on different types of Virtual Environments (VEs) and game genres. This part of the literature review aims to provide a general criterion for defining an ideal viewpoint in a VE of a game.

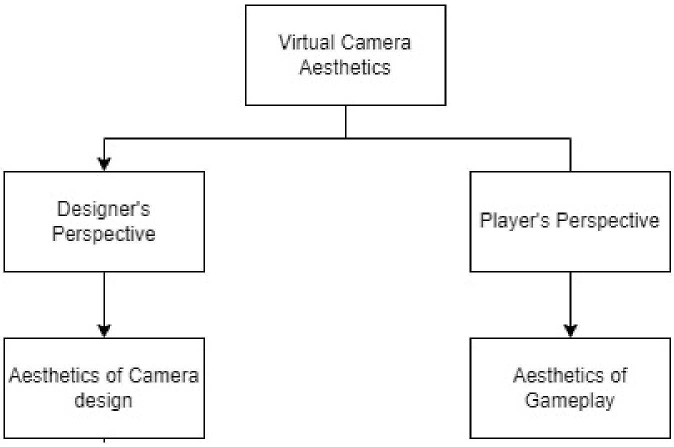


Figure 2. 3 Aesthetic properties stated in terms of virtual camera (Concluded from literature review) (de Wit, 2021; Fang, 2021; Nacke et al., 2019; B. Kim, 2015)

2.7.1.1 General Criteria for Aesthetics

The general criteria for Aesthetics has been adopted from Haigh-Hutchson's "Real-time Cameras: A guide for game developers and designer" (Haigh-Hutchinson, 2009) and GDC 2014 talk by John Nesky's "50 Camera mistakes" (*YouTube*, 2015) as given in Table 2.4. According to Haigh-Hutchinson the character control by the player is greatly influenced by the camera, which is ultimately dependent upon the type of game (the game genre) and games style of presentation. This has been described as a controlled reference frame (Haigh-Hutchinson, 2009). It describes using references of First Person (FP) (Hart, 2019) and Third person (TP) (Tsai et al., 2021) cameras. In both FP and TP, camera movement is synchronized with player movement however in TP the surrounding environment is more visible compared to FP cameras which helps the player in effective navigation in a VE.

Nesky explained that cameras are noticeable more when they do not work properly and can be seen to fail. They provide a useful viewpoint to a player (Nesky, 2015). The main purpose of the camera is to focus attention on a player with regard to something that might be helpful in navigating. So, he proposed a set of rules to avoid poor user experience. These 50 points can form the base on which to define an aesthetic criterion for the camera in a VE and form a theoretical foundation to form a taxonomy for the aesthetics of a camera viewpoint. This table of VE camera placement tools is a valuable set of guidelines to drive the acquisition of a virtual reality that can demonstrate the value of control features over a virtual reality environment.

Table 2. 4 General Criteria required for an Aesthetic viewpoint in a Virtual Environment (VE)(Adapted from (Haigh-Hutchinson, 2009), and fail (50 Game Camera Mistakes - YouTube, 2015))

	General Aesthetics Criteria for a Camera Placement in games
1	The Player's character should stay within view of the player. This is mostly required in Third Person styled games (Salamin et al., 2010; Gorisse et al., 2017) or 2D styled games (Smith et al., 2008; Khalifa et al., 2019). The major rule, guideline and principle required to be followed is Visibility (Keeping a character within bounds of a camera frame). (Details given in Chapter 5)
2	Avoiding a character from being occluded by the VE geometry or any other object in the environment. This refers to the principles of avoiding occlusion (a clear line of sight between a camera and a character). (Details given in Chapter 5)
3	Avoiding camera passing through game objects breaking camera's line of sight (A clear line of sight between camera and object). This also refers to avoid occlusion. In a game development engine like Unity (*Unity - Scripting API: Physics.Raycast*), Ray casting can help in such cases.
4	Avoiding positioning of camera outside world. This refers to the principle, guideline and rule of defining the boundaries of a VE to keep the character from going to unexpected places during a gameplay.
5	Avoiding unintentional camera motion while player is trying to move it in any other direction. This includes the principle to avoid over constraining of camera parameters such as position, orientation and Field of View (FoV). (Details given in Chapter 5) This principle is related to the aesthetics of gameplay of a game under consideration.
6	Smooth camera motion through velocity damping to avoid camera moving away from a character. This principle is also related to aesthetics of a gameplay of a game under consideration.
7	Retention of control of player reference frame to keep character within view of a camera. This principle is also related to aesthetics of a gameplay, especially during a falling of a character off the cliff or spinning of a car in a race game.
8	Limiting camera roll. This is also related to aesthetics of gameplay. This is related to the spinning of a car in a race game or a character falling off a cliff.
9	Retaining the same visual reference frame during repositioning Related to aesthetics of a gameplay (Same as Point 7 and Point 8).
10	Avoiding fixing character position on the screen Related to aesthetics of gameplay.
11	Avoiding camera occlusion for enclosed spaces

	Enclosed spaces like indoor camera scenes requires careful camera planning because there is a chance that the character might get occluded while passing through such spaces.
12	Avoiding occlusion from behind the player or clipping of rear plane intersecting the player character.
13	Using same FoV and keeping same distance for all camera angles such as worm's eye view, closeups, Bird's eye view and so on.
14	Defining "Lookat" for a character, in a videogame, to provide a sense of direction for the user or a player.
15	Keeping 180° rule ((Shim & Kang, 2008), (Kachkovski et al., 2019), (Kachkovski et al., 2019)) for preventing break of sense of direction for a player. 180° rule is a basic camera guideline to make sure that the two characters in a scene looks connected by showing them on the same imaginary axis ((Shim & Kang, 2008). It is also used for smooth change between two shots (Kachkovski et al., 2019).
16	Maintaining the Rule of Thirds (RoT) (Mai et al., 2011; Koliska & Oh, 2021; X. Li et al., 2022) when necessary. Details for the rule of thirds is given in Chapter 5.
17	Avoiding occlusion of a player character by its own body
18	Avoiding small FoVs for non-racing games

A view of a VE, for any real time game environment or any other real time applications, is represented through a camera. The camera view of the VE provided should be contextually appropriate and also aesthetically pleasing (Haigh-Hutchinson, 2009) for a viewer. A camera system that is poorly implemented will result in a poor application, whereas as a quality design is important for a successful application (Haigh-Hutchinson, 2009). There is an implicit effect of real time camera systems on the viewers perception of the control of VE required for interaction. Therefore, a good camera system needs to be developed for such VEs. The above-mentioned criteria given in Table 2.4 can be used as a guideline for developing a successful camera application however there are still no fix standards or guidelines or frameworks for placing a camera in games. In this study, a qualitative analysis has been carried out to determine the set of principles, guidelines and rules for implementation for an aesthetically placement of a camera in a VE of a game.

2.7.1.2 Camera Aesthetics Based on Presentation Styles of Games

Table 2.5 provides the summary of camera aesthetics based on a games' presentation style of a VE. There are two basic presentation styles in a game, those being 2D (Kelly, 2012) and 3D (Kanev & Sugiyama, 1998). These presentation styles are based on the dimensions used to represent a VE. In the early development of VEs there were hardware limitations and subsequently 2D games were developed. As the technology advanced, more complex 3D VEs were developed. In 2D VEs the game camera is developed with a fixed perspective, whereas in 3D VEs the camera can look to any side, which effects the overall aesthetic implementation of the two game styles. 2.5D games have a characteristic of both 2D and 3D VEs and games.

Table 2. 5 Types of Presentation styles of game's Virtual Environment (VE) and their aesthetic measures ((Kelly, 2012) and 3D (Kanev & Sugiyama, 1998))

Presentation Styles	Camera Properties	Aesthetic Properties
2D	**Orthographic Projection** Movement limited to scrolling. Example: Figure 2.4	**Single player:** Player character stays on screen always (Visibility) Player character to stay within the edges of frame. Synchronizing camera motion with a character movement Look-at position and desired position for a player should be aligned. **Multiplayer:** Game camera position centre or the average of the bounding box of all players to keep characters visible on the screen
3D	**Interactive** Two types of projections 1) Perspective and 2) Parallel Parallel projections include. Orthographic (Examples: maps, radars, so on.) Axonometric Isometric (All Axis are Equals, Used in Role Playing Games (RPGs)) 1) Dimetric (z-axis is short, *x and y* axes are equal (orthographic + depth)) ▪ Trimetric (All axes are different) ▪ Arbitrary movement ▪ Encompasses all requirements of cinematic cameras. Example: Figure 2.5, Figure 2.6, and Figure 2.7	Player character stays on screen always (Visibility) (Depending upon the perspective). Aesthetic changes as camera's perspective changes such as from Third Person (TP) to Third Person (TP) perspective. How realistic the view of the terrain will look depends upon the angles calculated for three Axonometric projections. Defining the Rule of Thirds (RoT) for character positioning on screen

	Cinematic Example: Figure 2.8	Shot composition principles such as ○ Line of action ○ The Rule of Thirds (RoT) ○ Visibility Mostly used for game narratives
2.5D	**Combined 2D and 3D** Example: Figure 2.9	Same as 2D games with limited view of a world to enhance gameplay.

In Orthographic Projection two common views are plan and elevation, which are usually called ‘top-down’ and ‘side view’ as shown in Figure 2.4. This projection can be easily implemented and used, since there is no need to worry about the third dimension. Two coordinates (x and y) are sufficient to describe everything in a game, including the game camera system. The aesthetic requirements for such games are that the player character always stays on screen (Visibility); that the player’s character stays within the edges of frame, that camera motion is synchronized with a character movement, and the Look-at position and desired position for a player should be aligned. For a multiplayer game, the camera position centre or the average of the bounding box of all players should keep characters visible on the screen.

Figure 2. 4 Examples of side Orthographic views Kikstart 2, Mr. Chip Software, 1987 (top), Metroid, 1986 (bottom), Nintendo (Jan, 2017)

In 3D games there are two types of camera systems, interactive cameras, and cinematic cameras (Haigh-Hutchinson, 2009; Meeder, 2020; Krichane, 2021) (Examples given from Figure 2.5 – 2.8). Interactive camera change response, whether motivated by the player’s action or any other element in a game, to real time events in a game. Cinematic cameras, on the other hand, are unaffected by the player or any other object in a VE in presenting a view. In order to overcome the limitation of the cinematic camera hybrid (Amerson et al., 2005; Lino et al., 2010; Krichane, 2021) camera systems have been developed, mixing up both interactive and cinematic camera effects in a 3DVE. The aesthetic criteria for interactive cameras are depending upon perspective, the player's character always stays on screen (Visibility). Aesthetic changes might change as the camera's perspective changes. An example of this would be when there is a change from FP to TP perspective. The viewing angle that the terrain will see depends upon the angles calculated for three Axonometric projections.

Defining the Rule of Thirds (RoT) is required for character positioning on a screen. Aesthetic criteria for such cinematic cameras are shot as composition principles. These include the Line of Action, the Rule of Thirds (RoT), and visibility, and are mostly used for game narratives.

Figure 2. 5 Examples of perspective cameras (Adapted from: (Simplified))

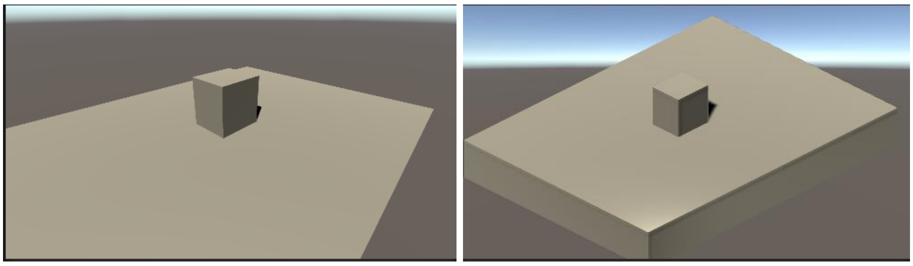


Figure 2. 6 Examples of 3D perspective (let), Isometric view (right)

Figure 2. 7 Isometric view of the RPG game (Freedom Force 2002) (Adapted from: (Old-games.com, 2002))

Figure 2. 8 Rockstar (Adapted from: (AROGED, 2021))

In 2.5D games ((Vince, 2018), (Runkun & Gopalan, 2022)**)** the camera system is between that of a 2D and a 3D camera system. These games are 2D generated games that are displayed or played in 3D perspective (Runkun & Gopalan, 2022). Figure 2.9 is an example of 2.5D game. The aesthetics of a 2.5D VE games are the same as 2D games with a limited view of a world to enhance gameplay.

Figure 2. 9 Viewtiful Joe (Adapted from:(IMDb, 2003)*)*

2.7.2 Types of Camera Behaviour and Aesthetics

There are three basic types of camera behaviour (Haigh-Hutchinson, 2009). These are seen as First Person (FP) (Muscat & Duckworth, 2018; Monteiro et al., 2018; Yun et al., 2021), Third Person (TP) (Denisova & Cairns, 2015; Muscat & Duckworth, 2018; Tsai et al., 2021) and Cinematic (Laukkanen, 2018; Ronfard, 2021; Wolinsky, 2022). Hybrid camera behaviour combines both FP and TP views in games.

In-game cinematic camera behaviours place an emphasis on applying cinematography principles to camera design (Haigh-Hutchinson, 2009). The cinematography principles (Moh & Zaidi, 2019; Louarn et al., 2018; Nathan, 2020) are the same as that applied for films and animations and are commonly used for an aesthetically pleasing experience of a game (Nathan, 2020). Cinematography was introduced in games to narrate the story or for story telling within the game. It was considered separate from the gameplay. Currently, cinematography has been adopted to improve the gameplay and to allow a player to have a more immersive experience (Han et al., 2022).

The aesthetics measures applied to these camera behaviours depend upon the game genre it is applied for. Aesthetics and gameplay overlap in the sense that an aesthetically pleasing view of a game world is important for the purpose of understanding the game's virtual world, which then in theory improves gameplay. They are both linked. Motion and orientation constraints of the camera are determined by the aesthetics associated with the chosen camera behaviour (Haigh-Hutchinson, 2009). The aesthetics associated with a camera motion may include defining acceleration and velocity limits, handling passing through geometry, and the position of the target object relative to the character. The aesthetics of orientation includes defining the camera's pitch and yaw for disorientation avoidance.

2.7.2.1 Game Genre and Aesthetic Measures

Some of the camera aesthetics details required according to game genres and styles are given in Table 2.6. Camera aesthetics varies with game genres. For example, is important to consider that the First Person (FP) perspective games are different from the aesthetics of Third Person (TP) perspectives. For FP perspective games, the viewpoints are actually the eyes of the player with a limited view, usually demonstrated when used in shooting games (Shao et al., 2019). It highlights the challenge in the recognition of a TP adventure games camera where it is at the back of a character. In TP perspective, the view of part of the character and part of the surroundings of the character. This perspective is usually used in role playing games (Tsai et al., 2021). Details of the game genres, along with definitions and examples are given below.

Table 2. 6 Game Genres with associated camera aesthetic requirements (Adapted from: (Wolf, 2021*; Haigh-Hutchinson, 2009; Haigh-Hutchinson, 2005)*

Game Genre	Definition	Aesthetic Measures	Example
FP Shooter/Adventure Games	Immersive view of a VE (Camera is inside player) (First Person)	Considering two properties for immersive experience Camera should be close to character/Most of the time inside a character	Metroid Prime Trilogy [Metroid02] Figure 2.10
		Motion is synchronized with a character. Camera position away from the actual position of eyes vertically for better VE view.	
		View should not be completed obstructed by a weapon/object / Sufficient View of the ground should be visible for navigation. Orientation: Limited control Limited field of view (FoV) to avoid distortion	

Character/action-adventure Games	Games based on characters. (FP/TP)	Camera is designed based on characters abilities such as position and orientation of a camera depends upon an ability of a character to traverse the VE. Two main types. Flying/Swimming: Aesthetics: (Stationary cameras for if small volume swimming areas)	Tomb Raider [Tomb96] Super Mario Sunshine [Mario02] Figure 2.11
		Ground (Run or walk across surface of VE) Aesthetic: (synchronized with the rotation of the player character by applying angular lag, Not block the view of a player while moving.) Avoid unwanted camera motion (Damping vertical motion) to keep character in frame	
Stealth	Close combat games (TP / Hybrid for shooting/aiming games)	A good viewpoint to present a relationship between a character and enemy. Aesthetics lies for both FP shooter and TP camera. Orientation to limited degree, not exposing whole area for viewing. Moving camera outside the world to ensure unobstructed game view.	Hitman: Blood Money Figure 2.12
Role-playing games (RPG) / massively multi-player online games (MMPOG)	Toggle between TP and FP Subset of character-based genre	Aesthetics: View of multiple players and game-controlled characters Elements of cinematography are incorporated in framing	Final Fantasy XI World of Warcraft
Sports	TV-style presentation Single-participant sports	Aesthetics: Non-perfect framing (Camera may not follow a ball going out of ground as in real sports) Camera replay based on external views such as closeups with visually interesting angles (May include cinematics) Viewpoint can change in Team sports from player to player. Showing game character irrespective of surrounding environment for indoor sports games	Golf Tennis Soccer
	Two- or four-participant sports		
	Team Sports		
	Court and indoor sports (ball or table sports)		
	Outdoor (Arena or free Form or tracked based)		

Racing Games	Predefined region Toggles between different views	Aesthetics of Third- and First-person camera. Replay cameras as sports camera. Cinematic effects are also included. Widening of Horizontal FoV to create the effect of speedy opponent car	Burnout 3
Real Time Strategic (RTS)	Several ways to view a game. Multiple strategic or high-level world views	Pre-defined camera views (Constraints based camera system can be used)	*StarCraft II*
Flight simulation	External camera views	Aesthetics of first-person perspective as that of racing games	Take Off
Puzzle/party games/board games	Sometime split screen multiplayer presentation	Player is not featured, only manipulation of game objects. Entire playing area should be visible on the screen. Predefined camera positions for the target object	Tetris Rubik's Cube

Figure 2. 10 Example of First-Person Shooter camera Metroid Prime Trilogy (Adapted from:(Webb, 2019))

Figure 2. 11 Example of Character/action-adventure games Super Mario Sunshine (Adapted from: (Hawkins, 2020))

Figure 2. 12 Example of Stealth Games Hitman: Blood Money (Adapted from: (Haj-Assaad, 2021))

2.7.3 Critical Analysis and Drawbacks of Previous Work

From the literature review the research gap was clearer in identifying and characterising the aesthetic features in relation to areas such as gameplay. This meant that although there are objective and subjective factors that can define aesthetics for any kind of digital or interactive digital media applications, there is still a need to investigate and understand aesthetics of "gameplay" for designing a camera for a 3DVE. In such cases using only objective and subjective factors might not be sufficient.

Based upon a review of the literature, there is a need for a blend of "aesthetic sensibility" and understanding of "gameplay" for designing a camera for a 3DVE (Haigh-Hutchinson, 2009). Camera positioning and orientation should be based on the game genre and the type of VE that has been developed for that game genre. Choosing optimal camera parameters is a time-consuming process and requires a lot of effort by designers and developers. Therefore, a system capable of finding optimum camera viewpoints can be used for automating the process of camera position and orientation based on aesthetics. This study is an attempts to solve the problem of camera viewpoint optimization based on aesthetics.

2.8 A Rules based approach for Camera Aesthetics

This review of the literature explains that Virtual Cinematography (VC) is an art, composed of many cinematography rules, developed over centuries (Mascelli, 1965; Friedman & Feldman, 2004; Heiderich, 2012). For instance there are various shot types such as a Medium Shot or a Full shot, and many viewing considerations are expected to follow the Rule of Thirds (RoT) (Roy, 1998). These VC rules define the structuring of visual elements on the screen. This paper considers the rules which provide aesthetic experiences to a user of a 3D VE (Atkinson & Parsayi, 2021; Burelli & Yannakakis, 2010). Using additional aesthetics approaches it becomes possible to add intrigue and heightened interest by controlling a camera behaviour where that behaviour is guided by VC rules. The ability to add a user's appreciation of what might otherwise be an occluded view is an important aesthetic inclusion.

The literature demonstrates that the Rule of Visibility (RoV) (Cozic, 2007) is noteworthy because it posits two main considerations. On the one hand we consider that in terms of Frame Bounds an object must be within the bounds of a frame. However, to satisfy Occlusion there should be a clear line of sight between a camera and the target object. In concert, these two subsets of the (RoV) do not allow for a more fully aesthetic experience. This added experience can be described as a third person view that depicts an import set of additional information such as a person standing behind a wall or waiting around a corner.

The need for increased emphasis on aesthetic characteristics shows a growing demand (Litteneker & Terzopoulos, 2017). An optimised visual shot can be more ideally driven by the inclusion of a TP element that will increase the aesthetic value of the experience. For instance, aP FP game such as Call of Duty (Ward, 2009) provides a different experience than a TP camera game such as Resident Evil (Sepúlveda, 2019; Capcom & Poland, 1996). First Person (FP) games have a direct view of what a character can see without any idea of the surrounding VE geometry. In contrast, the use of a Third Person (TP) camera allows a user to see over the shoulder, behind walls, and around corners. Such an addition provides increased interest based on the increased aesthetic elements of the wider surroundings. In this sense, the Rules of Visibility (RoV) are, in isolation, less helpful in allowing for a more fully aesthetic experience (Litteneker & Terzopoulos, 2017; Vasquez 2016; Cozic, 2007). They are insufficient in their own right to support the increased benefits of aesthetics in a VE.

Human effort in designing a high-quality aesthetic experience of a Virtual Environment (VE), such as video games, (using cinematography rules and principles) is a time consuming and costly task (Junaedi123 et al., 2018; Cozic, 2007; Christie et al., 2005). In addition, camera systems in a VE can be evaluated using several different dimensions. These go beyond a simple rules-based approach and include other aspects where aesthetics are beneficial such as the choice of TP camera positions based on storylines, plot evolution, and advanced game progress (Jhala & Young, 2010). Other elements beyond the rules approach include specific user experiences (Meeder, 2020). For example, players gaze, action, and game context has been recorded (Burelli & Yannakakis, 2015) exploring VE. An automated system for positioning the camera in a VE for capturing an ideal shot that delivers aesthetic benefit is an important additional area of research (Rautzenberg, 2020; Zhaohui, 2020; Schell, 2008; Christie et al., 2005).

In this study we have considered five measurement constraints based on virtual cinematography which have been adopted from Litteneker & Terzopoulos (2017) as given in Chapter 5. A detailed description of the parameters is given in the methodology chapter. These constraints are designed for a single target point in a VE for a single target object. A Genetic Algorithm (GA) has been developed as an optimisation method Goldberg & Holland (1988) and allows for optimised camera placement within 3DVE (Prima et al., 2016; Ranon & Urli, 2014). To test this a VE with a single target object and a single camera has been developed using Unity Engine (UE) 2020.2.2f. in Visual Studio 2019. It used C# as an API scripting language for implementation and optimisation of the camera parameters.

2.9 Technical Review

2.9.1 Genetic Algorithm

Complex engineering and scientific problems can be resolved using Genetic algorithms (GA). A GA is a meta heuristic approach for solving computation problems by the process of evolution (Alam et al., 2020; A. K. Shukla et al., 2019; Katoch et al., 2021). Each algorithm starts with an initial population, which undergoes the process of selection, crossover, and mutation to generate the new population for a fixed number of generations. The fitness calculations for the individuals for selection are assessed using the fitness function, also known as the objective function in any GA. Individuals with the best fitness values are selected based on the probability of selecting individuals from the population which depends upon the fitness probability of the objective function (Alam et al., 2020).

Table 2.7 explains various terms associated with GA. The best solutions are selected in every generation and new generations are created using crossover and mutation operators. A new generation is then transferred as individuals of the next generation, which are better optimized solutions than the previous generations. There are several different terms used for GA functions and operators. The six main descriptors explained below are based on agreement from known authors in Genetic Algorithm theory (Holland, 1992; Alam et al., 2020; Mirjalili, 2019; Kramer, 2017; Zeqiu Chen et al., 2021).

Table 2. 7 Main descriptor components of Genetic Algorithm (GA)

GA Functions and Operators	
Representation	Defines genotype for a GA problem
Initialization of Population	A multiset of Genotypes used to form a GA (A set of possible solutions)

Evaluation Function (Fitness Function)	Used for evaluation of population for Selection
Parent Selection (GA Operator)	A process for selecting individuals used to create offspring
Mutation (GA Operator)	An object used to create a different offspring
Recombination or Crossover (GA Operator)	The merging of Information from different parents

2.9.1.1 Representation in Genetic Algorithm (GA)

Details of various representation schemes used are given in Table 2.8. The representation is the first step in defining GAs for a certain problem. Individuals of a population in a genetic algorithm are shown through representation. The original problem, known as the "phenotypes" of a problem in GA, is encoded into a "genotype". Representation helps in the easy demonstration of a solution to a given problem. Any problem can be demonstrated by different representations (Aissaoui et al., 2018). The properties of the defined representation determine the performance of the search algorithm (Ashlock et al., 2012). A representation can be defined in many ways, including binary representation, tree structures, or real-valued vectors amongst others as given in table below.

Table 2. 8 Summary of various encoding schemes for Genetic Algorithm (GA)

Types	Explanation	Properties
Binary Encoding (Holland, 1992; A. Kumar, 2013; X. Zhu et al., 2020)	Strings of 1s and 0s for representation.	Faster implementation Drawback: extra effort required for conversions
Octal Encoding (Holland, 1992; A. Kumar, 2013; Rajasekaran, 2017)	Octal numbers from 0 to 7 are used for representation.	Have a limited use
Hexadecimal Encoding (Holland, 1992; A. Kumar, 2013; Rajasekaran, 2017)	Hexadecimal numbers (0 to 9, and A to F for representation)	Have a limited use
Tree Encoding (Holland, 1992; A. Kumar, 2013; Rajasekaran, 2017)	A tree functions or commands are for representation	Commonly used in evolution of expressions or programs.

Value Encoding (Holland, 1992; A. Kumar, 2013; Lino & Christie, 2015)	Real values for representation.	Specific Operators required

2.9.1.2 Population Initialization in Genetic Algorithm (GA)

The set of possible solutions for a GA is referred to as the population (Chen et al., 2021). It is also known as a multiset of genotypes providing units which are referred to as parents for the next generation. Individuals within the population of the same generation remain static, as they do not change or adapt. However, the population does undergo a change as different generations evolve. From the given population, the best individuals are selected for the seeding of the next generation or, in some cases, the worst individuals are replaced by better ones (Shukla et al., 2019). The population size remains constant throughout the evolutionary process. The initialization of a population is usually a simple step in GA, where randomly generated individuals are used to seed the first or initial population. The aim is usually to create problem-specific representation, which will result in a higher fitness for the initial population after evolution.

2.9.1.3 Evaluation Function (Fitness Function) in Genetic Algorithm (GA)

The evaluation function or fitness function (Eiben & Smith, 2015) in GAs forms the basis for selection among the individual in a given population. The feasibility of the solution is represented by the fitness function, where the higher the fitness value, the better the solution (Zeqiu Chen et al., 2021). A Fitness function definition depends upon the problem, which is intended to be solved through GAs.

2.9.1.4 The Mechanism for Parent Selection in Genetic Algorithm (GA)

The details of various selection schemes for GAs are given in Table 2.9. The process of selection mirrors the survival of the fittest in nature, and the selected individual is considered a parent for the next generation. Selected individuals are used to create offspring with different variations and improved quality. High-quality individuals having a higher chance of selection than low-quality individuals. The variation operators such as mutation or recombination are used for creating new individuals from the existing ones (Chen et al., 2021). These new individuals are then added to next generations and the process continues.

Table 2. 9 Summary of some Selection Schemes for Genetic Algorithm (GA)

Types	Explanation	Properties
Roulette Wheel (Holland, 1992; Rajasekaran, 2017; Yadav & Sohal, 2017)	Allocate a portion on a wheel for all individuals. Wheel is rotated randomly for selection.	Stochastic nature of the process results in producing errors.
Rank (Holland, 1992; Rajasekaran, 2017; Yadav & Sohal, 2017)	Modified version of Roulette wheel selection. Ranks individuals based on fitness values.	Used to prevent premature convergence of the solutions to a local minimum.
Boltzmann (Holland, 1992; Rajasekaran, 2017; Yadav & Sohal, 2017)	Uses entropy and sampling methods.	Premature convergence can be solved
Stochastic Universal Sampling (Holland, 1992; Rajasekaran, 2017; Yadav & Sohal, 2017)	Advanced version of Roulette wheel selection. Individuals are selected at equally spaced intervals, starting at random point.	This scheme allows equal chances of selection
Elitism (Holland, 1992; Rajasekaran, 2017; Natesha & Guddeti, 2021)	Elitist individual in each generation is moved to the next generation.	Automatically selects the best individual from the current generation and transfers it to the next generation. The best solution is not lost during the evolution process.
Tournament (Holland, 1992; Rajasekaran, 2017; Yadav & Sohal, 2017)	This selection scheme based on fitness. Individuals are selected randomly in pairs.	The individual with highest fitness value added as an individual of next generation.

2.9.1.5 Mutation in Genetic Algorithm (GA)

Details of various mutation methods are given in Table 2.10. In mutation, only one object or single variation operator is used and produces a slightly different child or offspring as an output. Mutation operators are stochastic, where output depends upon the random choices of the individual from the current population. The mutation rate is kept low, as a large mutation rate will result in exploration of data at very large scale effecting the converging process of GA (Chen et al., 2021).

Table 2. 10 Summary of some Mutation schemes for Genetic Algorithm

Types	Explanation	Properties
Non-Uniform Mutation (Lim et al., 2017; Zhao et al., 2007; Cathabard et al., 2011)	This mutation scheme mutation rate is lowered (may be to 0) as individuals of a population becomes fitter with increasing number of generations.	Used for Real Values
Simple Inversion Mutation (Katoch et al., 2020; Murata & Ishibuchi, 1996; Soni & Kumar, 2014)	Substrings are reversed to create the new solution.	Used for Binary
Displacement Mutation (Katoch et al., 2020; Soni & Kumar, 2014; Deep & Mebrahtu, 2011)	Substring is displaced to randomly chosen place.	Displacement is carried out in such a way that the new solution is valid and the displacement.
Adaptive Mutation (Lim et al., 2017; Korejo & Yang, 2012; Rosenberg, 2001)	Gradient simulation for a direction in searching.	Individual with best genes is used
Uniform Mutation (Holland, 1992; Rajasekaran, 2017; Lim et al., 2017; Soni & Kumar, 2014)	Gaussian distribution is used the replace the gene chosen for mutation. Range for Gaussian distribution is defined by the user.	Commonly used for Real Values

2.9.1.6 Recombination or Crossover Operator in Genetic Algorithm

Details of various recombination or crossover methods are given in Table 2.11. In recombination, the information is merged from two different parents with desirable features and the output consist of an offspring consisting of features from both the parents. Several offspring are created by the evolutionary algorithms through random combination. Some of the offspring will have undesirable trait combinations, some may be better or worse than the parents from which they have evolved, and others may have some improved characteristics. All are added as individuals of next generations (Zeqiu Chen et al., 2021).

Table 2. 11 Summary of some of the Recombination/Crossover operators used in Genetic Algorithm

Types	**Explanation**	**Properties**
Two and K-point (Katoch et al., 2020; Lim et al., 2017; Umbarkar & Sheth, 2015)	Need to exchange more than one gene.	Results in less diversity
Uniform Crossover (Katoch et al., 2020; Lim et al., 2017; Umbarkar & Sheth, 2015)	The head and tail rule is used for assigning genes to children. For every gene coin is flipped head of one parent and tail for another parent is used. First child gets the original gene whereas second child gets the inverse of the same gene (Lim et al., 2017).	Location of genes do not play any role. Less diverse population is created (Katoch et al., 2020).
Discrete Crossover (Lim et al., 2017; Umbarkar & Sheth, 2015)	This scheme is similar to one-point and uniform crossover (Lim et al., 2017).	
Arithmetical Crossover (Lim et al., 2017; Kora & Yadlapalli, 2017; Kaya & Uyar, 2011)	Arithmetic operators are used to generate genes There are various types of arithmetic crossover such as single, simple and whole arithmetic crossover (Furqan et al., 2017).	New individuals obtained through linear crossover of the selected parents (Katoch et al., 2020).
Single Point (Lim et al., 2017; Katoch et al., 2020; Umbarkar & Sheth, 2015)	Easy to implement exchanges one gene	Results in less diversity

2.9.1.7 Termination Condition for Genetic Algorithm (GA)

If the optimum fitness level of the problem is known, then this optimum level can be used as a terminating condition for any GA (Kumar et al., 2010). This can be explained when no optimal solution exists, and the process will go on forever. Therefore, the following four conditions that can be used for termination are.

1. by defining the maximum CPU, time elapses are allowed for a GA
2. or by limiting the total number of fitness evaluations

3. or by defining a threshold value for fitness improvement over a given time.
4. or if the diversity in population drops by a given threshold value.

2.9.2 Qualitative Analysis

Qualitative analysis or Qualitative Research refers to any type of analysis /research in which findings are not based on statistical procedures or any other method of quantification (Strauss & Corbin, 1998). There are four characteristics of qualitative research on which qualitative researchers seem to agree (Järvinen & Mik-Meyer, 2020). Firstly, there is the qualitative research purpose, and in particular with interviews there is an analysis of meanings and evaluation. In qualitative research reality is often seen from the perspective of the person studied and tries to understand the event or happening for those who are involved in the study. In some cases, it is possible for the research participants to have already interpreted the insight before scientists. Therefore, qualitative analysis not only includes peoples' perspectives but also includes analytical evaluation of their perspectives. Meanings are generated, negotiated, maintained, or altered in special contexts in qualitative analysis (Järvinen & Mik-Meyer, 2020).

Secondly, we should consider the "works with process as much as content" in qualitative analysis. Qualitative research does not represent the characteristics or specific features of a group of individuals but also includes analysis of characteristics and features in shaping people's lives. In Qualitative research processes are investigated as "mutual interaction mechanisms between people and their surroundings" that can be social or physical. In short, most questions in qualitative analysis are not "why" but based on "how" and "what" questions (Järvinen & Mik-Meyer, 2020).

Thirdly, the focus is on the context of the phenomena studied in Qualitative analysis. It is often the case in quantitative research that the phenomenon is isolated from its background or context and then across context it is generalised. This is avoided in qualitative research, and instead a specific spatial temporal and social context is used to see the phenomenon studied (Järvinen & Mik-Meyer, 2020). Fourthly, typically qualitative research has defined itself as inductive rather than deductive. This is because the understanding, concepts and potential theories are developed based on empirical data instead of collecting data to test deduced hypothesis or models (Järvinen & Mik-Meyer, 2020). Some of the details of qualitative research carried out in this study is given below.

2.9.2.1 Methods of Data Collection

Methods for collecting data in qualitative analysis includes numerous methodologies such as in-depth interview, observations, Focus groups (Rosenthal, 2016), and Think aloud sessions amongst others (Seaman, 2008). Summary of some of the methods for data collection in qualitative analysis are given in Table 2.12. The amount of data generated for each method used is substantial. Although there are a variety of study methodologies available, there are also different ways such as recording hand written notes or record videos of what is said and done during an interview or focus group (Sapsford & Jupp, 1996). If data is in the form of a recorded video or audio, then it needs to be transcribed before analysis.

Different methods have different ways of recording data. When there are in-depth interviews is it normal that open-ended questions are posed, followed by an investigation for in depth understanding of the experiences' of the participants through opinions, perceptions, feelings and knowledge (Patton, 1990). A Focus group is like an in-depth interview as this study also consists of open-ended questions to record responses of participants based on in-depth experiences. The difference between a Focus group and in-depth interviews is that it relies on the interaction between the participants to answer the questions to researchers' questions rather than an individual opinion or experience (Rosenthal, 2016). In this study A focus group method has been used for collecting data, since this study focusses on collecting the group's perspective rather than individuals' point of view about aesthetic viewpoint of a camera in a VE (or a game environment).

Table 2. 12 Summary of some of the methods used for data collection in Qualitative analysis

Technique	Based on Aim of the Researcher	Amount of Data obtained
Focus Group (Rosenthal, 2016; Seaman, 2008; Patton, 1990)	General opinion from group of people	Small
Interviews (Rosenthal, 2016; Seaman, 2008; Patton, 1990)	General information from an individual's point of view	Small to large
Observation (Rosenthal, 2016; Barrett & Twycross, 2018; Seaman, 2008)	Field notes are taken during observations	Medium to Large

2.9.2.2 Methods of Data Analysis

In qualitative research the investigator is trying to interpret from another person's perspective by using the participants taken part in the study (Sapsford & Jupp). There are commonly six types of data analysis techniques in Qualitative analysis as details are given below. Qualitative analysis includes most commonly six types of analysis. There is thematic analysis, content analysis, grounded analysis, discourse analysis, narrative analysis, and phenomenology/Heuristic analysis (Noble & Smith, 2014). Some of the details of these themes are given below.

Thematic analysis (Vaismoradi et al., 2016; Strauss, 2004) is commonly used in qualitative analysis. It forms a foundational method for qualitative analysis of data. It is used when there is a need to present a clear pattern of data using themes. Steps involved in thematic analysis includes getting yourself familiar with data by reading data repeatedly, initial code generation, code organization based on similarities, theme searching, and in the end review of merged themes and naming the defined themes.

Content analysis (Hsieh & Shannon, 2005) is based on certain words and concepts in the text. Content analysis results in emergence of themes or categories that is based on selection of words. This can be used for books, websites, interviews, newspapers, or essays and so on. The purpose of content analysis is to investigate the patterns, sequence of occurrence, or sometimes word frequency.

Ground analysis (Gullick & West, 2012; Strauss, 2004) is also called constant comparison analysis. It is a deep and detailed analysis of qualitative data. In ground analysis multiple rounds of interviews are taken, field notes are recorded, any other type of data such as documents, or pictures are taken. Initial coding is used to find the consistencies and differences in data, and flow charts are drawn to further understanding. In this three-step process various important things are found such as events, persons, and situation to form themes.

Discourse analysis (Johnstone, 2017; Strauss, 2004) is a linguistic analysis for flow of communication. It takes into consideration the social context in which certain communication has occurred. It is strictly related to study of sounds, grammar, and their associated meanings.

Narrative analysis (Sandelowski, 1991; Strauss, 2004) is based on analysis of how participants create their stories based on their personal experiences. This may include their personal stories, entire life story, and any important situations and events occurred. This analysis is used to identify non-verbal expressions, pauses, filler words (such as Uhh, Umm) or non-verbal gestures. Various components of the analysis are story's abstract, time and place, characters, sequence of events, reflection of a storyteller, and conclusion of a story with ending.

Phenomenology/Heuristic analysis (Strauss, 2004) is an analysis of how humans experience the world. This analysis only focuses on the participants experiences and excludes researchers. This includes an analysis of a teaching experience from a teacher's point of view.

In this study qualitative data analysis has been carried to obtain an aesthetic model for defining the aesthetics for a camera in a VE of a game or virtual simulators. Focus groups have been used as a data gathering technique, whereas thematic analysis has been carried out for analysis of the data obtained.

2.9.2.3 Tools used for Qualitative Analysis (QA)

There are a range of programmes that are available for assistance in qualitative analysis of data. Design and application of software programs may vary for analysis. There are three basic types of software programs, text retrievers, code retrievers, and theory builders. The two most common tools used for analysis are NVIVO and NUD*IST (Noble & Smith, 2014). NVIVO and NUD*IST are mostly used because they can manage large datasets and data retrieval because of their sophisticated code and retrieve functions and modelling capabilities (Noble & Smith, 2014).

2.10 Introduction to Unity Engine (UE)

The Unity Engine (UE) typically known as Unity3D is an Integrated Development Environment (IDE) and also a game engine for developing games or any kind of interactive media (Haas, 2014). A large number of publishing targets and fast prototyping makes Unity a highly regarded and widespread product. Unity was successful because it supported independent developers who were incapable of getting expensive licenses for sophisticated game engines (Haas, 2014). There are many versions of Unity released on an ongoing basis. Globally, people regarded Unity as the most widespread game engine and a product that was useful as an integrated development environment (Šmíd, 2017). It is easy to use and every one can start a development using this game engine. Another compatible game engine is Unreal, it is mostly used by professionals in studios (Šmíd, 2017).

In this study UE has been used for analysis and development of optimization algorithms in a 3DVE. Unity is used because the component architecture of this game engine in easy to understand. Scripting is in C# language which is fast and more efficient (Šmíd, 2017). It is easy to debug in Unity because there are plenty of online forums and help available for this game engine. In addition, there is an asset store available for Unity from where you can easily download and utilize assets which are also free sometimes. With the new versions available for UE, graphics are getting better, and better rendering is available for the game view.

2.10.1 Unity Editor

A screenshot of Unity editor in given in Figure 2.16. There are many windows in the editor but the most used are hierarchy, game view, scene view, and inspection windows. The project browser window (as given in Figure 2.17) is shown at the bottom of the hierarchy window (in Figure 2.16) and shows all the assets downloaded or bought for the project. Assets are first downloaded then imported into the project in Unity 3D. The layout is similar to that of any explorer in Windows (Šmíd, 2017), which makes Unity 3D familiar and easy to use without any professional training. Some of the details and purpose of other windows in Unity editor are given below.

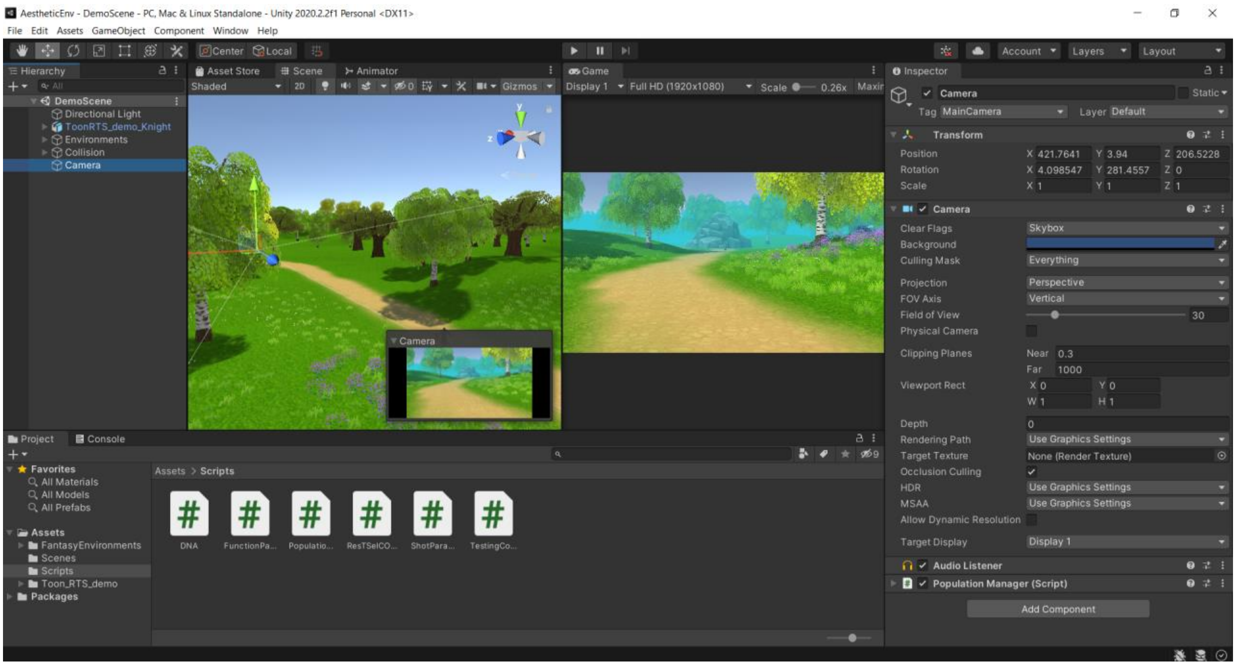


Figure 2. 13 Screen shot of Unity 3D editor

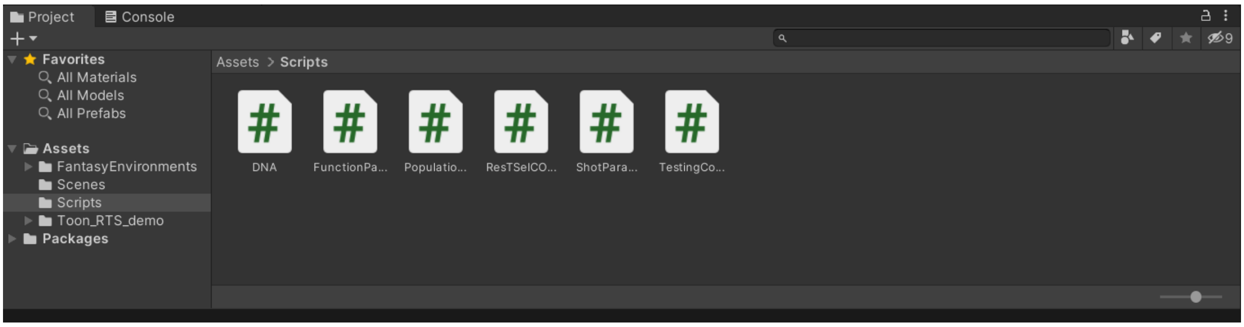


Figure 2. 14 Unity 3D Project window

The inspector window for Unity3D is given in Figure 2.18. Details of all Game Objects such as camera, lights, other 3D components are modified and viewed (as given in Figure 2.18, inspector window for game camera). Here, developers can adjust the values to get the perfect feel for the game. All the components, such as scripts, physics, sounds etc.) connected to the game object are shown here. Variables provided by the script can also be assigned or modified here.

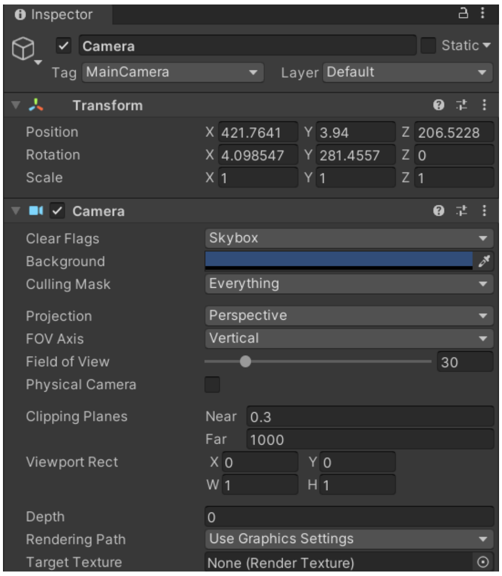


Figure 2. 15 Screenshot of inspector window in Unity 3D

The game view of the Unity3D is given in Figure 2.19. It provides the user with a preview of WYSIWYG (what is displayed is what is captured) that shows what the game will look like when the user creates the game (Šmíd, 2017). It contains complete input so developers can test their changes without having to wait for the project to be compiled and deployed to the target platform.

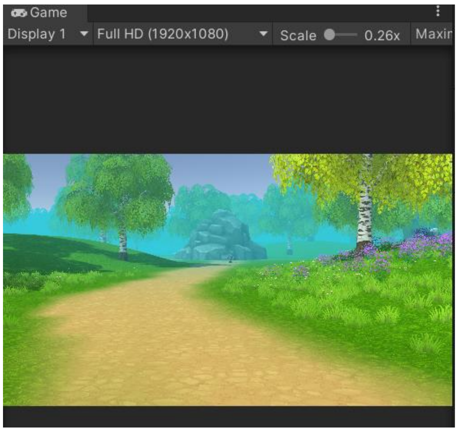


Figure 2. 16 Screenshot of a game view of Unity 3D

The scene view of Unity3D is given in Figure 2.20. is where the game is constructed. Assets can be dragged and dropped from the project view window. Familiar 3D handle controls and grid snaps allow users to position objects in perfect pixel-by-pixel position.

Figure 2. 17 Screenshot of scene view in Unity 3D

The hierarchical view of a Unity3D, given in Figure 2.21, contains the list of all objects that are present in the scene of the game environment. When the object is included in the scene, the hierarchical view list is automatically updated. This window can also help in defining parents and children by dragging objects one under the other.

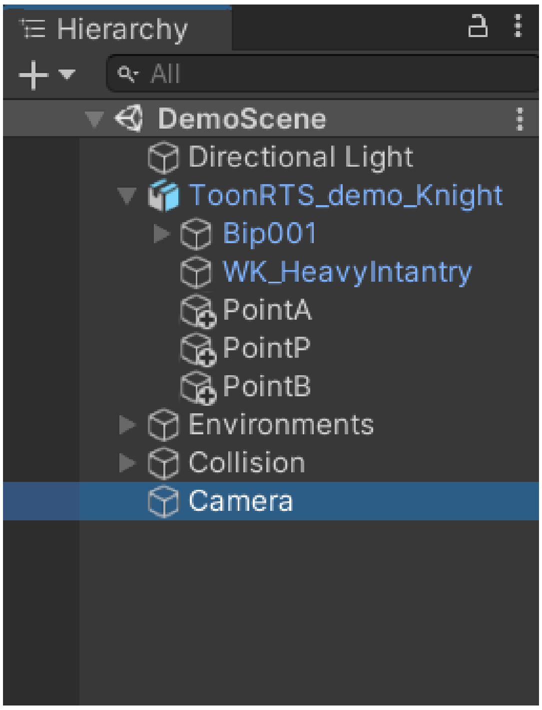


Figure 2. 18 Screenshot of Hierarchical view in Unity 3D

2.10.2 Unity3D Asset Workflow

Assets are the elements used to create games and apps in a Unity project. Assets can represent visual or audio elements within a project. This can include 3D models, textures, sprites, sound effects or music. Assets can also represent more abstract elements, such as gradients, animation masks, or text or numeric data for any purpose. Assets can be retrieved from files created outside of Unity including 3D models, audio files or images (Unity3D.com).

The workflow for Unity3D assets is given in Figure 2.22, each column shows individual steps involved. Firstly, the asset is imported into the Unity3D editor, which includes getting the source file of the imported models to be used for development purposes. Secondly, content is created for the imported asset using the Unity3D editor. This involves adding the imported as a Game object to a scene in Unity by adding script files to control the user interaction. The third steps involve building. In building the completed project it is converted to binary files that can be used to distribute and run on the platform chosen. For example, an .EXE file is created for running projects on Windows platforms. The fourth step is distribution. Once binary files have been obtained the next step is to either publish the project on an App store or to self-host on your own servers. The last step requires the loading of the developed project. The loading process and experience is defined by the rules and programming of the developer and how assets are bundled together in a project (Unity3D.com)

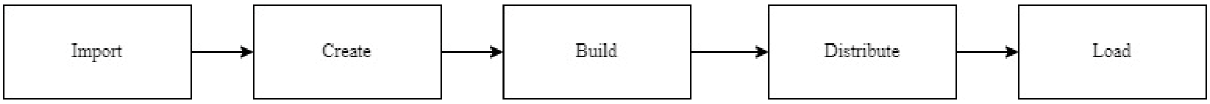


Figure 2. 19 A flow diagram to show an asset workflow in Unity3D. Adopted from ((Documentation, 2021a)*)*

2.10.3 Scripting in Unity3D

All applications require Scripting as an essential ingredient in Unity. Scripts are required to respond to inputs from the player. They are also required to arrange for events in the gameplay to happen when they should. In addition, scripts are used to create graphical effects, physical behaviour control of objects or also for implementation of a custom AI system for characters in the game (Unity3D.com).

Important components for setting up the scripts in Unity involve setting up a scripting environment that includes Integrated Development Environment (IDE) support (any editor compatible with Unity can be used.) In this study Visual Studio 2019 has been used as an editor. In Unity for scripting there is an implementation of standard Mono runtime but still practices its own techniques for engine access from scripts. Some of the most commonly used classes in Unity are given in Table 2.13. Notably the important classes are described as GameObject, Monobehaviour, Object, Transform, Vectors, Quaternion, ScripTableObject, Time, Mathf, Random, Debug, Gizmos, and Handles (Unity3D.com).

Table 2. 13 Some of the important classes in Unity3D. Adopted from ((Documentation, 2021b))

Classes	Feature
GameObject	Anything present in a scene is represented by GameObject. They are scenes' building blocks that determines the look and work of the GameObject used in a scene.
Monobehaviour	It is a base class. All scripts are derived from Monobehaviour by default. It provides a template script for further coding.
Object	This is a base class for all objects. Unity reference it in the editor.
Transform	GameObject's position, rotation, and scale can be handled via script using this class. Hierarchical relationship between parent and child can be worked with using the same class.

Vectors	2D, 3D, and 4D points, lines and directions can be expressed and manipulated using this class.
Quaternion	Represents an absolute or relative rotation. Provides methods for creating and manipulating objects rotation.
ScriptableObject	Large amounts of data can be saved using this class.
Time	Allows you to measure and control time. Also helps in managing the framerate of your project.
Mathf	A collection of common math functions commonly required in games and app development. Includes trigonometric, logarithmic, and other functions.
Random	Commonly required types of random values can be easily generated using this class.
Debug	Helps you visualise information in the Editor. This may help you understand or investigate project while it is running.
Gizmos and Handles	Allows to draw lines and shapes in the **Scene view** and Game view. Also includes interactive handles and controls.

Internally the Unity engine is built with native C/C++, however it has a C# wrapper to interact with it. As such, there is a need to be familiar with some of the key concepts of scripting in C#. The web document "docs.unity3d.com" is the User Manual that contains information on how Unity implements .NET and C#, and any exceptions encountered while coding. The document maintains all the information necessary for the development of a project for any platform using Unity3D.

2.11 Summary

This chapter provides a detailed review of the literature carried out for this study. This chapter has been divided into two parts. The first part consists of the overall view on aesthetics in general, along with aesthetics from the perspective of digital media such as 3D games environments. The second part of this chapter is a technical review of the optimization methods used and the tools used for the study. A brief introduction of various components is given in the technical review of this chapter. The next chapter outlines the methodology chosen and implemented within this research study.

Chapter 3
Methodology

This chapter provides the description and reasoning for the choice of research methodology that has been applied to this study. The chapter explains the context of the study and the importance of the research methodology that supports and directs the research steps that inform this doctoral research project. The individual research questions are addressed and there is an explanation of the methodology employed, and the meaning behind the specific steps that support the pathway that this research has been employed to complete. This chapter also explains the details of the sub-parts of the main methodology that have been included in this program of research.

3.1 Research Methodology

This study has drawn upon a four-step approach to answer the research questions as given in Figure 3.1. It follows a mixed-methods approach that is based upon three key areas of research, evidence development, and data acquisition.

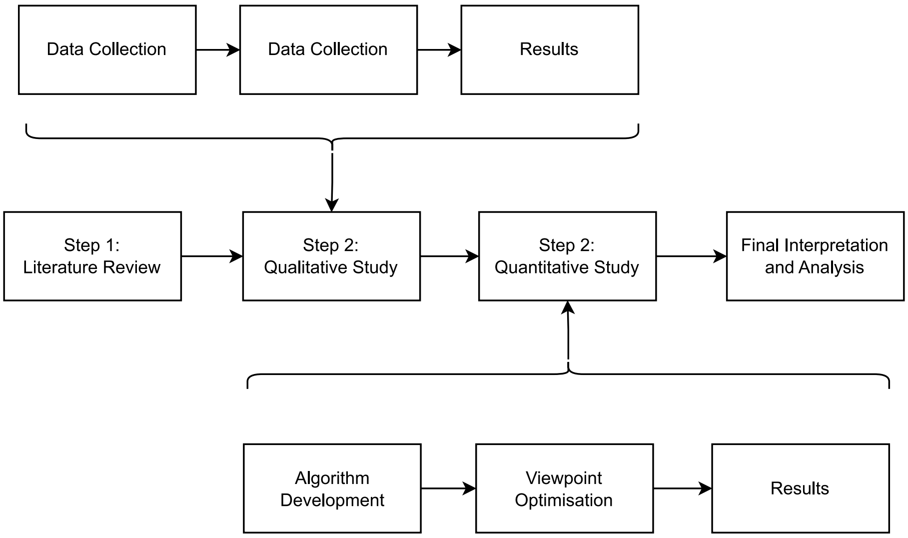


Figure 3. 1 Four key steps of the study

The methodology draws upon the four steps described above and should be taken as a single collective approach that was developed to specifically answer the research questions that form the basis of this research undertaking.

The first part of the four-step methodology involved a review of the literature. This comprised of two separate elements. The first is a general literature review. This included the early literature that fed into the initial research question and assisted in shaping the overall direction of the research. This literature was instrumental in the task to identify the research gap, and to ensure that the pursuit of that goal would render a novel component that would be regarded as the central aspiration of this doctoral work.

At an early stage of the research journey the research investigation (under the control and direction of the research candidate and the supervisory team) became aware that the research gap in terms of the definition of aesthetic interactive digital media was a deeper and broader challenge than had been initially thought. It was recognised that the narrow definition of interactive digital media aesthetics was not inclusive of the broad range of aesthetic values. This became evident in the initial work quantitative work with Genetic Algorithms (GAs) which was unable to provide optimised results for cameral positions that were fully inclusive of aesthetic conditions. The initial literature and early workings of this research clearly demonstrated the need to offer a range of values for Aesthetics in interactive digital media because there was no one set of rules or values that adequately covered the research domain (Figure 3.1).

The resultant literature review was then expanded to include a very specific scoping review that was more directly focused on the broader and more inclusive aesthetic features of interactive digital media, and other digital media. It is acknowledged that the total accumulated literature that was reviewed therefore includes both the initial literature review, as well as a specific scoping review with the explicit objective to identify the broader and deeper characteristics of the aesthetic values, interactive digital media, and digital media. Subsequently the inclusion of a Scoping Literature Review was followed (Peters, Godfrey, et al., 2020; Tricco et al., 2018; Peterson et al., 2017) that specifically chose to identify and make sense of the rich and varied elements that have been described in the field of interactive digital media and digital media aesthetics (Nayak & Karmakar, 2018; Griffey, 2019; Chamberlain, 2022). The literature reviewed as part of the scoping review was exclusively used to create the necessary questions for the second step of the mixed-methods approach and to ensure that a deeper and broader set of evidence was included into the consideration of the researcher for this thesis.

The second part of the approach was to develop a qualitative study using a thematic analysis (Kiger & Varpio, 2020; Delgosha et al., 2021; Delgosha et al., 2021) that would draw upon expertise from academic and industry sources to create a range of values that described the critical features of the Aesthetic elements that underpin interactive digital media. This involved the use of semi-structured interviews and discussions in the form of roundtables and created a novel and practitioner-driven collection of definitions and descriptions. This collection could then be integrated to form a set of guidelines that would satisfy the research gap in terms of defining Aesthetics in interactive digital media. These roundtable discussions involved the development of a set of semi-structured interview and discussion questions that allowed the panel of experts to answer questions at a high level of understanding that would benefit from discussions with experts drawn from industry and academia.

The third part of the methodology approach was to take a quantitative pathway that applied known existing rules, such as, the rules of cinematography and combined these rules with the novel set of aesthetic values so that a range of experiments could be performed against an algorithmic approach (H. Jiang et al., 2020; Litteneker & Terzopoulos, 2017; He et al., 1996) that could assist in the discovery of optimum placement and positioning for camera angles. This work allowed for the creation of GAs that could assist in the recognition of the key camera position and camera angles that are required for an investigation that looks to recognise the best positions for both cameras, and the participants. This work compared the historically recognised rules of photography and rules of cinematography This section sought to determine if they could be sufficiently deployed to recognise the full spectrum of aesthetic measures or whether there was a gap that required a broader and deeper understanding of the aesthetic features and characteristics of digital media and virtual learning environments.

The fourth step of this research was to draw upon the total evidence acquired in this study and to use the information to develop a framework. Such a framework would inform people of the risks of following the rules of cinematography exclusively and would allow for a full set of aesthetic values and directions that are embedded into a community of experts who work in the interactive digital media space on an every-day basis. The creation of the framework is regarded as the completed inclusion of contemporary aesthetic features into an outline that draws on a deep and rich set of aesthetically relevant values.

The methodology described here draws upon the four steps described above and should be taken as a single collective approach that was developed to specifically answer the research questions that form the basis of this research undertaking.

The research methodology follows a Mixed-methods research methodology that has been adopted from texts that specialise in the sequential mixed methods approach that is included here (Creswell & Clark, 2017; Baran, 2016). The steps can be visually interpreted and show a system that sequentially evolves knowledge from literature review at is given in Figure 3.1. The research questions of this study were investigated using a mix-method research methodology. This methodology has been used for comprehensive knowledge of the research questions (Cresswell & Clark, 2017). This has not only improved the overall strength of aesthetic understanding but also helped in drawing out new interpretations and by defining certain criteria based on aesthetics in interactive digital media such as games.

Mixed-method research methodology is used to solve ill-structured problems (Baran, 2016). Characteristics of an ill-structured problem are a high degree of vagueness, not any fixed definition structure, and disagreements (Baran, 2016). One such problem is defining the aesthetic criteria for placing a camera in a 3DVE in games. Therefore, mixed method research methodology has been used for this study to develop the theory and concept for defining aesthetic of such media.

3.2 Qualitative Research

In this study, a thematic analysis (Kiger & Varpio, 2020; Delgosha et al., 2021; Delgosha et al., 2021) has been used to understand the basic concepts and theories of aesthetics from the perspective of a both academic and industrial experts of interactive digital media and digital media. The inclusion of qualitative research meant that it was possible to aim to have a multivariate approach that includes aesthetics as a "range of values" rather than a specific set of values that do not change such as given in (Nayak & Karmakar, 2018; Griffey, 2019; Chamberlain, 2022). Qualitative research is an iterative process (Awasthy, 2015) for finding the solution to a problem. In this study qualitative approach has been applied to investigate details of the range of values about aesthetics of interactive digital media such as games.

The focus of this study was to propose the foundation for developing an automatically generated vision for an interactive 3DVE. For this purpose, an in-depth logical understanding of aesthetic was required. Therefore, qualitative research has been carried out for this study to have capture a better understanding of aesthetics in the context of placing a camera in an interactive 3DVE. The strength of this part of the research is that the study involves the exploration of a previously unknown combinational understanding of the aesthetics of interactive digital media. It uses participant perspectives to develop meaningful data/concepts. A qualitative analysis of this type, highlighting the importance of aesthetics from experts of interactive digital media in combination with established image-based and cinematographic rules has not been carried out before. This study will build the foundation required for defining and following characteristics and features that can inform aesthetics-based Artificial Intelligence (AI) systems that would involving human emotions in AI system.

This research will help people who are users, players, and developers of digital media and interactive digital media. This also includes people who are responsible for teaching the design and development of digital media and interactive digital applications. This study focuses on finding rules, guidelines, and standards for the incorporation of aesthetics that can be applied to digital media and interactive digital media. This study is designed to gather a range of different views and perspectives about the ways in which interactive digital media is perceived, especially in terms of aesthetic qualities. It is recognized as a challenging task because the evaluations within the foundational understanding of aesthetics are subjective in nature. This is a broad concept that has many different ideas but has no universally accepted clarity. Almost everybody has a different appreciation of what they see and how they interact with digital forms of media (Griffey, 2019; Chamberlain, 2022), but this study seeks to understand the importance of aesthetic for interactive digital media. It takes views from knowledgeable participants from both industry and academia in the interaction with a broad range of interactive digital media.

This study is designed to look at two important perspectives on aesthetics using interactive digital media. The first area looks at the industry's understanding of aesthetics with developing technology and considers various standards that are used in the industry. The second area considers a theoretical understanding of developing technology and asks about the professional importance of aesthetics through formal pathways. Together these two perspectives of research will provide a fresh, clear snapshot of the way in which aesthetics standards are applied. This study seeks to combine industry and academia in terms of these important aesthetic perspectives. Details of the methods used for data collection and analysis are given in the next section.

3.2.1 Achieving the Aims of Research through the Methodology.

The purpose of the study was to investigate the area of choosing aesthetically optimized views for camera placement within interactive digital media. To achieve this goal, it became necessary to follow an approach that drew from both a quantitative data set and a qualitative process that enabled the inclusion of a rich, deep set of aesthetically derived interactive digital media features. The literature clearly identified that aesthetics is widely described as collective rather than singularly definable components and that they occur in variable circumstances. As such it requires qualitative elements to sufficiently address the broader collective values of the area being investigated. It is important that the main research question draws from studies that adequately address the key differences in order to provide a rich and descriptive answer to the challenge of aesthetics in interactive digital media, whilst allowing for these variables to be applied within a set of rules and frames that provide a meaningful set of answers. To support this research endeavor, this research methodology is designed to allow for a fully informed series of sub-questions which are described here:

SQ-a for Qualitative Analysis: “How can aesthetic be defined for interactive digital media such as games?”

SQ-b for Qualitative Analysis: “Are there any industry standards that can be used to develop an aesthetic approach for interactive digital media?”

SQ-c for Qualitative Analysis: “Do the Rules of Composition in the form of measurable constraints, such as rules of photography or cinematography have any significance in defining optimized viewpoints in a game environment?”

SQ-d for Qualitative Analysis: “Will it be possible to define an aesthetic-based Artificial Intelligence (AI) system for game design?”

SQ-e for Qualitative Analysis: “How can a player experience can be improved based on aesthetics?”

After the collective analysis and development of answers to these questions, the key output of this research is to provide a model that allows for the exposition of aesthetic inclusions as part of an approach to interactive digital media. This methodology is used in this doctoral research to deliberately create and actively inform the requirement for a rich, deep set of understandings which underpin the aesthetic values of a framework that is suitable for interactive digital media.

3.2.2 Method Used for Data Gathering

To support the qualitative phase of the research it was necessary to adopt a method for gathering evidence to support the need for a range of aesthetic understandings. The method described here for data gathering has been based on semi-structured interviews (Gill et al., 2008; Kakilla, 2021; Rahman, 2019). Interviews were conducted with multiple focus groups in different sessions. Participants consisted of people who used, played, developed, designed or taught in the field of digital media, and interactive digital media. The Semi-structured interviews have been based upon key pre-framed questions (described as constructs) to focus on different areas for exploration (See Appx D). These questions/constructs also allowed the interviewer as well as the participants to respond in detail by augmenting the discussion to include multiple aspects of digital-media aesthetics. The semi-structured interview format used in this study was designed to assist respondents to focus on interactive media topics and to discuss and elaborate the information considered important by each of the participants.

This research study uses a qualitative approach that has been developed to gather data using roundtables of 2-8 people. The roundtable discussions, in the form of semi-structured interview, were intended to last for approximately 40 to 60 minutes. Participants were asked to provide their own views and have a discussion on the views of others. The total number of participants interviewed were 32. The participant pool included developers, designers, and gameplayers (users) of digital media, and interactive digital media. The roundtables were designed to provide a range of responses - all of which are de-identified in terms of information that would otherwise point to a specific person or identity. The roundtables are recorded in audio format and from there a transcript is developed that provides a set of different comments for review and comparison.

The number of people who were selected for the roundtables represented a set of professional, industrial, and academic opinions within Western Australia. The participants were drawn from known associates. They were sourced professional associations, local digital media associations and professional groups. This also included people from academics, professional forums and discussion groups. Participant selection used snowballing through the professional association cohorts to include subject matter experts. All participants were asked to participate of their own free will, and participants were free to leave at any time during the participation and during the roundtable discussions.

The formal recruitment was by means of an invitation in the form of an email that invited participants to be part of the study. All participants were asked to sign a letter of informed consent (See Appx C). All participants were asked to participate of their own free will, and participants were free to leave at any time during the participation and during the roundtable discussions. To avoid any issues regarding 3rd party knowledge or results of significance, all participants were de-identified. All participants for this study were de-identified for data collection and reporting results.

3.2.2.1 Objective of Roundtables

The main objective of conducting roundtables was to explore the views, experiences, and motivations of professional and practitioner-based individuals in defining the use and importance of aesthetics in the field of interactive digital media especially games. Additionally, the roundtables were designed to promote a multivariate approach that includes aesthetics as a "range of values" rather than a specific set of values that do not change.

Roundtables were used to collect data from participants. Roundtable interviews are beneficial in studies where some amount of information is already known and detailed information is required from the participants (Gill et al., 2008; Cresswell & Clark, 2017). Semi structured interviews were carried out to capture detailed insights from the expertise of digital media and interactive digital media users, designers, and developers. Their overarching objective was to lay the foundation for defining the aesthetics of vision in a 3D VE.

The physical method of data collection was by two means. Firstly, there was an audio recording of the roundtable. Secondly the Chief Investigator and author of this thesis recorded a set of notes during the roundtables. The roundtables were led by a facilitator who led the discussions and offer opportunities for participants to comment and discuss individual areas. Data was recorded as audio files that was transcribed later for analysis. There was a risk of capturing the identity of participants. Subsequently, this data was de-identified so that names are replaced with codes such as respondent 1, respondent 2, and so on. Any data that was stored or retained was encrypted to prevent access by others.

3.2.2.2 Constructs for Roundtables

The constructs used for roundtables are given in Appendix D. Constructs were specifically designed to elicit the opinions of experts from the perspective of digital media and interactive digital media. It focused on areas such as what respondents thought about aesthetics, their views on incorporating aesthetics from both the users and developers' points of view, and how aesthetics can affect the gameplay and game design from both developers/designers and players/users' perspective. Optimum viewpoints from a 3D VE were also incorporated into parts of the constructs. Different viewpoints were presented, and comments were recorded. The optimum viewpoint of a 3D VE was queried in order to get an opinion of how a camera can best be placed with respect to the user preferences.

Each roundtable construct was designed and written in such a way as to get the perspective from both the users and developers' points of view on the importance of aesthetics in digital media and interactive digital media. The constructs maintained an emphasis on open-ended questions to yield as much information as possible. This was used to obtain the aims and objectives of the research that was inclusive of incorporating aesthetics from an Artificial Intelligence (AI) perspective. The initial questions were about the general concepts of aesthetics, and then subsequent constructs focused on research topic specific questions. This resulted in the generation of rich data that collected multiple variations on aesthetic values and features.

Respondents were informed about the study details and ethics (such as privacy and confidentiality) through the information letter (See Appx C). An information letter was provided so that the participant was informed abouts what to expect in a roundtable interview. Roundtables were conducted in distraction free areas and locations that were suitable for participants. Some interviews were conducted online as some participants were unable to attend at locations chosen for roundtables. A semi-structured open format of questions was used and on occasions respondents were asked to provide further clarification. At the end of each interview roundtable respondents were thanked for attending the roundtable and being part of the study. All respondents were given the opportunity to add additional information regarding anything they want to add. This encouraged participants to reflect on thoughts which were not asked during the roundtable. All interviews were digitally recorded, and transcription software was used for creating the word file to keep the record permanently for data analysis.

3.2.2.3 Expertise of Participants

Focus groups totalling 32 participants were used for data gathering. Participants were sought through professional contacts and came from professional groups and associations. Participants had expertise in game designing and development, gameplaying, cinematography, digital app development (such as websites, mobile apps, and other digital mediums), and social media activist for different game forums.

3.2.3 Data Collection

Data collection was collected between August and September 2022. Data was recorded two devices for face-to-face roundtable. The first device was a Philips Voicetracer (https://www.dictation.philips.com/us/products/audio-video-recorders/voicetracer-audio-recorder-dvt4110/), and second device was Samsung Note Ultra using Otter (https://otter.ai/) as recording application. For some participants for whom face to face roundtables were not possible online Team meetings were held and recorded through Microsoft Teams and the data was obtained in a hybrid mode of meeting (https://www.microsoft.com/en-au/microsoft-teams/group-chat-software/). All participants for the focus group were recruited using email addresses. Email addresses were taken from online groups and websites to whom the person was working with. The interviewers were also given freedom to ask queries if they did not understand the question. Industry-based language was used during the roundtables.

A pilot study was conducted earlier before the beginning of the data collection and research. This study allowed the participant to express thoughts, feelings and experiences related to the constructs given in Appendix D. This opportunity allowed the researcher for this study to resolve any complexities with the constructs and the formation of the semi-structures interview processes. It also identified questions that might make a participant feel uncomfortable.

3.2.4 Creation of Roundtables Questions

The questions used to drive the discussions of each roundtable were formulated from three key areas. The first area included the known work from the existing literature which clearly described the problem in terms of the multiple possible understandings about aesthetic values within digital media and interactive digital media. The second area was developed to include current and industry-driven thinking in terms of existing media and digital games development, whilst the third area recognised the important application of aesthetics to the content users (rather than the content developer) of the interactive digital media. Each Roundtable question has its own specific initiatives that are designed to drive a robust discussion from within the roundtable group that was formed.

To establish critical differences in the application of aesthetically defined features a thematic analysis approach (Kiger & Varpio, 2020; Delgosha et al., 2021; Delgosha et al., 2021) was applied. It facilitated the qualitative comparison of aesthetic values in digital media and interactive digital media constructs. A small group of experts were used to consider a wide range of digital media and interactive digital media constructs through a series of roundtable exercises. These experts represented knowledge areas in digital media, interactive digital media, virtual reality, gameplay, games development, and game users.

The system of data collection used data cleansing, transcriptions, text and spoken comparisons, and re-evaluation processes to form a rich and highly descriptive dataset. Each sentence, descriptor, and feature was subjected to close inspection to ensure that each characteristic was accurately captured, defined and categorised as part of process of data analysis and final dataset establishment. The analysis of this data included the generation of coding and construct differentiation using nodes as part of the thematic analysis and generation. The final presentation of thematically analysed data generated the specifically characterized themes for Aesthetics rules for digital media aesthetics.

3.2.5 Method Used for Data Analysis

Once recording was complete the next step was generating transcripts of the recordings. The transcription process helped in developing a greater understanding of the research topic by repeatedly reading and listening of the transcriptions. There were specific tools and applications used for transcription. They are recorded as Otter (https://otter.ai/) and Microsoft

Teams (https://www.microsoft.com/en-au/microsoft-teams/). Otter is an application used for recording meetings and generating speech to text transcription. Otter generates real time transcriptions for meetings using AI and machine learning. These transcriptions and notes can easily be shared and transferred from one device to another. Microsoft Teams was used for online discussions and videoconferencing. Transcripts were generated during the meetings that were easy to download and share. Both tools were helpful in recording interviews both online and in person. Transcripts generated by the application were copied into a Window-based computer system, and in order to ensure a high level of transcription quality some effort was put into to cleaning and arranging transcripts.

The next step after data cleaning was data coding. Details of the coding steps are given in Chapter 4. Keywords were used as the code to categorise text. The data was further analysed into themes and sub themes emerged during the process of coding. The emergent themes were assigned specific codes for clarity and identification. The next data collection step identified reoccurring themes by highlighting what was similar and different in the data. The final stage of data analysis involved a verification process. This process consisted of validating the understanding through rechecking of codes and transcripts again.

3.2.6 Tool Used for Data Analysis

In this study an NVIVO (Phillips & Lu, 2018; Edhlund & McDougall, 2019; Dhakal, 2022) software program was used for data analysis, which is easy to use and can manage any amount of data collected for analysis. A technical review is given in Chapter 2 of this thesis. Transcripts (generated using Otter and Microsoft Teams) were added to the project created in NVIVO software program. Codes and themes were identified during data analysis. NVIVO has an easy to use interface in which codes and themes are easy to manage. References to codes and themes were obtained and duplicated references were removed during the analysis. Findings obtained after data analysis are given in Chapter 4 of this thesis.

NVIVO supports multiple data formats and types (Dhakal, 2022). This software program is instructive in structuring, categorizing and evaluation of qualitative data. The use of software tools such as NVIVO can help in a better quality analysis (Dhakal, 2022). This software tool can handle any amount of data up to 100 of interviews. NVIVO presents the coded texts or audio in such a way that it becomes easier for the researcher to handle any amount of data. NVIVO also consists of project maps that can be used to create the visual maps for codes and nodes of the project.

3.3 Ethics

Ethics is a discipline that deals in defining right and wrong based on obligation and duty within the moral framework (Conroy, 2010; Dehghani, 2020; Dewey & Tufts, 2019). Ethics approval was applied before commencement of the data gathering. Ethical approval was granted by the Ethics Committee for commencement of the research (2020-03468-MAQBOOL). It is unethical to gather information without informing the participants, therefore participants should be willing by signing the informed consent form. Hence, according to the ethics consideration the researcher informed the participants that their participation was voluntary, and they could withdraw at any time before or during the data collection. Prior to data collection all necessary information such as place, and duration of the interview were informed through an information letter, and consent forms (See Appx C) were signed by the participants. The National statement on ethical research is given on (https://www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018). Participants were also informed that if they did not feel comfortable in answering any questions, they could simply refuse to participate. After the interviews participants were asked for final comments and recommendations on the research topic and constructs used for interviews. Participants were assured that their participation would be anonymous, and that no names would be mentioned in the study (See Appx C).

Chapter 4

Qualitative Data Analysis and Results

4.1 Introduction

A thematic analysis approach (Kiger & Varpio, 2020; Delgosha et al., 2021; Delgosha et al., 2021) was applied in order to achieve a level of data analysis by means of a qualitative study to research aesthetic values within digital media and interactive digital media constructs. An ordered set of steps was applied for data analysis. The data consisted of responses to a range of digital media and interactive digital media constructs that were asked of small groups of experts via a means of data collection referred to as roundtables. A total of 32 respondents were selected on the basis of their expert knowledge in the areas of digital media, interactive digital media, virtual reality, gameplay, games development, and game users.

The first step of the data analysis consisted of data cleaning. This was required because the data collected from the roundtable discussions required the production of transcripts of the spoken words, which required checking and re-reading to make sure that the final data, as collected in textual form, clearly matched with the original spoken data from the roundtable events. The data was collected using two main forms of digital software. Those used in this research were Otter (https://otter.ai/) and Microsoft Teams (https://www.microsoft.com/en-au/microsoft-teams/group-chat-software). To ensure that the data in recorded format mirrored the original spoken words, the use of data cleaning was used to ensure that words and sounds were authentically preserved with accurate transcription. These transcriptions needed checking and cleaning as there were repeated words and jargon in the transcripts. The transcripts were generated through Microsoft Teams in those instances where meetings were held online for the respondents who were not able to attend the roundtable in person, whereas the "in-person" meetings were recorded using Otter. Recordings were listened to carefully to clear the repeated words and jargons generated by the tools used during the interview. After data cleaning there were still some sentences and words that needed to be understood in order to make sense. These sentences were subjected to closer scrutiny in transcription as part of the process of data analysis and final transcribed data.

The second step involved undertaking an analysis of the transcripts. These were collected from a total of 32 respondents. These recordings were listened to by the researcher using a process of reiteration to make sense of the statements and responses of each of the respondents.

During this analysis, the context in which research questions were asked, (along with information from the literature review) were kept in mind. Initial codes were generated and centred on constructs used for data gathering (See Appendix D). As the qualitative analysis progressed, the codes were changed into nodes, which in turn merged into sub-themes from which main themes were generated.

Details of the third step are given in the next section. The formation of codes and the allocation of closeness to determine nodes led to the creation of sub-themes and themes for the qualitative analysis. The third step, therefore, consisted of condensing the lists of words into identifying lists of themes. The final iteration of this list of themes was considered as the defined themes for aesthetics rules for digital media aesthetics.

4.1.1 Coding and Recognition of Themes

Codes, nodes, sub-themes and themes are generated through qualitative data analysis in a step-by-step process as given in Figure 4.1. Code generation requires familiarising the researcher with the data by using interviews and recordings as well as any other data that might be collected during the interviews. After data cleaning, new nodes were generated that were further modified and used for this part of the study.

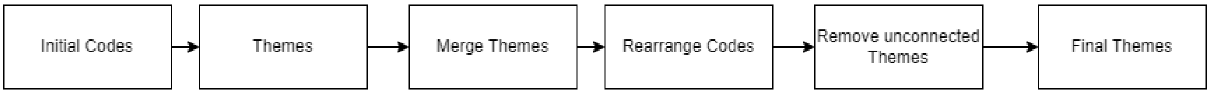


Figure 4. 1 Steps in Qualitative Analysis

Data was organized into meaningful and logical structures to generate initial codes. The method used for data coding for this study was chosen based upon the systematic literature review (see Chapter 2) and initial research questions (see Chapter 1). The literature review revealed a set of known available standards for digital media and interactive digital media aesthetics. However, for interactive digital media, like games, the literature review also revealed a gap in terms of a well-defined system that allowed for the identification and analysis of aesthetic standards and patterns (in digital media). For this reason, an applied approach for determining thematic analysis was carried out to understand these standards and patterns by gathering responses from a set of expert opinions from the broader field of digital media and interactive digital media.

The initial coding of these expert opinions resulted in a set of transcribed responses. These responses were reduced into small data segments using logic-based constructs (See Appx D). The initial coding comprised of separating each segment into noteworthy responses to the research questions. Not all segments of data were coded because some were deemed to be irrelevant to the study. An open coded method (Vaismoradi et al., 2013; Neuendorf, 2018) was used for coding themes. Using this approach, the codes were not pre-determined, but rather they were initiated, developed and modified as the coding of data progressed.

A qualitative approach to the analysis of the collected data was carried out using NVIVO (NVIVO, 2022). NVIVO was used as an analysis and development tool to ensure that a wide range of data was considered, and a rich data set was created that showed a depth and breadth of expertise and understanding from the targeted respondents (See Chapter 2 & 3). This was used for forming the codes and themes. The initial ideas about codes were developed after the first analysis of the data. For example, respondents gave their perspectives about aesthetics based on specific contextual propositions such as aesthetics for narratives and aesthetics for storytelling. These context-driven perspectives were different from the action-based highly interactive game perspectives that emerged from the viewpoints recorded from other respondents. This step helped in developing an important range of views on camera positions in Virtual Environments (VEs). It provided a unique collective of understandings that informed definitions and characterisations that drive aesthetics for interactive digital media including games.

An initial approach to the coding of responses was formed after discussions with the supervisory team. The coding was based upon the use of transcriptions from the recorded commentary through the roundtable discussions. Further clarity was sought through consultation with a literature-based review of several review papers. Each transcript was read separately and the text segments relevant to each research question and associated literature was recorded in the form of codes and nodes. As the process of data analysis continued, codes were compared and modified, and new codes were generated. In some instances, initial codes were even deleted due to the repetition of similar or closely related codes. Unconnected and isolated codes and themes were also deleted during this analytical approach. A clear understanding of codes was required, and this was achieved through a simple visualisation technique whereby a visual picture, by means of a simple sketch, was generated on a wall using sticky notes. The visual sketch was created to verify the clarity and intelligibility of the codes and themes that comprised the information acquired in discussions. From this coding approach it became possible to organise data into emergent themes.

A theme is defined as a pattern that can capture something interesting or meaningful about the data (Maguire & Delahunt, 2017; Castleberry & Nolen, 2018; Braun & Clarke, 2022). In generating themes, codes were examined, and those that clearly fitted to same characteristics were merged into themes. These themes were related to a variety of elements such as the artistic concept of aesthetics, the gameplay concept of aesthetics, and aesthetics as player centricity amongst others. Several codes were found to support some of the common themes. Initially codes were merged into two nodes recorded as “Aesthetics in General” and “Aesthetics in Games”. Later, these nodes were merged into a single theme of digital aesthetics that consisted of a further ten sub-themes.

This process of generating thematic direction from coding, sorting through nodes and clusters, and through the elimination of outlying information was used to develop a set of relevant, combinational, and emergent themes. Figure 4.2 presents the initial set of emergent themes that were obtained at the end of the initial steps of the data analysis. This allowed for a map to be automatically generated using NVIVO (see Chapter 2 & 3). Figure 4.2 represents one portion of the generated map in NVIVO. A complete map could not be displayed here due to its size and lack of visual clarity. One part of the project map is given here to offer a sample demonstration of how such maps can be seen in the NVIVO generated format. Themes were further modified, and a much clearer map was obtained based on ongoing and further iterations of the data and their connections and relevance. The folder icons that show a “cross” represent the deleted codes and themes from the figure.

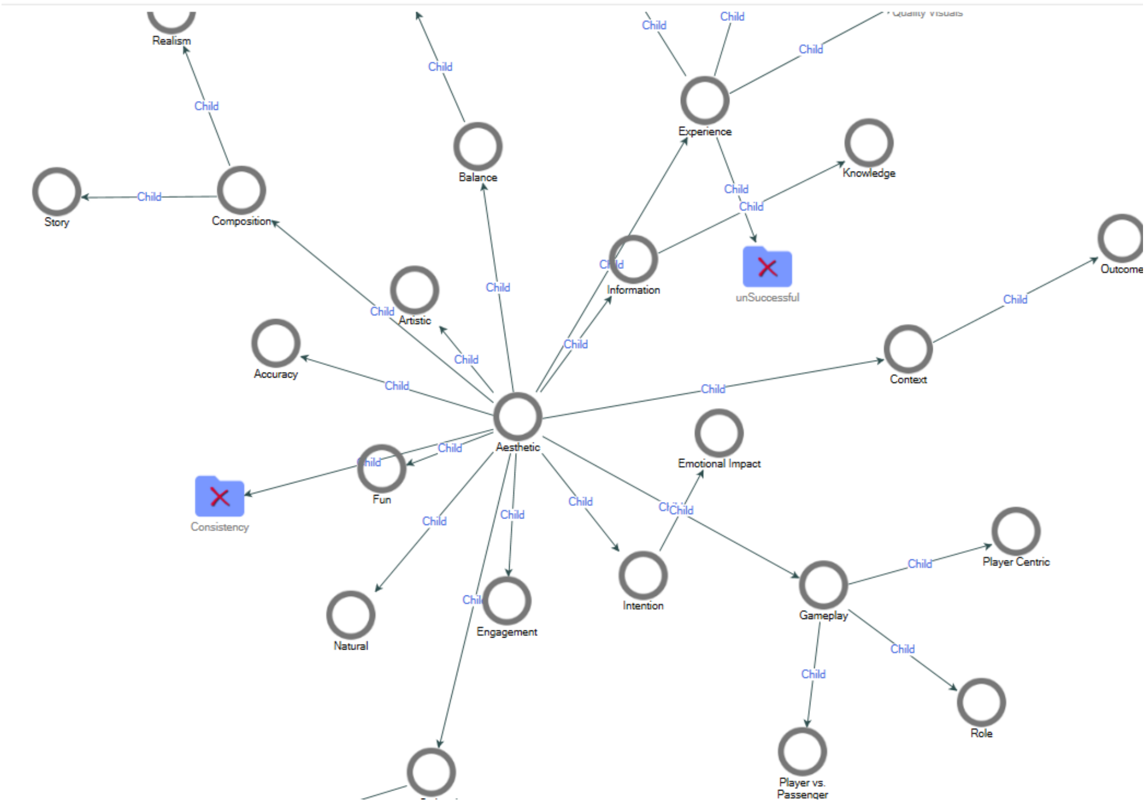


Figure 4. 2 Indicative Map demonstrating codes and themes

4.1.2 Main themes

Six main themes were acquired from the data during the analysis as shown in Table 4.1. These themes further consisted of sub themes that laid the foundation for defining aesthetic for digital media and interactive digital media aesthetics in light of the broad range of expert opinions. Not all themes were allotted sub themes. The first theme "Aesthetics in General" consists of eleven sub-themes. (Details are given in section 4.4 of this chapter). These eleven themes are captured and labelled as: "Aesthetic as an artistic quality"; "Aesthetics as a knowledge driver"; "Aesthetics as an experience or a feeling"; "Aesthetics as tool for engagement"; "Aesthetics as a gameplay"; "Aesthetics as intention"; "Aesthetics as a function of realism"; "Aesthetics as a function of fun"; "Aesthetics as a state of flow"; "Aesthetics is about understanding the context"; and "Aesthetics is player centric".

Table 4. 1 List of themes

	Themes
1	Aesthetics in General
2	Aesthetics rules for composition
3	Challenging areas in game design
4	Role of user in design and development
5	Known industrial standards for aesthetics
6	AI in game design

Table 4. 2 List of sub-themes

	Sub-Themes
1	Aesthetics as an Artistic Quality
2	Aesthetic as a Knowledge Driver
3	Aesthetic as an Experience or a feeling
4	Aesthetics as a tool for Engagement
5	Aesthetics as a Gameplay
6	Aesthetics as Intention
7	Aesthetics as a function of Realism
8	Aesthetics as a function of Fun
9	Aesthetics as a State of Flow
10	Aesthetics as Context Understanding
11	Aesthetics as a Player centric concept

4.3 Respondents

The expert opinions of 32 respondents from different backgrounds working in the field of digital media and interactive digital media were captured by means of roundtables where respondents were interviewed in groups. A variety of software, including Microsoft teams and Otter, were used for recordings and generating scripts. Data was collected by several methods. In combination with the recorded conversations, the Chief Investigator (CI) kept a set of handwritten annotations that provided reference points in line with the roundtable questions and the visual representations that were presented to all respondents. The 32 respondents were processed by means of a series of roundtables. Each respondent was involved as a participant of one of several focus groups.

Focus group 1 consisted of 8 respondents comprised of both gameplayers and independent ("indie") developers. Several of the respondents had experience in the development of Virtual Reality (VR) based applications for school students. Some respondents had experience in game development. Most respondents had experience in user application development (other than games), photography, and game playing.

Focus group 2 also consisted of 8 respondents who were mostly game developers. They had experience not only in third person game development, but in everyday work connected with VR based systems. These developers were also working in academia and research, and were able to provide a comprehensive understanding of the development of interactive digital media.

Focus group 3 consisted of 3 respondents with experience in cinematography. Some respondents held experience in digital media development and design however all respondents had professional experience relating to how aesthetics could be defined in cinema and interactive digital media applications.

Focus group 4 consisted respondents who held extensive experience in game development and game playing. Most of them had broad experience in a combination of digital media skills ranging from game development, gameplay and in game application.

Focus group 5 consisted respondents with experience in the design and development of web application and smart phone applications. Most of these respondents also held experience in gameplay and game applications.

Focus group 6 consisted respondents who were experienced in the field of game players. They held experience in a broad range of different styles and genres of games, from early 2D games to current 3D games.

The remaining respondents were a diverse collection of respondents involved in the designing of digital media and interactive digital media with a focus on aesthetics. Some were undertaking university-level training and education in game-design. Other respondents held expertise in game studies and design, including the teaching and lecturing of digital media and interactive digital media where aesthetics was an inherent component of their work.

All of the respondents were asked the same introductory questions, which then lead to a series of semi-structured conversations. In some instances, these conversations were short with simple responses that showed an immediate deference to one or other specific position. In many instances however, the semi-structured elements allowed for bespoke differences and nuanced responses. These responses formed the critical components of the focus groups, providing a rich, diverse set of responses that informed the key discussion areas of the study, and provided a range of response positions that allowed for the creation of a well described complex understanding of the aesthetic characteristics that underpin camera positioning within digital media constructs.

4.4 Findings

The main discoveries from the roundtables and focus groups are addressed in two ways here. In the first instance, a set of central themes was discovered. These themes were created through a process of analysis and comparison. Where there was a range of coded segments, these segments were ordered and placed to show areas of similarity and areas where there were complementary interests. At the same time, other areas provided by the coding of ideas were considered to be competing interests rather than complementary interests. The collation of the sum of these coded segments provided a set of themes that present the key characterisations of the aesthetic criteria that impact upon and influence the decision components of digital media and interactive digital media.

Themes formed during the qualitative analysis are given in Tables 4.1 and 4.2. There were six main themes and ten sub-themes that were developed after the coding process and subsequent data analysis. The steps used during this analytical approach and the details of the respondents' expertise have been explained in the previous section. This section elaborates the initial coded elements with a detailed explanation of the various expert opinions and the development of the main themes. The themes were developed from the coding of the collected data in the form of transcripts and voice recordings. Expert opinions (from the Respondents of the roundtables) were used to formulate the critical understandings about the aesthetics of digital media and interactive digital media. Details of each theme are given below in section 4.4.1.

4.4.1 Aesthetics in General

In order to address multiple aspects of the aesthetic characteristics of digital media, interactive digital media, and camera positions, several constructs (See Appx D) were presented to respondents and a series of discussions and conversations were recorded. These discussions were driven from a set of visual comparators (images in PowerPoint form - see Appx D), in combination with a set of semi-structured conversations that gave a rich and varied set of responses to the key elements of the study. The results for the qualitative study were based on gathered data that is described below. The theme of “Aesthetics in General” was a principal theme which emerged from the data analysis. This theme consists of multiple sub-themes that (in combination) provide clarity and nuance about the way in which aesthetics can be most accurately defined for interactive digital media. The details of each of the sub-themes is given below.

4.4.1.1 Aesthetic as an Artistic Quality

The first set of pictures that were presented to respondents included two images of the same object (in this case a tray of grapes) from two different lens viewpoints (See Appx D, C 1). The first of the two images showed an exaggerated view of the grapes that was created using a heavy depth of field to place a deep focus on the grapes, whereas the second image showed the same set of grapes arranged on top of a transport cart. This second image could clearly be discerned from a wider contextual view that included grapes, the transport vehicle and a driver. The purpose of comparing the two images presented was to seek a judgement by asking respondents to consider distinctions based on different aesthetic qualities. In this first visual question, the respondents provided differing perspectives of their understanding of the two images. Approximately half of the respondents saw a greater level of aesthetic qualities in the first image whilst approximately the same number of respondents saw greater aesthetic qualities in the second. The key differences are stated below:

Half of the respondents thought that the first image was more aesthetic than the second image (See Appx D, C1) because it was considered to have greater artistic qualities. According to the respondents the first image included a range of effects such as lighting, angles, and blurring. These responses typically demonstrated a sense of exaggerated imagery. Here the image of grapes showed differences in the foreground and the background. It suggested that an image that held blurred or overstated elements that these would hold greater value to a viewing audience. The following responses were recorded as stated below:

"I personally think Figure one (is more aesthetic) because more effort has been put into the lighting, and the angles. Figure two could just be a generic shot of the guy farming."

(Respondent 1)

"Figure one is sufficiently close enough to see how fresh the fruit is. Figure two is just a pile of fruits, and the depth of field is like luxurious in Figure one"

(Respondent 12)

"Figure one has less details looks more appealing because of this blur effect and those small lighting effects. On the other hand, Figure two has more details but less interesting because of the berries that do not look very aesthetically beautiful, and I wish there were more details of the berries covered that's why I go with Figure one".

(Respondent 29)

Respondent 9 preferred Figure one for its aesthetic value as it seemed to have applied photography techniques like a shallow depth of field. Similar characterisations were given by Respondents 18, 22, 27, 28 and 29. Their comments include the following:

"I feel Figure one for me looks nicer and I guess it doesn't have a human driving a tractor which I don't find particularly interesting and also the lighting of Figure one makes it look more beautiful."

(Respondent 9)

"Figure one because there is a tendency to play with lighting and focus, whereas the bottom one is obviously there's a focus on the cart, the soil is in focus and the background isn't. But the top one is sort of playing with those elements a bit more."

(Respondent 18)

"Figure one going for the aesthetic value. Figure 1 had a half that's out of focus and that looks quite nice".

(Respondent 22)

“I would say Figure one is more aesthetic to me. My reason would be because of the sun and the way, it's perfectly set with the middle ground being in the centre, while the background like fade out”.

(Respondent 27)

“I would say the shallow depth of field is quite appealing and I think it has much more warmer lighting, so it looks more like a studio sort of setup”.

(Respondent 28)

“Figure one had a half that's out of focus that was kind of looked quite nice. Whereas Figure two is just more of an actual photo of what's happening, kind of like littering”.

(Respondent 23)

The artistic quality of an image can be of value where the image is perceived as more aesthetically fulfilling, different, flavoursome, or pleasant. The artistic elements of these images suggest that because they may hold different or unexpected elements they may then be considered as have a greater aesthetic benefit than other images. Similarly for other Respondents the first figure (See Appx D, C1) has been described as more aesthetic than the second figure (See Appx D, C1) because of it has an artistic kind of perspective and is closer to an art form.

“Figure one is the kind of thing if I was going to set a background on my phone, like an artistic kind of perspective.”

“Figure one is closer to what I consider art.”

“If it was just facing value, Figure one definitely is more aesthetically pleasing”.

(Respondent 2)

“Figure one is like more artistic”.

(Respondent 3)

The first figure (See Appx D, C1) was considered more aesthetic because of the way in which photographic techniques were applied while the picture was taken. One of the respondents explained that if a picture is taken through the use of good photographic techniques, then it results in a beautiful piece of art that can have a very high aesthetic value. The contention is that the value of an ordinary object associates itself with high aesthetic values through the creation of such pieces of art.

“There are a couple of experiments out there where they showed a picture of some really ugly looking person to somebody and then they asked people does

this look good or not, and they did it very aesthetically, in a high quality, so, even the ugly looking person basically was found very beautiful because of just how their picture was taken".
(Respondent 19)

The use of a greater adherence to specific photographic techniques can increase the expected artistic appreciation of an image. This can result in a greater aesthetic value. For Respondent 19 both images were deemed to have a high level of technical photographic value because they incorporated different photographic perspectives that resulted in an image of grapes which demonstrated highly aesthetic qualities.

"From these two images itself. I think they're both very well taken from camera technique".
"Techniques of both photographs is very, very good. It's simply very well taken, the lens work, the exposure … and the composition of both pictures is very well done".
(Respondent 19)

The use of some photographic techniques may have greater aesthetic value than others. Respondent 17 chose Figure 1 as the more aesthetic image even though Figure 2 was deemed to demonstrate more of the knowledge and background story relating to the harvesting of grapes. The reason Figure 1 was chosen was based on the way the photograph included techniques such as a shallow depth of field, noteworthy colours, and a narrow focus upon the grapes. The following response is from Respondent 17:

"For me it will be Figure one because it's telling quite an interesting story, focusing on grapes and the second one it does have a different story. It is telling more on harvesting the grape. Figure one to me it's visually more interesting because there's a shallow depth of field which is blurred on the side and then focused on grapes. The colour itself are quite interesting too. So, to me Figure one is a little bit more aesthetically pleasing, that would be the one that I'll go for".
(Respondent 17)

4.4.1.2 Aesthetics as a Knowledge Driver

Whilst some aesthetic values are levelled at the human experience of beauty or simplicity, there are alternate considerations in regard to aesthetics. Knowledge is described as a quality that can be derived from digital images. Many of the respondents recalled experiencing that one of the two images could be regarded as more aesthetic than the other if the image conveys or provides some kind of information, background knowledge or context in which that particular image was taken (See Appx D, C1). The responses from the two images shown in this task demonstrate that the connection to information holds greater aesthetic value than simple beauty. The suggestion here from some respondents is that information (if it carries the sense of being "informative") holds greater aesthetic engagement than images with little or no informative values. Respondent 8 described aesthetics in the following manner.

> *"Sometimes beauty is about knowledge. I really like that because I can know something".*
> *(Respondent 8)*

The theme of the value of knowledge and information can also relate to the idea of storytelling. If an image can convey some type of story, it can be deemed as holding greater aesthetic value because it gives a richer sense of information. The image in Figure 2 (See Appx D, C1) has been described as a picture that provided information and that conveyed some kind of story which was deemed to be of interest to the respondents.

> *"Figure 2 is more informative".*
> *"Figure 2 tells a bit more of a story".*
> *(Respondent 2)*

Some images demonstrate a greater sense of purpose, activity, or information than others. In this sense some images hold a greater aesthetic value because their greater sense of activity conveys something of greater interest. If, by comparison, one of the images has much less information, and if there is no sense of activity or purpose about an implied activity, then that image may fail to capture the same level of aesthetic engagement as the other. According to respondent 26 the second image/picture could be deemed to contain more information and hold a greater sense of purpose than the first image (See Appx D, C1).

"For me because of more details Figure two. In the background you can see greenery like this figure conveys message. In Figure one less information is there some fruits and grapes but no purpose. So, I will go with Figure two."

(Respondent 26)

"Figure two is more aesthetic to me. I can see much more visual information there. I can make the context. In Figure one I cannot make out the context."

"For me Figure one is not artistic. It's just a blurred image. I would say it is artistic if there is no blurry effect for the close-up grapes. But this blurry effect of grapes looks like a blurry image".

(Respondent 30)

"For me Figure two is more aesthetically good because the image is quite clear, and we can see details".

(Respondent 31)

"For me Figure two has more details and you can see the story behind it".

(Respondent 32)

"If you wanted to use aesthetics that would allow people to be more focused and able to absorb information Figure two would be better for that to fall".

(Respondent 20)

Some images hold values that relate to an implied dynamic. Even a still photograph with no moving parts can convey the expectation of a dynamic outcome (e.g., change of direction, or the completion of a journey). According to Respondent 19 a picture that is more dynamic conveys more information that can be useful for the audience.

"Figure 2 there is movement like a tractor story and also that it's more dynamic. Figure 2 is more dynamic because there's movement in the picture because you have a tractor running around.

I think that Figure two conveys somehow more information because of more objects in the picture the diverse one is tending more to focus on something on a special point."

(Respondent 19)

"Figure two has whole background of a farm and it's look like some grapes or some berries on some crate or something. So, the second one is good".

(Respondent 4)

Some images provide a greater level of subject clarity. The suggestion is that clarity of subject matter can imply clarity over the information that can be ascribed to that image. It can be suggested that clarity provides greater information which subsequently drives a likelihood of greater aesthetic engagement. In simple terms some respondents felt that if the image is clear then this image might be more aesthetic than the other object because it will provide more information.

"Figure one seems like there's more colour and more things to sort of distract you from focusing on the berries or whatever it is that they're trying to get you to look at. Figure one just seems clearer what to find".
(Respondent 21)
"I can't tell if Figure one grapes are actually, it could be blueberries. It's not clear to me exactly what it is. I get the sense from the second figure because it's got leaves and .... I'm thinking it's grapes and it's a grape vine".
(Respondent 15)

4.4.1.3 Aesthetic as an Experience or a feeling

Aesthetic values have also been described as "experiential". The idea that an image or images can convey an experience has been described as an important aesthetic quality. Here respondents have suggested that if an image can make a person get a sense of an experience it can hold a greater level of aesthetic value since it is engaging in terms of a feeling rather than a tangible quality. Feelings can be good or bad, threatening or calming, exciting or boring. Experiential qualities are often different for individuals and therefore the experiential aesthetic qualities that one person derives from looking at an image can be very different to another. For some respondents, aesthetics can be considered as an experience or a feeling. From a planned sense, a games developer might deliberately set out to convey a specific type of feeling in the form of an experience. These feelings might extend to an experience that relates to a mystery, or something odd and unusual, or a creepy feeling. These qualities are highlighted by one of the respondents.

"My understanding of aesthetics is, it is an experience, like a feeling. So, it depends what kind of feeling you're trying to generate. Like, to me it's not a thing in itself other than an experience."
"It's not like that one is objectively better than the other. It's kind of just depends what kind of feeling you're trying to go for, for example, if you're trying to

generate the feeling of like creeping up on someone or being a bit mysterious. It depends upon what experience you're trying to, what feeling you're trying to facilitate."

(Respondent 18)

Many responses suggested that the type of experience generated for one particular user depends on story type and context. A user experience that varies with a story context needs to define certain things such as the story type, the way the story needs to be experienced, and the purpose of the constructed visuals amongst others. In some instances, these experiential feelings are complex, and are assigned through the combined connection with multiple different elements. A story derived from an image can be boring or it can be exciting. These experiential feelings depend upon how the story has been interpreted by the user. The following information narrated by one of the respondents are.

"My understanding of aesthetics is more than visual. From my understanding of aesthetics is experience as well. Like, what story do you want to tell? How do you want the viewers to experience that story? And what purpose are those visuals being constructed?"

(Respondent 17)

"When a movie director gets the script and he makes something out of that, he can make it completely boring, or he can make it completely exciting. He can do it as a first person or as a comedy move or as a drama and then he selects from his toolbox camera movement, which colours and actors to use, and from these tools he built this thing to get all the experience".

(Respondent 19)

Experience is also about the ability to use something as well as the success of the usage of that thing. A user can either have a good experience or a bad experience. A bad experience is the one in which a user is unable to use or interact within 3D VEs such as those that appear in a game. Regardless of the variety of usage it all falls under the consideration of being a user experience. Additionally, if a user experience holds a less satisfactory sense of usage, he or she may see visuals that look quite pleasant yet resulted in an unpleasant experience.

"I would call aesthetics as part of the user experience. It looks good, or it doesn't look good as part of that user experience. Like if it looks so bad that you're unable to use it. That is something that I put under user experience, because it's your ability to use".

(Respondent 21)

"I think aesthetics are very important when it comes to user experience because you want to avoid getting in their way or making things more difficult".

(Respondent 2)

"Because if the user experience isn't good, they're not going to look at the nice design".

(Respondent 2)

"I would say the user experience is 80%. So, if the user doesn't like it, a good design isn't really going to make up for it".

(Respondent 21)

If there is a disconnect between expectation and looks of a game than a user experience can be affected by it. As quoted by one of the Respondents.

"Battle Angel Aleta, I just watched recently. There's a lot of common commentary around it, a bit disturbing because the main character moved around like a normal person but because she was kind of anime inspired and had slightly larger eyes and all Barbie human characters, that was weird. I think with realism in games, there is an issue that people are more comfortable when they're like 90% real and you can still tell that it's not real but when you get too close with them, it just feels odd. Then there's like, some people don't really bother. I can understand why the technology is there to have ultra-realism. But then the expectation of what happens and then what actually happens sometimes is there".

(Respondent 3)

By describing imagery in terms of its "interactivity" it becomes easier to make an image relate to an aesthetic quality because there is a sense of engagement and connectivity. Interactivity therefore forms a strong part of the user experience. The experience of a user can be dependent upon the way the user engages with the media and make his or her choices of interaction. As quoted by one of the Respondents.

"The interactive part of the game is part of aesthetics because that's part of the experience of engaging with that piece of media. If you're going to evaluate any piece of media, you have to be like what's special about this piece of media? Obviously, for games have seen interactivity generally."

(Respondent 18)

"If you're going to develop a game or a media piece, you're sort of trying to give it the potential to generate certain aesthetics when someone engages with it. Like the designer might be like, this is the kind of experience I want the user to have, and I would talk about that in terms of affordances, like what affordances have you tried to design that piece of media to have, but you can't guarantee that the user is going to have that specific experience. You can make it pretty likely. You can be like 99% sure they're going to do this and they're going to feel like that, but you can't always guarantee that, and I guess the choices that the user makes when engaging with that media will influence what kind of aesthetic experience they have."

(Respondent 18)

"If you ask me visually, both images are fine (See Appendix D, construct 6), but if you ask me the aesthetics of storytelling, the experience of understanding the stories I would say Figure 6 because aesthetics is not just on the combination of colour and the composition. It's about the pleasure (See Appendix D, construct 6) of interacting with the content of the image as well."

(Respondent 17)

The way in which people manage their expectations can have an impact upon the aesthetic values that an image may portray. Experience is also dependent upon the way that a person manages their expectations. Managing user expectations can help in enhancing the user experience. An example of this can be seen in digital game play where the act of introducing sliders if the display is too bright or too dull, can enable a user to move in and out of the camera range based on the gameplay and the expected experience.

"I think it's around expectations management because it will be hard to win something like "Battlefield" because it's a triple A and you pay 100 bucks for it. So, you can sort of pass it off as this is an amazing AR experience. But if it was like always pitched as this is, like if it's a learning activity. This learning activity has these three core learning outcomes that you will experience, and you may nail them. You've managed the expectation. So that will be the user experience and then how that design relates it's kind of as long as it's good enough".

(Respondent 3)

"When I was building as putting a VR chemistry thing, and I've tested some of the students, and some of the students saying it was too dull, and then others are saying it was too bright".

(Respondent 4)

"If I was playing a strategy game than I would like to move the camera in and out because you want to get good controlling drag across".

(Respondent 2)

In digital media, aesthetic qualities appear to be different depending upon whether a person is a player or a passenger. The perspective of being a player and the perspective of being a passenger can affect the user experience. A passenger refers to an audience who is watching the game being played whereas a player refers to the person who is playing a game. There is a difference in experience between these two different perspectives. Both perspectives can be used for different purposes. One such example is when viewing a game as a passenger it can help the user to understand the context and improve his or her performance. Different Visuals can be designed based on these perspectives to create a different type of aesthetic value. For example, if we consider digital media that is cinematic in nature it can be vastly different depending upon whether the user is a passenger or is player centric. The following responses highlight this issue:

"If it's something like a training by doing, its player centric. If it's a training by observing, then maybe cinematic is the best way because you can make it the most compelling experience possible".

(Respondent 6)

"If it's training sometimes you can learn by watching someone else do something. So, you're not necessarily looking through the eyes because you don't want to experience your arm being cut off by doing something wrong, but you could watch someone do the wrong thing".

(Respondent 6)

"you're trying to teach someone parallel parking, through a video. So, you'll get a lot of benefit from them sitting in the car, looking around, experiencing with your limited visibility … you'll also get much utility from playback of what they did outside the car, because the positioning of the cars quite important. When you start turning out, turning in … and you don't really appreciate how well or poorly you did that from sitting in the car. So, the camera view switching to a

God view from above, or third person view would have a lot more impact. So, it might be that the best played from first person and then reviewing is from third person. It depends on how they're learning. The whole experience will be a value from first person but if there were other people observing that person than third person might be better".

(Respondent 6)

Variations in the type of digital media interaction have a range of impacts upon the aesthetic qualities of a piece of digital imagery. An experience can also be dependent upon how the user interacts with the media based on his or her experiences, and how he or she uses it. Aesthetics could be defined on the level of experience that a person holds. It is important to consider the experience of how a person got used to a certain kind of view to play a game. Such variations differ from player to player as well as from developer to developer.

"I'm trying to imagine playing "Mario 64", like the ones in third person, but if that was in first person, it will be really different. Perhaps, if the game was always like that you are kind of used to it."

(Respondent 21)

"you've obviously going to make conscious choices which depend on the feeling you're trying to generate the game genre it is. Probably technical restrictions as well."

(Respondent 18)

4.4.1.4 Aesthetics as a tool for Engagement

Aesthetics can be used as a tool to drive a higher level of engagement. In this sense the use of aesthetic qualities can be demonstrated as a range of different viewpoints and variable backgrounds and foregrounds. It is suggested that varying these aesthetic elements can result in grabbing a users' complete attention. By way of example, a player's understanding of the game by looking at character design, game surroundings and story can result in stronger engagement. One possible way of improving user engagement could be by introducing cutscenes by means of a cinematic view. Cutscenes can be deployed as aesthetic tools that help a user to understand the story of the game and thus improve their level of engagement. The following responses are instructive in terms of this type of aesthetic understanding:

"Idea of aesthetic elements is to be able to grab the viewers' attention and to let them not take their eyes off the screen".

(Respondent 27)

"Cutscenes help, players understand the game world as well as understand the objectives, and also immerse them into the game even more".

(Respondent 27)

The engagement of a user can be augmented through the adherence to traditional photographic structures. The inclusion of digital photography-based techniques such as the Rule of Thirds (See Chapter 5) can also help in improving the engagement of the user. By applying the Rule of Thirds, it is possible to extend a user's understanding about what is important on screen and provides useful signposting that assists in deciding where to focus during gameplay. According to Respondent 32 the application of the Rule of Thirds can be regarded as an aesthetic tactic that can lead to stronger engagement.

"If it is following the rule, like where it appears on the screen is important for the user experience because the more I know what the character is doing, the whole aesthetics of it, I get more engaged".

(Respondent 32)

"Photography point of view, rule of thirds, is like one of the most basic rules given to beginner photographers to try and impose interesting picture. So, I think like in any visual dynamic it's a useful mechanism. Like if you had to create a set of rules to tell people how to make something that's going to be more engaging, this could be something they use".

(Respondent 2)

"When you're taking a photograph, and you want to make it aesthetically pleasing, it's useful to use this rule to put whatever it is you're focused on a slightly off centre".

(Respondent 14)

The application of the Rules of Photography was regarded by some respondents as tactics that were not absolute in the sense that they required strict compliance, but rather that they represented a set of tactics that could be combined and grouped to provide a greater set of aesthetic values within a single set of images or digital visuals. In this sense it appears that some respondents do not see the Rules of Photography as strict rules, but rather that they can be selected as different augmentations to a portion of digital imagery. These elements could be used, but not exclusively as required elements on each and every occasion.

Applying only the Rule of Thirds might not be sufficient to improve engagement in a singular sense but, where other factors were considered, an advantage could be obtained through the combination of various aesthetically engaging mechanisms. This is especially clear in digital media and digital games, where there can be many options available on how a specific camera view is selected for a particular gameplay. Choosing the right view for a portion of gameplay can make the experience more immersive and engaging for a user because it helps in building a story.

"Rule of Thirds is just like one part of a composition. All the other parts you need to mix them to get right".

(Respondent 24)

If you're on the right view, that would be a lot more immersive".

(Respondent 13)

"I can move the camera through when I'm playing to pick the best view for the situation. Guild Wars 2 as played while they added camera to move from first person or third person and they made the zoom out from first person all the way to this view where you're very far away from a character and then you can swing all the way around the character and get a really good view. So, that really helped aesthetics for me when I was playing because I could get the visual impact that I wanted, and especially with a game like that, where they put a lot of effort into the graphics the game has a really nice vista or something".

(Respondent 2)

"I think your imagination carries right away as well. Why? Because the camera helps tell the story which builds the immersion. If it's boring, but pretty, it's not going to last".

(Respondent 3)

"Can you imagine if you're trying to play the game, and there's a wave of enemies coming at you, but you can't see that. I feel quite frustrating.

(Respondent 11)

Choosing a right camera view based on game type is also important for user engagement. There are different types and styles of games, and if the right camera view is not chosen it will impact the user engagement and overall satisfaction of the user.

"Typically, the top-down view, that you toggle, to see where you are on a map. You have to provide the overview first and then you can zoom in for actions in the game. Use the right view because it's a matter of the type of game you have." *(Respondent 19)*

"Some racing game, while you're driving a car, you can change the camera from different ways. If it was all from down there it will be very difficult to drive." *(Respondent 25)*

4.4.1.5 Aesthetic value to Gameplay

Games are measured in terms of gameplay rather than game design. A game may have a basic design but be regarded as engaging and satisfying if the gameplay draws a user into an extended and continued experience. Some examples of this can be easily described. Parameters such as defining the limits for a character to move on a map, the time limit to finish a level and the camera viewpoints can provide a heightened experience through improved gameplay. In this sense, responses to the research interviews suggested that aesthetics had less of an influence in terms of adding matched colour palettes, and greater influence in terms of more engaging gameplay. If the gameplay is considered to be average, expected or predictable, it affects the overall aesthetics of the game.

"For games. It's not about how, but it's more about giving the player options on how to play. Giving them a parameter of rules so that they don't go beyond, but rather on how the game play goes like some areas which are very difficult." *(Respondent 27)*

In this sense the ability to provide a range of choices and options with the gameplay structure of a game has a profound effect on the engagement and the experience of the user. The research responses showed that there were two kinds of choices that are built into games. The first kind of choice provides for cosmetic changes such as changing the physical characteristics of a player/character such as colour of hair, clothing, and other physical characteristics. The second kind of option provides for changes that affect the outcome or interaction from within the game. Choices over character speed, agility, breadth and depth of vision are all described by respondents as features that hold a greater connection with the aesthetics of the game than clothing and other cosmetic differences.

"There was a game previously called "y2k", which was a game that entirely focused on aesthetics to like an extent that was like, absurdly well done, but look

crap and played crap and no one liked it after a certain point because it wasn't very well written. So, they put all their effort into this like, matching color palette, had hues that all worked within one frame and everything in the shot worked with that and then you play it and you'd be like, Oh, I hate it and that sucks"

(Respondent 22)

"At the end of the day a video game is meant to be played. If you want to focus so much on aesthetic, just make a movie or something. Cut scenes in your game that's a great time to relax because the player has a time to sort of contemplate what they've just done".

(Respondent 24)

Some respondents spoke in favour of beautiful visual aspects, however there were no respondents that ranked these visual features as highly as the options that impacted on the outcome or conclusion of the game. Beautiful costume or scenery details are momentarily eye-catching but are not sufficient in their own right if the extended gameplay is not there. The responses suggest the need for a balance between these two areas of differentiation. There should be a balance between the visuals and the gameplay to provide the user with an experience that holds a greater connection with the outcome and interaction of a game in the form of gameplay. The responses show that there are two dimensions that ae discussed. On one level of discourse, the notion of a game being pretty, or having excellent graphics is mentioned in terms of an aesthetic view. On a different level the responses show a discourse that retains a firm hold on game outcomes, game engagements, and a range of choices, options, and possibilities. In simple terms the respondents suggest that this is because a person not only looks at a game, but they also play it. The engagement aesthetics that are raised in these responses show linkages to the ability to make use of strategies and tactics. The greater the options and variability from within the gameplay, the more likely that users will develop ways to extend the aesthetic experience by means of planning strategic changes and tactical differences in game iterations. The specific type of game is important to note. Defining the gameplay for a particular gaming type such as the games that respondents describe as strategy games is instructive. The research reveals that some respondents see the value in examples such as a top-down view because it can be used to retain an informational view that shows the whole team on screen as well as the ability to see the world/environment around the main focus of the view.

“Sometimes you can have a game that visually is beautiful, but the gameplay is a bit crap”.

“I've got a friend who like to play games that look beautiful because he loves the visual design, but at the same time a lot of games that visually are beautiful just aren't that engaging or there's not a lot of depth to the game play or there's glitches. So, I guess for a game developer's point of view, you're trying to reach balance between visual looks and the game play because you know you don't just look at the game, you play with it. So, you want to make sure that the gameplay is actually good as well.”

(Respondent 18)

“There is a constant struggle between trying to have something which looks good, but also it plays well, and it's fun to control. I think Resident Evil is actually a very good example here. Like you'd have a lot of stylized cameras, have tight rooms with the camera looking down to rooms and you feel really claustrophobic. Then when you enter a room, because of the camera, you can't see what's in various parts of the room until you change the room which then adds into the surprise. There was something about when you're playing Resident Evil two, you're pressing forward and the camera angle changes in your character, instead of running that way he is running in reverse, but you're still holding your control in the same direction, because it's the orientation of the camera. The character in the world changes via camera, so that produces gameplay, which at times isn't as fun as it could be”.

(Respondent 9)

“If it's like a strategy game it's not about the specific characters as such, it's more about like managing all your units on the screen. I would suggest in that kind of game the focus isn't on each individual character, the focus is on the bigger picture of what's going on, whether that's like a battle or if it's like a management town or management game”.

(Respondent 18)

Responses to gameplay showed that camera positioning and camera viewpoints are important elements. Gameplay aesthetics are affected by the way the camera viewpoint is chosen for a gameplay. If a player is not able to control a camera then the aesthetic engagement and interaction is decreased. In some cases, this loss of option in terms of camera placement and camera control has a strong impact on the interaction, leading to a loss of aesthetic value for a player. Some responses showed that this loss of aesthetics can be described by a range of emotions varying from annoyance to anger and fury because a player might hold an expectation of the camera control as part of an expected gameplay. If a camera view is not right then a player might not be able to see where his or her character is on the screen and where the enemies/combatants/team members are situated. The responses show that a player may also hold the expectation that they can understand what actions need to be performed based on the provided scenarios in a game.

> *"There's like an optimal view, definitely want it to look nice above all things, but in reality, the nicest looking camera probably not player controller would be even more annoying for the user".*
> *(Respondent 10)*
> *"I think the camera really does add a lot more so than the game looks, especially after going through those examples (See Appx D, VC 7). All of those shots would have been good even if the quality wasn't as good or the quality of game setup."*
> *(Respondent 3)*
> *"If I was playing a strategy game, I would like to be able to move the camera in and out, because when you want to get good controlling drag across".*
> *(Respondent 5)*
> *"I think for RTS obviously top down, I would be inclined to agree with that, and say that composition actually does work quite well trying to have that space in front of the player, which is empty, because that is where something is going to happen where you want the player to focus. The player on the right is more out of focus because you do want to be focusing more on what your character is doing, and how your character will be going to react. Maybe, if you had some options to then press a button and your camera zooms out really wide. You can see what everyone else is doing. But if your player is just focusing on what they're doing in the game, even if they're working in a team, you want them to be able to do that. and you might have a great view of what your team is doing. But if you can see that they're killing enemies and you can't see where your enemies are, then that's not very helpful."*
> *(Respondent 21)*

“So, it does come to how we how the camera control is, is defined in the game because that's probably going to affect your gameplay right?”

(Hira Maqbool)

“100%”

“Like Mario (the Game) as well. It's easy to see how far you can jump if you're on the side like driving distances. It's hard to judge distance like in first person”.

(Respondent 21)

Adding certain views also affects the way the game is played. The responses showed that in teams-based games the ability to switch camera views and to revert to picture in picture views is very important for users and that there is an active and a passive component. In the course of 5 people playing a “five-a-side” game, the emphasis on camera selection allows some players to be active and deploy strategies whilst fellow team players might sit back from active gameplay and strategy, and plan and design a subsequent move or game iteration.

“It's easier to incorporate certain views as well. Like maybe the one on the right (See Appendix D, construct 6) here is really good for a turn-based game where the characters each take their turn and plays an animation or something like that. So, its' like definitely easier to incorporate different views and different games.”

(Respondent 13)

“If I think of a game, for example, “League of Legends”, where there's multiple different views at any given moment, people and the players go to a team-based game. So, there's five players constantly switching from top down over realizing and understanding of different things unfolding. The image on the left (Appendix D, construct 6) is so much more powerful than the one on the right (Appx D, C6), which is quick, great, and good.”

(Respondent 15)

There is an effect on gameplay when the user is either a player in a game or just acting as a passenger (observing audience) for the same game. The respondents’ comments suggest that choosing an optimum view might help tremendously in improving the overall gameplay. Responses show that the way the camera control options are offered to a player to engage with a game is important. Limitations in this form of optioning are aligned with a decrease in aesthetic value and engagement. Camera variations are also an area of consideration. Good camera lenses or good camera optics can be of great value in terms of a game’s aesthetic values. These camera-based options are part of a strong and varied discourse that exposes the nuance of camera play as an aesthetic subset of gameplay.

> *"If this is like a cinematic shot, you can get a bit more creative with your composition. When you have a fight scene, and you want player to actually control things. You probably need to rein it in a bit and go back to a more standard angle that gives the player the easiest control".*
> *(Respondent 13)*

> *"It's like you saw that with the Resident Evil example, that probably had the most aesthetic camera angles, because the designer went in there and handpicked every single each angle for each part of the scene that you walk through. But in terms of controls, I imagine every time you go into a different camera controls or changes like I want to do forward angle changes. Now, this is forwards now, this is forward. Yeah, doesn't make much sense".*
> *(Respondent 10)*

> *"If this is like a cinematic shot, you can get a bit more creative with your composition. When you have a fight scene, and you want player to actually control things. You probably need to rein it in a bit and go back to a more standard angle that gives the player the easiest control".*
> *(Respondent 13)*

> *"Gameplay does really help convey the role that the player does as well. when you're viewing the camera through a CCTV style camera, you feel more like I'm watching events that already have happened and I'm sort of analysing them. That way if you in first person, it's more like I'm really in this or if you are an RTS top down I've got the command on the controller of everything. that's sort of helps to find role of the players".*
> *(Respondent 21)*

> *"It also depends upon what surroundings you want to show, what type of environment you want to show, like the guy is going through a forest and show too much around the guy. This seems like a shooting game also. Such games have different maps and user can select surroundings he wants to play. If only one map user will be bored. It depends, but the main thing is that static elements are important, but the main idea is that you should give the user more options actually, and a choice about where he wants to play that game."*

(Respondent 29)

4.4.1.6 Aesthetics as an Intention to evoke or provoke an audience, player or viewer.

Images and visual content convey different meanings and engage people in a variety of diverse ways. The composition of visual imagery in digital media can provide an important connection with an audience or a player in terms of how each image can convey different senses, connotations and intentions. They are often used to interact with a target audience but can also be important as a mechanism to deliver the details and development of a story, or to send and deliver a message or assumption that is conveyed (or is attempted to be conveyed). The intentions of a story or a game form a different set of criteria for defining the variations and characteristics of a planned set of images.

The responses from participants suggest that these variations have a profound effect upon a range of human emotions. Story-based imagery is a powerful tool in defining the context, background, and starting point for a piece of digital media. The responses from this study reveal that all of these characteristics hold aesthetic value. They can be used to start an engagement with a viewer or user, or they can limit and restrict an interaction, allowing for development and further creation and engagement over a period of time.

"The intent more basically the foundation of determining which of a set of images is the best image".

"As a media creation professional outline my first question is what is your intent with the picture? So, they both (See Appx D, C1) have a plant product, like a food plant product. Are you attempting to sell me the plant product? Are you attempting to have me understand the plight of farmers like what is your intent with the picture? Because that would influence which one is more aesthetically in line with able to influence my emotions."

(Respondent 20)

"How do you want to define aesthetics in this situation? Is it about the practicality of how people see and interpret the story or the message that you want to tell through the visuals? Or are you talking about how beautiful it is there? To me they're quite two different things."

(Respondent 17)

Similarly, the intentional characteristics of an image can be used to justify choices and decisions that will influence the aesthetics of an image. For example, the aesthetics can be changed by choosing a different colour, or a camera viewpoint, to begin a set of images or to influence the scenario in a game or digital story. The responses from the study show that these image aspects can deliver influential messaging upon a digital media piece or digital game. This messaging is a form of aesthetics. Some images can provide this type of influence in a superficially simplistic manner. For example, an iridescent green colour in a game can represent a poison, or a red colour to make a player aware of danger and so on.

> *"Aesthetics depends on something what you actually want to do"*.
> *"Even starting with things like colour, for example, why did you use green here? Which effect do you want to achieve in this picture? If something turns violet usually somebody's dying in a movie. If something is red this can be the danger or intended to love. In some countries red does not mean love it set a different meaning. So, colours have all these standards or meaning, like green is for grass, for freshness for the planet, for life but green also means poison. If you give somebody a bottle with a green liquid, typically, you perceive it as something poisonous. This is entirely depending on your intent and your audience and even your style of game."*
> *(Respondent 19)*

Some responses refer to and described an intended emotional impact or emotional connection. They indicate that intention is also related to what emotional impact is planned to be shared or delivered with a given audience. The aesthetic values of digital imagery are often linked with characteristics that bring out emotional response and engagement with a digital environment.

> *"The aesthetics of the images differ depending on the intent and the emotional impact you intend to have on your audience"*.
> *(Respondent 20)*

Camera placement in a 3D VE can affect aesthetic values through the deliberate and intentional placement of the camera at obscure, unusual, or unfamiliar angles. These actions can instigate emotive responses. These deliberative camera placement decisions are able to create interest, intrigue, and engagement through dissonance, awkwardness, and conflict sometimes described as discomfort or uneasiness. These intentional camera viewpoints are important because they can dictate the composition of a viewpoint through the suggestion of secrecy or mystery.

"I put the camera low up because I wanted to get that that deeper emotional impact. I put the camera to the left because I want the audience to feel slightly off centre and uncomfortable".

(Respondent 20)

"If I wanted to take a screenshot of the game, I'll go to Figure 3 (see Appx D, C5) but if I was just playing the game, I would go for Figure 4 (see Appx D, C5)"

(Respondent 25)

"In Figure 6 (See Appx D, C6) it is easier to kind of see what's going on in terms of the character and its sort of better, but Figure 5 (See Appx D, C6) again, could be used to give the feeling that, like someone's watching the player or following them. So yeah, I guess it just depends on what you're going for."

(Respondent 27)

4.4.1.7 Aesthetics as a Function of Realism

Realism is an important aesthetic factor when game applications, like learning simulators, are developed. Learning simulators are used for training purposes using virtual reality (VR) or augmented reality (AR) based applications. Models created for learning simulators should consider realism in order to resemble the real-time scenarios in which a user works. Various responses demonstrate the importance and worth placed upon authenticity as a characteristic that holds an aesthetic value.

"I would call aesthetics as making sure that the forklift that you're putting in the simulator is the same. Looks same, feels same, buttons are in the same place and the colour of the thing are the same. So, when you go to sit in that forklift, you say, this is just like the simulations".

(Respondent 21)

"The point of the simulator is to be as accurate as possible. So, there wouldn't be much room to like, change your camera angle the way you want to. I feel like you'd want to design it in such a way that if you want to sit back into a forklift, your head would have been same as in the simulator like that".

(Respondent 22)

"I feel like simulators people general always prioritize the realism factor. "

(Respondent 10)

Changing camera angles for a training simulator or learning simulator might hold less benefit in teaching and learning terms, because the story being delivered through learning software is less connected with a creative narrative and more closely connected with a training lesson or teachable moment. In this kind of scenario, it is important to ensure that the steps being taught are accurate and close to reality. Authentic learning requires a realistic resemblance to the real-world environment. In this sense realism is an important aesthetic factor for such games because it may augment and heighten the learning experience through the adherence to an authentic facsimile of the actual activity being expressed through digital media. The emphasis here is based upon clarity, originality, and precision rather than creativity and imagination.

> *"The story that you're trying to tell is not really a story in terms of narratives. What you're trying to tell here is the clarity of step one, you need to do this. Step 2, you need to do this and if you do this wrong, this will happen. So, this is slightly different angle that the simulator show, the angle of a driver, where your hands are. So, from that perspective, this angle is right because it actually shows you this is what you're going to see when you sit down. So, for example, if you want to make it more dramatic do the other angle, it will not work because it doesn't serve the purpose of that experience of you being there driving the forklift.*
> *So again, composition is important to show what you want to show, but at the same time the aesthetics of this actually comes in experience of engaging with the visual so that you understand what to do next. The aesthetics and the experience involved in this example (See Appendix D, construct 8) is quite different from the previous views because the previous were of entertainment nature. This one is a training nature, so you need to get it right. If not, then people don't know how to operate the forklift".*
> *(Respondent 17)*

A useful example of the importance of authenticity in camera position is described in terms of the teaching and learning of forklift driver training. In this example the position of the target object such as a steering wheel for a forklift can also affect the user experience. The steering wheel should be at the same position as that of the real-life forklift. If that is not the case, then the purpose and value of the training is diminished, and the learner may be unable to distinguish between fact and fiction. This is especially important in hazard-based scenarios such as with heavy equipment. It is important that the aesthetic retains realism over creative expressions in the quest for teaching and learning clarity and unambiguity.

"More likely in training, the focus on everything is recognizable like a steering wheel, positions matter way more than overall look."

(Respondent 5)

"Trying to teach people how to train, the same position with a steering wheel or those things are probably more important than any visual function."

(Respondent 3)

"Your main view is going to be on the steering wheel, then at the different levels, to operate the machinery. So, if that's going to be potentially a default or a constant view, you may want to think about how I can frame this or what would be considerations".

(Respondent 9)

Composition rules (See Chapters 1, 2 and 5) can provide less benefit for VR based simulating applications used for training purposes. Participants were asked if the Rules of Composition will be beneficial for such training simulators. The responses from participants illustrate that knowledge transfer and intelligibility are greater values and therefore require a greater focus on information that is accurate, factual, and valid.

"Probably not, because at least in this sort of situation, it's not about looking good that helps sell it, but it is purely about the transfer of information and making sure the player knows exactly what they need to be doing and exactly what has happened in a very simple, clear way".

(Respondent 27)

"I argue no, because that will take away functionality. So, this means you can obviously do minor aesthetics, but you don't want aesthetic composition to be taking over in something like this in which you're just trying to teach someone something".

(Respondent 11)

For learning simulators, the training models used should be highly detailed models, but where the details of the background and foreground surroundings have less value. This is because the user's focus in not on the surroundings but on the actual object that informs the objectives of the training.

"you've probably made the models pretty high detail because you're always going to be looking at them. So, maybe you'd have a really high-quality steering

wheel and levers, but maybe the rest of the scene you'd leave it a bit lower quality because you're not focused on it".
(Respondent 10)

Having an accurate camera angle in a game can also affect the realism factor of aesthetics for games more than for training simulators. Unique and elaborate camera angles have aesthetic elements that differ significantly between training and gaming.

"The one game which this is a very good example was playing "Chivalry: Medieval Warfare". When it first came out it was a hack and slash, and you can go to first person view, and when someone runs with a sword, like chops you in the shoulder, my heart rate goes up. The camera angle was had relatively good realism but the atmosphere from the camera angle view really added to that".
(Respondent 3)
"You could do fancy camera for training simulator, but at the end of the day, if this is training you for the real thing, in the real thing, you're not going to be flying above a tractor. Sitting is the most important angle you are looking at".
(Respondent 11)

4.4.1.8 Aesthetics as a Function of Pleasure

Whilst there are many attributes that form the full set of aesthetic values, the traits and features most commonly referred to in conjunction with aesthetics are those connected with pleasure. Pleasure and enjoyment from the use of digital media draw their characteristics from a range of simple features. The inherent pleasure of a game (in many instances) is not closely related to complex positioning or narrative-driven curiosity. In these instances, the aesthetics of a game are based on the universal appeal of simple gameplay.

If a game is simple and fun, then a user can enjoy the game even if the graphics are simple like a simple 2D game. With a simple colour palette, and simple gameplay, a game will be aesthetic enough for a user because it is simple and fun to play. In addition, if the game is functional, according to user requirements, then the game will be fun to play. Simple graphics, narrative-driven curiosity, and complex attributes are not always the most important features of a game. Simplicity, ease of use, and reduced complexities are often recognised as the key features of a game and are described in terms of their ability to draw a user into a highly engaging experience.

"Scorched Earth is a very old game. That's a 2d game, pixel based. It's like four colours or something like that. Improving the aesthetics of that would not improve gameplay at all because it's just, it's simple and fun".

"Horizon, Forbidden Horizon, that's gorgeous and it's a fun raising game. You know, like, if you cut the graphics in half, it would still be a fun raising. "

(Respondent 3)

"A really good example of where aesthetics come into play Battlefield 2042 shooter, FPS, gorgeous looking game, looks amazing, gameplay is pretty much there but then there's another game that's come out just recently. The graphics are horrible, simple stuff, all the mainstream has started playing this game and they say the gameplay, the gunplay, everything about it is perfect. Because it's hit the nail on the head, and they don't even care that it looks blocky and rubbish because it's fun".

(Respondent 2)

"Anything like Stardew Valley, it's like a really good example of it doesn't matter how crappy it looks because the game just is so much fun to play".

(Respondent 6)

4.4.1.9 Aesthetics as a State of Flow

Camera flow affects the overall aesthetics of a piece of digital media or of a game. Smooth camera movements are effective if the objective is to keep a sense of flow throughout the digital vision. The reliance upon flow is essential in vision and in games when switching between cutscenes and gameplay. Similarly, if a transition from first person to third person is not smooth it will break the flow in the scene during gameplay. A strong sense of flow in a game or passage of digital media can result in an immersive game that is less affected by the visual artifacts in a game.

"Most of the game like they have transitions that can ruin everything".

(Respondent 25)

"Trying to transition to super important".

(Respondent 2)

"Our eyes do really weird things, like we only see that much our brain and our eyes wiggle around to capture and remember it. So, if we're immersed enough to be into a state of flow, whether that's photo real pixel perfect or five colours

that level of stimulation completely immaterial because where you got into that state of flow you no longer care what it looks like".

(Respondent 3)

"Do I care about aesthetic on making this in three days? Probably not. I care about seamlessly changing between scenes. Don't make one to swap between cinematic and first person, that would change the experience in a way I don't want it to."

(Respondent 11)

Game flow can be affected by interruptions or changes to smooth camera movements. This is an important challenge if the evenness of the flow of movement has fluctuations and variations that take place within a piece of digital media that is fast paced. This can devalue the aesthetic benefits of the digital media in cases where the game is fast paced and there are cinematics involved as an integral part of the narration of a story.

"There are also things that sort of under aesthetics as well like smooth camera movement. Fluidity of the camera movement sets things like looking between the camera position, the players input, and you can make things really twitchy. So, the cameras react to what you're doing, which is probably good for really fast paced game and the game if you want to be kind of cinematic".

(Respondent 10)

Game aesthetics are influenced regardless of whether the game is slow-paced, or if it is a fast-paced game. If it is a fast-paced game, then the surrounding imagery will not have a great impact upon the game experience as the user/player will not have enough time to appreciate the surroundings. If it is a slow-paced game, then the surrounding environmental characteristics will be influenced by aesthetics which can strongly impact upon the user's experience. This can bring about noticeable effect upon the flow of the game.

"The pace of the game makes a difference because if it's a slower game, then you'd expect it to look better, because you'd spend more time looking around. If it's fast paced game, it doesn't matter like your textures can be a lot smoother and it wouldn't matter because you're moving around so much".

(Respondent 6)

"If it's a racing game, it fast paced. You probably don't want to obsess over what the tree position is, grass and shrubs because I'm just going to walk straight by".

(Respondent 13)

4.4.1.10 Aesthetics as Context Understanding

Aesthetics are additionally influential based upon the context in which a developer or a designer sets the perspective, for a user, to tell a story. Consider, for example, the task needed to be performed by a character in a game while holding a sword or a gun. A weapon such as this can be of varying interest and engagement based upon the context of the digital imagery. Contextual differences can powerfully define aesthetics. Contextual features can be directly influenced by three things: the application (game or learning simulator); the game style; and the game genre. Responses from participants showed a number of context-based examples that were connected with aesthetic values.

> *"We can give more comment on that particular picture (See Appendix D, construct 4) if we know something about the game like what task a character has to do. I believe if there is a sword in his hand then there are enemies coming. If enemies coming from all sides than top view more suitable, you can see everything what happening there. We cannot judge from this picture only. Just from the view and landscape Figure 4 (See Appendix D, construct 4) is better because you can see more around the character".*
>
> *(Respondent 29)*
>
> *"let's say you're trying to do an introduction to the character obviously you would want to like see from far, before getting closer, before narrowing it down to that one single point that you want to focus on".*
>
> *(Respondent 27)*

The positioning of a character on a screen is also affected by the game type and the game genre. For example, if the intention is to show a scene where a character is being watched by someone then it is feasible to have a partially occluded view. However, if it's the other way around, where a character is talking to someone, than partial occlusion is unlikely to be the best choice of viewpoint.

> *"For a third person game, we've seen behind the player, and you want to be able to zoom in and out and scroll around them. So, it has to really suit application. Like the show with just dating scenes, the Japanese games, like the panel games, they take a lot of attention to where they placed the characters as they're talking about. Application is important".*
>
> *(Respondent 2)*

"Figure 3 (See Appx D, C4) feels really weird. You get occlusion. But it also depends on if you're trying to have someone from behind the bush one of the points of view. If you're trying to get someone to watch. You might want to use the Figure 3 (See Appx D, C4) and if there's another character then our character can be seen actually talking to someone. Figure 4 (See Appx D, C4), you expect character standing to the left and the person, but it will be really weird to have a camera with a bunch of weeds covering the person that the person is talking to".

(Respondent 2)

Shadows also play an important role in the interpretation of context for a game. Shadows are also influential upon the positioning of a character in a game situation where the shadows provide a clue / forewarning of someone's presence. This is very effective for a thrill-based game but impractical and ineffective if it is a game design meant for children. The use of shadows as a means to infer an aesthetic characteristic requires a judgement about whether the intended meaning is one of thrill and excitement or one of danger and foreboding. Shadows are capable of conveying powerful aesthetic value to digital images.

"What do you think about shadows? Because you could have going back to your illusion, you could have someone hiding behind a wall so you couldn't see them, but you could see the shadow and you might get some feeling about the fact that you knew that there was something or someone perhaps. Does that have any effect on this?"

(Respondent 8)

"I think that's what you're trying to convey, do you want the audience to have a clue that there's going to be someone there".

(Respondent 3)

"You're tasked to set an ambush, which is perfect, so much better aesthetic. It's just the context".

(Respondent 3)

"E*specially if it's like a thriller where they're going to jump to get freaked shadows are very, very important. But if it's like a kid show, shadows not going to be as important because you generally want a nice, bright and colourful with the sound".*

(Respondent 2)

"It depends on like, what the outcome you're trying to achieve is and how important that aesthetic element is. I mean, maybe you're teaching someone how to play hide and seek and then there's purpose."

(Respondent 5)

"And what the developer actually use game, like a cinematic game for a story?"

(Respondent 1)

"Could be like a safety training simulation and then the aesthetic and the realism might be super important. And then the amount of time might be worth spending more on to reach the desired outcome".

(Respondent 2)

The below given response is related to Figures 5 and 6 (See Appx D, C5) and are connected with the context in which a story has been narrated. If the narrative is considered to have aesthetic value and if that narrative creates a form of benefit, then the digital image will draw a greater sense of engagement. In these responses, the participants are indicating that narrative benefit is not something seen in isolation, but rather as a component of digital imagery.

"The important part is just what story are you trying to tell is important".

(Respondent 11)

"The guy in Figure 6 (See Appx D, C5) looking for a horse in the car to shoot them or is looking for fair of something that's running through the grass? Or was he lost like in Figure 5 (See Appx D, C5)"

(Respondent 14)

The amount of time spent on the development phase is also dependent upon what kind of story needs to be told to the audience. The aesthetic value of digital images is sometimes judged on the simplest conclusion that is most likely to be noticed by the audience or players. However, in many instances, the creative and subjective elements of the digital imagery allows for a number of possibilities that all have suggestive power and evoke divergent emotions and engagements.

"You could easily get lost in Figure 5 (See Appx D, C5) and spend an enormous amount of time on any number of possibilities. Whereas Figure 6 (See Appx D, C5) somehow has called you back to some extent. Some of those possibilities are no longer in line. So, he's not necessarily lost, there's a path. So, if he's lost on the path as opposed to just lost in general. So, both have different interesting aesthetic features. Figure 5 has a breadth and depth, an almost unlimited set of aesthetic possibilities and storylines and so on."

(Respondent 15)

The use of *Rules of Composition* and camera angles are often invoked on the basis of a chosen or sought-after context. Choosing one specific camera angle can generate an effect upon the overall aesthetics of a story that is intended to be conveyed to the audience. The case for the use of the *rules of composition* is dependent upon whether the intention is to narrate a story or whether the same rules should be limited in usage and sidestepped based on a required gameplay that has a more important contextual need.

> *"Context is really important. In this scenario, you probably want to be following stuff like trying to show three people but given another scenario, you might not want to follow the rules of composition but if this is like a cinematic shot, you can get a bit more creative with your composition. When you have a fight scene, and you want player to actually control things. You probably need to rein it in a bit and go back to a more standard angle that gives the player the easiest control."*
>
> *(Speaker 13)*
>
> *"In context it's really important are we doing cinematic or are we doing the fighting scene that will determine what rules you want to follow".*
>
> *(Respondent 11)*
>
> *"But in the context of a lot of game development now, top-down, and cinematic, get both of these views and switch multiple".*
>
> *(Respondent 15)*
>
> *"It really comes back to what kind of story do you want to tell? How do you want the viewers to interact or to experience the visuals because having that rule the character falling on the right-hand side of the third creates a dynamic. But you know the same frame having the character, let's say on the right of the brackets and the crosses, if you have a low angle or a top-down angle, it gives different kind of aesthetics. I am not saying that one is better than the other. Each of these angles tell different stories and give people different sense particularly sense of space, for example, bottom up, it gives you more of a mysterious something's going to happen, if it's eye level, then it's just telling a normal story of one person moving through the wall".*
>
> *(Respondent 17)*

In cases where the digital imagery is intended for gameplay the player centricity is a key factor. Whether the game is player-centric or not is dependent upon the context in which that game has been developed. For example, if the digital images are portrayed as a cinematic game, then the deployment of a story with the emphasis upon the narrative rather than an emphasis on the player will have less player control. In contrast, a fighting game will place a greater emphasis on providing full camera shot selection and camera viewpoint control to a player.

> *"It depends on the game. If we're doing a cinematic game, you wouldn't care about being player centric or being actively controlling the player."*
> *(Respondent 11)*
> *"If you would ask me between Figure 3 and 4 (See Appendix D, construct 4). I can't in this situation, I can't really tell because I want to know what's the context of you trying to tell what stories you're you trying to tell? Are you going to show this warrior? Or is it telling a story of this person going from one place to another?"*
> *(Respondent 17)*
> *"If it is story, then I think cinematography is okay. But if it is no story then player centric is better because player wants to take different views".*
> *(Speaker 30)*
> *"Like in a game if it's a story driven game, and there's not much action going on I prefer better aesthetics of when it is competitive or action game".*
> *(Respondent 1)*
> *"Recommendation should always be made with aesthetics in mind, you've got to know what style you're going for at least."*
> *(Respondent 11)*

In instances where the narrative is well known (via some previous assumption) then the audience is treated as if they are cognate to some of the expected elements that will accompany the digital imagery. If the audience identify with, or recognize elements of, the story then the aesthetics arise routinely as the story is unfolds.

> *"If you have the context of the story that you want to tell, then you can focus more on how you want to tell the story, and then the conversation and the aesthetics come in organically, not technically.*
> *Aesthetics is how you want to tell the story. So come back to my preference in this case is Figure 3 (See Appendix D, construct 4) because it tells the depth of field and the depth for me to understand the environment a little bit more. So, what I'm trying to get here is, it is not a black and white answer, yes or no, it's*

applying the concept of conversation organically in relevance to how you want to tell the story.

If you know the story, then it's naturally there would be some aesthetics involved in. How you want to tell the story? Who your target audience? When you do all of those thing's aesthetics, it's always there. It's not something that is separate that you do because if you know what you're want to convey, your composition would be quite different. Like we can show the scene from a top-down perspective, or we can show the storytelling of surprise, with the Dragon coming out behind the rocks, then image on the right serve more interesting composition because suddenly the dragon will come up behind the rocks.

But if you are telling the stories on how big this environment that these three soldiers are in. Then the top-down angle will tell a better story, and that conversation will be more aesthetically pleasing to understand. The whole compound, the whole environment of where these three soldiers are in this, that makes sense."

(Respondent 17)

For a game developer and a designer there is need to understand what type and style of game they are developing. The game composition and aesthetics should be chosen based on this important distinction. Gaming media makes use of a wide variety of camera possibilities and therefore there are many viewpoint options. These decisions extend beyond the simple objectives or simple plot structures to be more deliberatively transferred to become critical selections for the developer. These are choices that affect the augmentation or diminution of each aesthetic benefit. Aesthetics can be used in a variety of circumstances across the wide range of digital media options, however the choices that are driven in terms of gameplay have nuances and peculiarities that generate different aesthetic advantages.

"Different games deserve different cameras to design, like you could not do a third person game with VR. You could but would it work? It has to be really strange during the gameplay. There has to be some weird character involved around it. Generally, you would do a first-person game whatever VR game you're doing. You have the player as a first person, whether that's a commander or a thing … but you couldn't really see outside of that first-person".

(Respondent 21)

"In correspondence to players movement because so many factors are involved like what kind of perspective are you set on and then what's the genre of the game? and then what's the type of mood that you'd want to set in within the game?"

(Respondent 27)

"If you're having something which is a serious training thing. You do not want to remember artistic things from this because if you made the camera angles artistic that it potentially detracts from the fact that it's actually a training simulator, for serious use not for enjoyment."

(Respondent 19)

4.4.1.11 Aesthetics as Player centric Concept

The choice of the best possible aesthetics is an important one if the objective is to improve the digital media user experience. One of the key differentiators is in the development of the media in terms of whether the developed design will be user centric or a player centric. The design of the game (and its aesthetic influence) will depend upon either the target user/target player or upon the audience. Responses to different types of game media show that aesthetics are more carefully considered in adult and serious gaming media rather than those elements that are directed at younger persons.

"The player centric approach determines how the player approaches a game and how they play it".

(Respondent 27)

"It depends on the game and also depends on the users who are going to play it. If you are designing a game for kids, small kids probably they would not go for much aesthetics, just want the character to move. But if you are targeting people who are adult probably over 20 may go for more details. Before developing games define requirements and use cases and set goals."

(Respondent 28)

If the game is not player centric and there is a conflict of camera settings between user preferences and gameplay preferences, then it will affect the overall aesthetic experience of a user or player. The responses from participants indicate that there are questions about the way in which aesthetically relevant choices should be applied at the development stage of a piece of digital media.

"I found in a game called "Armour 3". There's a lot of times I'm sitting there I'm driving a vehicle or I'm moving around in third person and the vehicle for me just takes up too much space at the screen. Luckily if I hold "Alt (keyboard key)", I can move the camera to get a better view. But as soon as I let go, it snaps back the decision I don't want to. So, I'm always holding his button and then as soon as I need to do something that requires me to press anything else I have to get back to its view, which I do not like. So, if there was an option to change the view and then keep it there and say this is the view that I want you to automatically go back to this view this is my favourite, then that would be a good one fun to play."

(Respondent 22)

"You can see that in "GTA" five most popular games of all time. They have the camera which is great but when you're driving and then you just immediately get hit by car off screen and then you just spin out and then hit, just jams into a wall and you're like, I have no idea what's going on anymore. Probably not the best player centric way."

(Respondent 23)

The responses from participants suggest that providing multiple views to the user can help in improving the experience of user by providing them with multiple options suitable for gameplay. There is strong support for the need for selections and flexible opportunities in the options provided to users of digital media.

"There should be some kind of options available to the gamer that he or she can choose whatever view is more visible and easier to play with.

My personal experience from the first-person view, I used to get nausea and it was claustrophobic as mentioned in video construct 1 (See Appx E). If it is just a single view it will be hectic after some time. So, there should be some flexibility to change views from one to another. I mean they've been doing this from so many years. So, I think this should be done in all games.

I still remember there was a game probably 25 years ago. It used to call Doom, and then Doom one, Doom two, Doom 3 came. So, Doom used to doom me all the time. I mean, that time we didn't have many options for playing, but after an hour I was totally insane. First-person camera view I hated it."

(Respondent 28)

The responses from participants demonstrate that, whilst there is a general acceptance that cinematics can be useful for games, there is a stronger suggestion that cinematic emphasis can play a part in limiting the user interaction and freedom of the experience. Games can have more appeal if they are player centric. Player centricity appears to be valued independently of aesthetic values.

"Elements of cinematography are useful in games, but games are different medium to films. So, some things can be useful, some might not be as effective. Games can be more effective if player centric kind of implies like first person. You know like the idea that we can control, how we like move through an environment would suggest it's going to be different cinema."

(Respondent 18)

"To me what's important is to allow the user to choose his or her interaction."

(Respondent 27)

Player centric or non-centric player conditions are dependent upon on the type of user experience that is intended for the users or players. If the most important feature is the telling of a story, then the digital media is more directly suited to a cinematic experience rather than a player centric involvement. The responses suggest that the level of audience engagement is a choice that is usually made at the development stage rather than handed to the user / audience. However, some responses indicate that there is room for both sets of user considerations and that there are circumstances where the gameplay can and should also hold aesthetically influences cinematic experiences as well.

"There's a difference between a passive audience and an active audience. So, in an interactive experience, the audience will go passive at certain points. The audience will switch to active at different points. Yes, the compositing the camera view is great for storing moments like cutscenes and important points like that but when the player is just running around, doing whatever they want, if the camera keeps flicking around, they want to lock it. A good example is Red Dead Redemption. Red Dead Redemption 2 had a cinematic mode camera that can be turned on the whole time. So, you could play the entire game with an AI cinematographer repositioning your camera for better shots. And now lots of players didn't turn that on because they wanted to have the game on basic gaming experience. Me as a cinephile I actually played through game with that turned on because it created a more cinematic and story driven experience for me … and I didn't run off and do a whole bunch of gathering things and crafting things and all the little time sinks that are key to a lot of gamers experiences. But

for a story driven experience, it felt good that there was this AI that was essentially an AI cinematographer, giving me a more aesthetically pleasing experience."

4.4.2 Aesthetics Rules for Composition

Respondents were asked questions regarding the inclusion of the *Rules of Composition*, with a specific focus on the *Rule of Thirds (RoT)*. Composition rules are defined by numerous factors such as functionality, and context. These factors ultimately affect the experience of a user. If a player's experience improves based upon the application of composition rules, then the idea that these rules should be used is dependent upon the style and game genre. The responses indicate that there is no single factor that drives these differences. Some versions of game media accommodate composition rules well, whilst others do not.

"If you can't get that immersion, then people aren't going to be interested long enough to get into your game. So, I think you can kind of bend the rules of composition to tell your story of a user experience."

(Respondent 2)

"What was really interesting is you know, the rule of thirds, either games, intentionally did it, "Resident Evil" or like in "Uncharted" game, the camera angles change to complement the story. But I don't expect that to work because that's a core part of the gameplay when you actually have like full autonomy in a scene. I'm confident most games sent to you back again because like if you're in a combat and you're playing offset, it's actually hard to be accurate. So, it's more like an artistic thing when it doesn't impact the experience and if it enhances the experience".

(Respondent 6)

"I feel like when there is a lot of different elements, like different characters or different subjects. You would want to do more of the sort of top-down shot Like what's happening on the left-hand side."

(Respondent 27)

In some instances, composition can define what is important and what is not important in a scene. Such information can assist in the choice of focus about what should be ignored and what should be encouraged during a gameplay. Some responses attempt to order and rank these choices with the emphasis placed upon the narrative ahead of the gameplay. Other responses indicate ambivalence towards a specific order, preferring to place the choice based upon the nuances of the factors involved. This would suggest a game by game evaluation, where aesthetic values are important to, but not overwhelming influential upon, the important aesthetic value that can be diminished or augmented through camera positioning and viewpoint choices.

> *"Rule of Third is very important in visual composition because it breaks down the visual hierarchy and it's pleasing in a way that we create. Straight away we know what to focus on. I think that's the key for a rule of thirds."*
> *(Respondent 17)*

> *"The question is, what is the important focus in this case, because what I'm getting from both figures (See Appx E, C3, Figure 1 and Figure 2) is the ground important because taking up 50% of the image, the character is forced to the side but if we want to communicate that the characters important, actually more central closer."*
> *(Respondent 11)*

> *"Starting to the first question, is there consider aesthetic some point of your composition? I'd say like yes, definitely. Even though it'll just be a frame of still image usually it still can communicate something with composition. I like the first, I think the second is too far back always unimportant. But yeah, it's interesting that the ground is taking up two thirds of almost all the frames both."*
> *(Respondent 12)*

> *"In terms of visual hierarchy, in terms of storytelling, I think composition is very important. I won't say you throw away the rules of thirds or rules of composition totally. But I would say apply it organically, not technically. So, the difference to me is if you apply rules of compositions technically, which means it needs to sit here, or it needs to sit there but if you apply it organically, then you ask the questions, what do I want my users to read first, second, third and so forth? Where do you want the story to flow? So, then you place the objects and the background and the foreground strategically so that people can read the story in a way you want them to read."*
> *(Respondent 17)*

Besides placing a character on a screen, other object-related elements can also affect the aesthetic qualities of a scene based on composition. The responses from participants show that other features compete with target objects in terms of aesthetic seniority. In some cases, the decision is affected by there being more than one single target object. In other examples, the respondents place the emphasis more strongly upon the other various factors (foreground and background) that are in some form of proximity to a target object. Several responses point to the need for combinational factors rather than the expressed focus on a single area of attention. In this sense, aesthetic values are comprised of complex characteristics that are multifariously dependent upon other factors at the same time.

> *"There are other competing elements within both of these figures (See Appx E, C3). In the case, Figure two, you've got a large expense of green grass, which is a completely different. So, there's two different aesthetic feelings. One's green. Figure two has a much greater composition amount of green and Figure one has a much sandier ground space in front, plus it has a dark shadow from the overhang of the tree. So, the aesthetic components are not directly attributable to the target object, but the other factors around it. So, from my perspective, in terms of working out, which is better, the decision that's been made here has not much to do with the target object. In fact, the decision is actually based on the other competing features that are in and around the target object. "*
>
> *I probably wouldn't try and point at the ground. Maybe I wouldn't use the rule of thirds in that top corner maybe use the bottom corner to get more of the sky there might be more natural. Then obviously if you've got like trees around you or something, you might try and frame it, but tree is slightly out of focus. We can do all sorts of things like that. So, you kind of using a combination of them rather than just focus on a single aspect.*
>
> *(Respondent 13)*
>
> *"What is the relation with other objects or what is the importance of other objects."*
>
> *(Respondent 10)*
>
> *"If I'm looking at these two images (See Appx E, C5), and I'm assuming it's the exact same moment in time. Figure 5 does not show the path at all. It's a very interesting shot but it does not show that it might be a bit of a later or a previous shot. The pathway as in Figure 6, which tells me that there is a pathway. Figure 5 to me looks like a man wandering through tall grass with no path. So, from an aesthetic perspective Figure 5 may have much greater interest because it's got some different elements to it, whereas Figure 6 clearly shows a path and clearly shows a person on it. So, when we compare the two, aesthetic interest in Figure 5 is much broader. There are all sorts possibilities and in Figure 6, it's defined*

not so much by the aesthetic by the definition of a clear pathway to find whatever the story is. In Figure five, the aesthetic is far more interesting. It dominates so much more of the picture because there's no path you can tell."

(Respondent 15)

"In a way that people actually remember the experience forever. That was what happened when Star Wars came out. It's just little models that people build but the way that position, those models, the lighting and composition and everything, it tells the depth of the space and everything. "

(Respondent 17)

"I guess it kind of depends on what you're going for, but I mean having so Figure 1 (See Appendix E, construct 3) there's a lot of kind of dead space with nothing happening. So, it feels like Figure 2 (See Appendix E, construct 3) is kind of more aesthetically pleasing because it's further out and you can see more of the scene in the context to the shot. But where it says, "Is it sufficient for an aesthetic view? Do you mean like can it? Can it be called an aesthetic view just based on these rules? I'd say no. I feel like it needs other elements together."

(Respondent 27)

Respondents were asked if the *Rules of Composition* can be ignored for the sake of aesthetics. Their responses were overall aligned to a position where the *Rules of Composition* were not ignored. The notable exceptions centred around the occasional desire to represent a set of digital images that were generated within an environment supportive of chaos and disorder. Under these conditions, it is possible to forego the need to adhere exclusively to the rules of composition. However, overwhelmingly the responses indicate that the *Rules of Composition* can be broken in support of aesthetic functionality. The emergent commentary is that there is a visual hierarchy of rules and that the order of that hierarchy changes in different circumstances and for different effects.

"If you want to create a sense of chaos or disorder or dis harmony, you can intentionally not go with the rules to sort of try and create".

(Respondent 27)

"In terms of aesthetics, I think we're not talking about how beautiful it is, but we're looking at more on the functionality of aesthetics in which can we straight away see where we want to focus. That's what we call visual hierarchy. So, in this sense how you follow the rule of thirds is important, but at the same time, if

you look at, in photography and in videography how we use rules, that is quite flexible as well. It's not always that we need to place it in junction of that cross."

(Respondent 17)

Responses from participants indicated that the *Rules of Composition* may also have a deleterious effect on the functionality of the application such as VR games. The responses show that there is no one single variant that allows for a firm set of defining rules for systems such as those applied when using virtual reality. The freedom of movement and ability to engage across an enormous variety of player choices make it difficult for the establishment and applicability of aesthetically-driven adherence to *Rules of Composition*. The responses showed that composition is an essential element in the design and development of digital media imagery. Whilst some responses referred to a need to retain composition as part of the development of a game or set of digital images, there was agreement between participants about the need to keep aesthetic characteristics included regardless of whether the camera mode was cinematic, POV, or other positional viewpoints.

"Because in virtual reality the eye of the viewer is always on the move, so they have their own personal interests, so it's hard to determine the aesthetic composition rules in that point".

(Respondent 27)

"If we take a training simulator, the view, because here we are training a person. So, it should cover a view like an actual first-person view. So, not only first-person view, a whole view of forklift, so, that I can follow the instruction. I can train myself but even if it is just first person view even then it's not okay because I don't know what is on my left on my right. Normally we know when we sit in the car or in the simulator. So, I think for the VR things whether they should be some other kind of parameters for composition."

(Respondent 30)

"It's good to have things that are nice on the eyes, but ultimately it comes down to the function and the ease of use."

(Respondent 2)

"This comes back to the Resident Evil stuff, like functionality versus aesthetics in this point, because if it's a training simulator, you want it to be very functional but if it's more of a cinematic game, you want it to be very aesthetic.

(Respondent 11)

"The composition rules would apply only to the extent that they're useful for the functionality of the game or simulators."

(Respondent 14)

"For VR making sure your field of vision isn't too tight. So, I guess if you're obviously trying to train someone to use this, the forklift or whatever vehicle that is, moving your head around, then the frame will change because it's VR rather than being a fixed camera. You've got to try to keep it realistic. I suppose if you want it for training, so you can't manipulate stuff to look prettier".

(Respondent 18)

"Composition is essential to everything regardless of whether you're using a cinematic camera mode, a follow cam, a character POV composition is super important. So, for example, your top down to composition is designed in using the rule of thirds usually with your user interface. To make sure that there's an aesthetically pleasing balanced user interface."

(Respondent 20)

Responses from participants acknowledged the need for development of digital media that was inclusive of a balance between freedom to interact, and a pre-determined set of objectives that could be applied to the digital media across different iterations and interactions. Composition is also defined by the objectives that a developer wants to achieve in order to better engage with each player. Boundaries need to be set for defining the user experience. It also depends upon the type of surroundings that need to be presented so that there is an alignment between the digital vision and a match with the story the developer wants the user to understand about the game.

"It also depends on what is your set goal. You don't have to spend too much time on that, but enough time is definitely required, so you have to draw a boundary. What is too much and what is the required. So, I would say if it's enough required, if it's some the detail which is required for the game than you are good to go."

(Respondent 28)

4.4.3 Challenging Areas in Game Design

There are many factors that are challenging in game design. Participant responses collectively refer to the need for balance between what is designed in advance of an engagement and what can be attained and engaged with as part of an interactive experience.

The first, and the most important, is keeping a balance between the gameplay and game design so that with nice looks a good user experience can be provided to a user. This can be achieved if the design of the game is in the context of a story narrated to a player. Some participants acknowledged the difficulty in incorporating aesthetic characteristics that generated sufficient engagement and interest without removing the supporting authenticity for the story in a game. The emphasis from responses was the requirement to prevent the emergence or generation of digital imagery that would feel or appear irrelevant to the player. Balance is clearly both important and challenging for game aesthetics.

> *"I would say the most challenging part is working out the balance between how well you make something, look nice and aesthetic, and how much you focus on gameplay and how playable your game is. It's something that if I had to bring in an example, I'd say "Team Fortress two" does very well in their character design. Their characters are very aesthetic, but also incredibly practical. They all have a very unique silhouette. They all have backlighting on them to make sure you can see him and they're all distinct. So, you know that's an enemy, that's a friend and you know what they're doing, and you know what weapon they're holding and how they're doing. So, these are all things that are conveyed really easily and that's something I would say the most challenging area in designing a game camera for aesthetics. How do I make something look really good and sound really nice and feel very nice, but still be practical and still play nice." (Respondent 21)*

Placing a character in a VE and designing a game with a camera accurately controlled by a player can be challenging. Participants in the discussions sought to describe the problem of designing a player centric camera that incorporated aesthetic attributes. Responses showed that the greatest area of difficulty was ascribed to the area of new game developers.

> *"If you're new to game development, you don't think about until you actually do have to make a camera, or you do have to make something you realize your game is going to be player centric. You realize, oh, wow, I have to think a lot about this, and I would say it's quite a challenging thing. Like pretty much everything you do in game design like making UI or making movements it's one of those things that you can choose to not think about very well and then you just have a poorly designed camera system, works but everyone hates it and annoys everyone. Your camera flips and constantly zooms in and out. So, it's one of those*

things that I would say is challenging if you choose to focus on. So, even if we're going on to example games that are built around tricks with a camera like "Face" which is entirely about having a 2d camera that's in a 3d world or another game. It's more of a concept game called "Darko", which is, same idea, but it's a 3d camera in four-dimensional world. So, those can be quite challenging if you're trying to build a whole concept around the camera, and how the player sees the world."

(Respondent 21)

Many of the participant responses articulated the idea that developing a player-centric approach can be challenging as it is hard to meet all the expectations and requirements of the user. If there are multiple views then it is hard to find the right one unless the user explicitly clarifies which view is the most sought-after view or viewing experience. The challenge is described by multiple participant responses which nominate a variety of possible options but without a unified answer to the task.

"You probably always start player centric in terms of what's most challenging areas."

(Respondent 10)

"To select the right view for a particular situation. I think that is the hardest because there are many options. I think that this is a difficult part"

(Respondent 32)

"I think it can be like it will make gameplay more complex. So maybe two or three like discrete views. Not a continuous take of control."

(Respondent 30)

"I would say the most challenging area is keeping players immersed and keeping them emotionally engaged in what's happening and keeping players on the Golden path to making sure that they come back to whatever path they need to be on to continue the game."

"The entire process is a challenge. The challenge is balancing core gameplay mechanics of like rules, goals, challenge boundary and feedback and making sure that the player has all the information they need at any given point without needing to ask and without the developer's hand being intrusive and kind of breaking that emotion."

(Respondent 27)

Adding cinematographic elements in a game-based camera design is challenging in circumstances where the game engines are not designed by a cinematographer and where cinematographers are not part of the game engine development. This can become problematic with issues such as setting the game camera with specific aperture settings. Some game developers do not conform to the rules of cinematography.

"My biggest issue with using game engines, to try and use a cinematic camera and provide an aesthetically pleasing cinematic experience when a cinematic camera is coded by a person who's never studied cinematography or understands how a real cameras' physics work. For example, Unreal Engine still doesn't let the aperture affect, the amount of light that actually gets into the camera. I have to manually adjust the EV setting when I change the aperture so that it can reflect real world apertures which I have to do through an extra script which I had to code myself. It is a function that is physics. When the aperture goes up and down, the amount of light going into the lens goes up and down. The amount of light go into the sensor goes up and down and you get a different image. Unfortunately, they have not coded that and that is my biggest thing is that if you want to make a virtual version of a camera, ask a person who knows how a camera works".

(Respondent 20)

Several respondents acknowledged that a significant challenge faced by developers is to keep up to date with the current standards of developing games. This was noticeable amongst several responses in examples such as with the seamless switch that often occurs between different camera views, such as between cutscenes and the gameplay. Multiple participants made mention of this with specific reference to 3D VEs.

"The challenge is sort of like trying to keep up with the latest standards because where we have cameras like little Warren software, it goes from cinematic to the play seamlessly because now we don't have the limitation of having to cut and load a cutscene".

"If you think about a 2D game versus a 3d game as well, an example of Mario, the camera angle stays there in 2d games, really traditionally have very tight controls and it's not just because you have removed one of the dimensions but because that camera is fixed you can really work on the controls. In 3d games maybe the camera design really is an issue. It's a lot harder to this, I think it's a struggle."

(Respondent 9)

"As far as I know, the challenge for game designer and developers is making the environment more real and for me, design industrial standards for aesthetics."

(Respondent 30)

"I think for me the hardest would be to develop a player centric approach because most of the games have good aesthetics now but not many games are player centric."

(Respondent 32)

"The entire process is a challenge. The challenge is balancing core gameplay mechanics of like rules, goals, challenge boundary and feedback and making sure that the player has all the information they need at the at the at any given point without needing to ask and without the developer's hand being intrusive and kind of breaking that emotion."

(Respondent 27)

One of the undercurrent themes that carried across responses throughout this research study was the ongoing challenge in terms of a lack of consistent standardisation through the digital media industry. The challenge for aesthetic values in particular is the lack of specific conformance within a codified set of guidelines or rules that indicate the correct order and weighting of differing directions.

"I guess with there being no standardized ... without there being any sort of standardized rules for aesthetics in games like there are in cinema, because you might have more cinematic games, less cinematic games, things like that. It is challenging, so I guess that would be a good starting point would be to try and formalize aesthetic rules to games."

(Respondent 27)

Digital media now draws upon a variety of media playback equipment ranging from 4K screens to VR headsets. These diverse media playback devices give rise to diverse forms of digital media. For example, there are media-specific challenges associated with designing a camera for a VR based system. This can be divergent because gameplay will not usually accommodate abrupt changes in camera parameters. Such variations and transformations across the digital media spectrum can serve to confuse players and abrupt camera changes can jumble the overall VR experience of a user.

"I mainly work with VR development and that sort of has its own set of challenges, like not making the player motion sick with the camera work,

because in VR, the camera is entirely player controlled. We have to be extremely careful when doing things like if we want to move the player from one point to another, we need to warn them and the kind of like faded to black and then come back in and we have to be very careful because they were quite sensitive. So, I think it depends on what medium you're working with and what your target audience is at least in training. For instance, the training VR systems, we're working with people who don't necessarily play games, so they're not used to the medium and so they have to kind of be like spoon fed everything."

(Respondent 27)

4.4.4 Role of Users in Design and Development

User experience is an end of development function that is often overlooked in different digital media formats. The importance of the user experience is critical in terms of overall satisfaction and drives the acceptance (or lack thereof) of new technology formats and novel equipment standards. Based upon the responses from participants users should be a part of the design planning and implementation at every stage. User experiences are heavily influenced by the design of a game or digital media vision imagery. User experiences that are seen as beneficial are achievable through systems that place the design as a function of the user's expectations rather than the expectations of the developer. Participant responses suggest that this becomes imperative at some stage because the end product will be used by a user.

"I think aesthetics are very important when it comes to user experience because it's more so that you want to avoid getting in their way or making things more difficult".

(Respondent 2)

"If the user experience isn't good, they're not going to look at the nice design".

(Respondent 3)

"If you're trying to, like, facilitate a certain experience, you have to anticipate how the user will engage with that media to determine what kind of experience are going to have."

(Respondent 18)

"If you want an example of the game which should work well in first person view but doesn't play "Firewatch". It's only about five hours long but I've got motion sickness".

(Respondent 6)

"Generally, people are going to interact exactly how they see it. So, kind of understanding how someone with no knowledge is going to interact with something would determine how you're going to design that thing."

(Respondent 23)

Test audiences and professional users are important for releasable products such as games. The participants in this study responded with explanations that a game design should be player centric, and that a camera should reflect the ease of use and functionality of the selection of a different viewpoint. If a game design is not user friendly then the overall usage of a game is likely to be less accepted than other games platforms.

"You need to involve the user each phase of the of the experiment, so you don't just exclude him completely."

(Respondent 19)

"Test audiences or professionals, etc. are all very important to the design process for a releasable product, specifically referring to your image that you have on the slide (See Appendix E, Construct 2). That is what that is an example of is beautiful design aesthetic. They built the nice path in the spot they thought it would be pretty without considering the user experience. So, that is actually the opposite of what we're saying, which is that you need to build function before form. So, because they built the road in the wrong spot that's why it looks ugly at the moment because the users had to make it ugly to make it work. If the road had gone the correct direction in the first place, then it would look pretty as well."

(Respondent 20)

Some responses took the user experience design challenge even further, suggesting that a given design can be more valued if the user is considered as a part of a design. Participants responded by suggesting that the user experience can be more valuable if the user is involved within the design process. The respondents suggest that the more collaborative the design process, the greater likelihood of a better user experience, and this in turn will support the design by assisting it to function better.

"I would say that you have to nail down the user experience first and then you build. So, if you're designing the user interface, or whatever it is you're designing, you want to see how people are going to use it, and what they want

to use, because that complements the design, rather than if you come up with a really aesthetic design and try and build your user experience around it. if you're wrong about something that people don't like. It's much harder to change."
(Respondent 21)

Signposting is an important element within the design, test and final user-experience of a piece of digital media. In the case of many games the use of signposting can raise the quality of the final test process. In such instances a user can be given some indications and notions on how the game can be played. For example, one method that is acknowledged by respondents is the practice of highlighting the path which can lead a player to their goal or final destination. In some instances, this also involves limiting the movement of the player to certain parts of the terrain instead of a whole terrain where a player can get lost without achieving the actual goal. The responses show that this type of signposting is beneficial in terms of the user experience and overall satisfaction, whilst not limiting the user to a specific route or set of instructions.

"For games it's not about how, but it's more about giving the player options on how to play. Giving them a parameter of rules so that they don't go beyond what they want, but rather how the game play goes like some areas which are very difficult. It mostly comes like when it comes to obstacles, or let's say routes that they can use.
Like if you play the last "Uncharted" game. It doesn't tell you where to go first. The way you play the game is entirely up to the player. Like they've given you where you need to go but they don't tell you which one to go to first or second or third. That one is entirely up to the player."
(Respondent 27)
"I think we should allow the user to choose his/her interaction."
(Respondent 32)
"Just taking the control away from the player is dangerous because they can start to resent that, and it breaks the emotion. But at least in the something like the "Last of Us", it gives the player the option, so it sort of pops up with a thing on the screen saying, "Look at" and a button prompt and you don't have to do it, so the player still retains their agency, but it is there to sort of aid them."
(Respondent 27)

Responses from participants in the roundtable discussions highlighted the need for the incorporation of aesthetic characteristics from both the developers' side as well as the users' side. Responses demonstrated a strong preference for the combination of aesthetic values development on both the user and the developer side of the progression and of digital media. The responses validate the suggestion that users and developers should work side by side in order to create digital media that incorporates a range of aesthetic values that are useful for both users and developers alike meet the objective of digital imagery that will satisfy a hierarchy of aesthetic features and values. The responses also support the inclusion of more than one single camera viewpoint as a base-level standard for aesthetically robust digital media. This baseline is the requirement that multiple camera viewpoints (minimum of two) will increase the usability and functionality, and will improve acceptance, usage, and design through the increased generation of aesthetically robust features.

> *"Co code designed, which means designers working with the users in a design process. So, engaging the users in the decision making and the design process."*
>
> *"If you asked me which is more important, I would say being inclusive and including users in the design process and decision-making process is very important. But again, it's not a one-way street that we need to follow everything that the user tells us. A lot of time what user want is quite surfaced. We need to do a lot of more in-depth research to understand how it function.*
>
> *So, I think to me it's not a direct answer which is more important to me. I think both working together iteratively. It's the process that it's more sustainable moving into the future."*
>
> *(Respondent 17)*
>
> *"I'd say that probably close to being equal and importance. I feel like you kind of have to think about both at the same time but probably design at first and then including more focus on user experience at later stages, but I would say probably in terms of importance, I would say both."*
>
> *(Respondent 27)*

Additional responses from participants indicate a very strong level of support for the design of a game camera for 3D VEs where a user-centric design includes the provision of multiple views to a user. Such a camera design should (according to responses) allow a user to select among a variety of different views. The participant responses indicate that limitations of user options are likely to cause frustrations and will allow for designs that deviate from a player-centric approach.

“Actually, what I believe is that if I am a gamer and I play game I should have multiple views to choose from and I can choose any of the view which is acceptable to me, and it happens in most of the games you have the authority to choose different views as required.”

(Respondent 29)

“I would also say the same that you have the room for the view, otherwise you're in trouble. For instance, in Figure one (See Appx E, C3), if you don't know what is happening on the right side and based on these two figures, I would probably go for Figure two (See Appendix E, Construct 3). I mean there's more view. I can see they're standing in front of the road, that's cool but if I'm seeing something coming from the right side, I can attack it. There should be some kind of margin or some kind of option available to the gamer that he or she can choose whatever view is more visible and easier to play with.”

(Respondent 30)

4.4.5 Known Industrial Standards for Aesthetics

The majority of respondents were asked if there are any known industry standards that considered aesthetic values as part of game design and digital media development. Respondents answered that there is no singular inclusive standard but there are guidelines and principles that can be used for designing. These principles and guidelines can vary depending on the purpose of the developed application and game. Additionally, there are peripheral rules and guidelines that are instructive for use with people with visual impairment or other incapacities. Different respondents cited the need for standards, whilst no single inclusive standard was known to any of the respondents.

“From my understanding there is no standard for aesthetics. There are principles but it's not an industry standard that things must be done this way.”

(Respondent 17)

“No, there are none that I've thought I haven't heard of any industry standards that I follow at the moment.”

“What people find aesthetic other people might not like … So, it's very hard to create a standard can be reproduced because it's not settings, aren't one-size-fits-all like Maths.

There are tips for like there's not like standardized rules, but there's maybe recommendations on the dos and don'ts.”

(Respondent 27)

"I would say if it touched on usability and inclusivity, they might need to have some standards because a long time ago in graphic design there's an ISO on how we need to use color. For example, you know green text against red background, people with visual impairment won't be able to interact with. So, I would say if you were actually creating animation to help, let's say, people with learning disability to understand how to cross a road with traffic light then yes, they might need to have some industry standard on what would people with learning disability learn things through visual composition."

(Respondent 17)

"Sort of like unspoken recommendations of doing it, but not hard and fast guidelines except for when it comes to accessibility then you do have some more tried and tested methods".

(Respondent 27)

"No, I don't know about standards. When you get into things like accessibility and there are probably standards for different genres, so players will expect certain genres and certain types of games to look a certain way. But I don't think anything is set in stone, but I think they're all sort of just based on like recommendations based on what's come before."

(Respondent 27)

In the context of a lack of a single standard, several respondents referred to the *Rules of Composition* as a set of useful guidelines. Responses suggested that the *Rules of Composition* present as useful guidelines in emerging areas such as for the placement of a camera in a 3D VE. Participants posited that the *Rules of Composition* can be a useful starting point for camera placement. Further additions to options for camera viewpoints can be changed based on the story context and requirement of gameplay.

"I would say composition rules are guidelines for generally how to make things look good, but they're not hard and fast rules."

(Respondent 18)

"I feel like the rules of composition should be used as a framework and then on top of that you kind of build your own aesthetic by being able to break the rules."

(Respondent 27)

"I do not think you can just throw rules away. I mean rules are the basics whatever you design, whatever you built it must follow some kind of basic rules.

Whoever designed it has some kind of sense behind it. So, you cannot put it in a trash. You have to follow that after that you can make some adjustments. So, I think that should be the way that you start with basic and then carry on your own way."

(Respondent 29)

"I think when you say making a game or taking a photo, for example, rules of composition they're almost like a good starting point. For example, I'll do something which other people have done or is a proven technique to look good and then for that, you may frame something and then you may think, oh, if I kind of move it a bit, or if I kind of do this zooming in or out and then if it breaks that rule it doesn't particularly matter because then you get to a point where this for some reason looks better than before, but those rules are good for just, you know, expression.

I always like to consider basic rules of composition as a starting point".

(Respondent 9)

"They say the rule of thirds is like, it's a guideline that, yeah, you don't have to follow these things but there might be a good starting point when you're designing something."

(Respondent 18)

Responses from participants make reference to the use of standards and guidelines as being important starting points for the creation and development of most digital media formats. They note that understanding context is important for using rules during design and development. Starting with basic rules and changing them based on context as the process of design, appears to represent a benchmark approach to the way that digital media is created, designed, and applied.

"Industry standards aesthetics gives you like a starting point, which you can just follow, or you can extend from cinematography in a game and then you can also switch back to the player centric and it's just depending on what you want to make. I think context is so important with decisions".

(Respondent 9)

"You could have a real time strategy game and you're probably going to look at the industry standards and that's a top-down view because obviously then you can easily select all the units that you want to move around the map, but then

you might incorporate some cinematic angles when the units clash, and it shows a close-up of units attacking each other.

Responses from participants demonstrated that state of the art games and emerging digital media can be used as a way for re-defining industrial game design rules by developers. They also suggest that potential rules can be modified according to emerging game design requirements. This is important in areas where new and emerging formats of digital media provide for greater options in regard to camera selection, positioning, and transitional flow.

You start looking at what are the games that in your genre that you're making? Or that you want to make? What are they sort of using? And then maybe it might look at some of the more creative games can I try to break this if I want my game to be unique?"

(Respondent 10)

"All those industries standard stuff was formed from like the original games, which they originally looked at what's important".

(Respondent 11)

"Like there's always going to be a game where people will say this game is the best or this game did the best and that would be the closest to a standard. There's always going to be something that's recognized as what people would like. Like "Gears of War" at the time was pretty revolutionary and story driven. Won game of a year award. It was gorgeous for that time, still stands up, and I think those the aesthetic of how it looks really does add to it."

(Respondent 1)

"To a degree I think they certainly shape the aesthetic, but I think the aesthetic should always take precedence over composition.

There's are certain directors, for like TV shows, that will put the camera near the corner of the screen and make them feel isolated and that's their aesthetic. So, if you watch this show, you know which director it is and games designers have a similar thing, I think as well, we're looking how certain games are made. You can like oh that was made by their studio".

(Respondent 9)

There are some standards that are already defined for certain game genres and scenarios. Some respondents have indicated the challenges with cinematic digital input. For example, where there is narration of a story, cutscenes are used that have cinematic properties like that of a cinematic film or movie. These then extend to standard camera angles for games like RPG strategic games, or AAA games.

> *"Some games have their own standards; these standards maybe don't change a camera while they're developing a new version again. They keep the same camera".*
>
> *(Respondent 24)*
>
> *"If you see a camera in a cutscene, especially if the character was going through like a really skinny gap where the camera came in, focused and showed him edging through … and then once he was through would come back out and show the bigger picture and what he was looking at all this kind of stuff. So, if you want to look at camera usage, look at "Naughty Dog" (https://www.naughtydog.com/) games, because they they're generally regarded as being really good for the camera and it's always third person. It's always cinematic in adapting the fly."*
>
> *(Respondent 1)*
>
> *"It definitely is a combination of all three depending on the sort of rules boundaries and other sort of gameplay mechanics that are in effect at the time. So, if like with "the Last of Us", if you need the player to take in specific information that will affect the camera placement. If you're trying to build like an emotional investment or something like that then you need to make it more cinematic and things like that."*
>
> *(Respondent 27)*

Several responses discuss the importance of purpose and intention when describing the rules that assist with aesthetics in digital media. Rules should not be followed blindly but the purpose for which the rule is applied or broken should be justified during a design process. This is because some rules might work for one design, but it will be useless for another based on functionality.

> *"Rather than making the rules when studying an art form, it's not important to know what the rules are. For example, I should never break the 180-degree rule in cinematography, because it confuses my audience. You don't need to know; I should never break the 180 rules. What you need to know is how to ad that will does. Then you can decide if you want that effect, or you want to avoid that effect. The same goes for every rule. So, all of these aesthetic rules, the composition … it's not about game designers going this is good or this is bad. It's about going this does achieve that?"*

(Respondent 20)

"It's the same thing like at the beginning of cinema, the one aesthetic rule you need to have to come at a fixed position and then feel it like a little box like a theatre. That was at the beginning of cinema, very strong rule, for example, don't move and let the audience explore and this got broken. The same goes for computer games, for example, today's movies when you see all the fighting scenes in Lara Croft, like she's beating somebody, you don't even show how other people get beaten completely, but then they disappear. That aesthetic elements which come from computer games into film because the young generation wanted to see such stuff because they got used to it via computer games".

(Respondent 19)

Several responses talk to the issues of choice and justification. There is a need for digital media rules regarding camera positions and viewpoints to be accompanied with a suitable rationalisation that provides the reasoning and sense-making involved. The emergent guidance for digital media is clearly an area of inconsistency. Additionally, the responses strongly contribute to an understanding that aesthetics-based rules are required for digital media in terms of camera viewpoints, yet the inconsistent application of varying guidelines demonstrate the need to be clear about the reasoning for the acceptance of one set of guidelines over another. If a designer is breaking a rule while designing, then justification for breaking a rule should be provided to the audience.

"Breaking the rules, you should always be able to justify why you're breaking the rules. The rules are default, for a reason, for example, crossing the line is a thing when you've got two people, you always have the camera over the right shoulder, one left shoulder, another etc. Kind of thing so you don't mix up who you've got. You don't go over 180 degrees. So, you set a line and you only move the camera around this 180 You can't go all the way around the other side. Spielberg is known for constantly breaking that rule and going on the other side. The reason you don't do that is because the audience gets confused, they feel unsettled. They feel uneasy. He does it to make them feel uneasy. So, breaking that particular rule is a hallmark of his way of manipulating his audience."

(Respondent 20)

4.4.6 AI in Game Design

Artificial Intelligence (AI) can be used in game development to assist with automation processes that could be applied to camera positions and viewpoints. Given the capability that can be driven through the application of AI, it is important to note that several responses from participants show that AI might be more helpful for the developers than to game players or for the purpose of gameplay. There are different types of AI that can be used such as scripted AI instead of machine learning. Additionally, respondents note the value of using AI for the implementation of more creative ideas by the game directors and developers. In some applications AI has been used to procedurally generate the content and algorithms that emulate certain behaviour of characters in a story. Additionally, AI can be applied to automatically correcting the position of the target on the screen. Examples of such applications include games like FIFA, Red Dead Redemption, Empire at War and Star Wars amongst others.

> *"AI is more helpful for the game developers but not for the game play. For instance, FIFA if we talk about 2023, they have AI human behavioural imitation. You can imitate the real gestures from the player. So, AI is more helpful for the game developers but not for the game play. I mean, I'm playing FIFA for like more than 20 years now, gameplay would still be the same. I mean AI cannot interact with me ... I don't see it right now, but from game development point of view, yes it can help you a lot".*
>
> *(Respondent 28)*
>
> *"Definitely useful in the future, but we need some way to feed them what we want what we're looking for. We want the player to be seen. We don't want to see the tops of buildings."*
>
> *(Respondent 11)*
>
> *"I can definitely see a camera angle system though that was AI control, where you're controlling like it's a third person view and you're trying to incorporate multiple characters in shot but you still want to keep the player in shot. There are scripted approaches that might do the same thing but maybe the AI is able to keep the rule of thirds and those other things as well as the characters in. There probably is definitely a use for it."*
>
> *(Respondent 10)*

The majority of the respondents acknowledged the value of AI usage as part of a solutions-based approach to looking for optimised viewpoints and camera positioning decisions in digital media. If enough data is provided to AI algorithms to understand human emotions, and how a story is narrated, then a satisfactory AI game development system can also be created.

"The way I understand an AI is machine learning. So, if we have enough data on how people perceive and how people look at things and how people understand narratives and stories, I'm pretty sure the machine can learn that as well. So, I'm not sure about that. I'm not familiar with technology and AI and conversation in this time, but I'm pretty sure it can be done."

(Respondent 17)

"I think people sometimes like it's this magical thing that can just come up with all. No, you have to feed it information. You're sort of giving it guidelines to function on."

(Respondent 18)

Despite the widespread agreement between the majority of respondents, there were responses that supported a scripted AI version over a Machine Learning AI approach. For some respondents, machine learning AI might not be helpful in game design and gameplay, and instead scripted AI would work better.

"Scripted game AI and not a machine learning AI. Big differences. A game AI which is a scripted thing, which determines what actions you're playing or you're doing with what other things are in the scene and randomly chooses from a set of predetermined camera positions."

(Respondent 20)

For some participants the observation was made that AI would limit the way some games are developed and created. For some participants it was judged to be an opportunity to understand how aesthetics can impact the problem of game development by an AI system. Some respondents retained the judgement that there is still room for human involvement in game design that should not be ignored.

"Artificial Intelligence can help, but it can also be a hindrance because they'll have a specific idea like don't leave room for new perspective. It can solve problem for camera placement, but then if it can pick a specific method, then keep repeating that method and then might not consider, let's say, if someone comes up with a much better solution."

"Perhaps like procedurally generated stuff if you have enough sort of inputs and things like that, enough variables that you know beforehand work then I'd say

so, but I think it would still be up to a point where then a person would have to probably take over. There could be some middle ground where it works.”

(Respondent 27)

“If AI is deciding I do think than it's important that the AI client knows what we're wanting to do”.

(Respondent 11)

“I think up to a point it wouldn't be enough to leave it on itself and you would still need some the human eye to be like. Yep, this works kind of thing or like improve it, but you could probably use I can imagine using AI say a camera placement as a starting point and then so you're not starting from scratch and then making adjustments to it.”

(Respondent 27)

“I won't say challenges, but I'll look at it as more opportunities because then you know with AI and VR all this kind of thing people actually look at it then players control how they want to see things. So, a lot of games you're providing an environment for people to interact differently. So, then the composition is not fixed. So, I think that puts your need right there to explore what is the aesthetics? What are the experience factors that would impact on people interacting with stories and narratives in AI and VE?”

(Respondent 17)

The majority of responses from participants showed that AI can be helpful in game development by generating a number of random events. Developers cannot generate every possibility. Responses support the idea that in certain situations an AI based guide can be used to help a developer to generate casual and chance events that can possibly save time in development. In simple terms, predetermined camera positions can be helpful for scripted AI models or algorithms.

“AI is incredibly if you have a massive open world game, a lot of those games, not even the developers know all the things that are going to happen. I mean, do you imagine how many things happen in “Fallout four” or “Fire watch”. Those games they're so large, and suddenly random events happen, so you as a developer can't account for every one of them. So, having an AI that can sit there and go.”

(Respondent 21)

“A game AI which is a scripted thing, which determines what actions you're playing or you're doing with what other things are in the scene and randomly chooses from a set of predetermined camera positions.”
(Respondent 20)

4.5 Summary of responses

This chapter has discussed a wide variety of themes and sub-themes that reflect the different characteristics that are connected with aesthetics within interactive digital media and games-based images. These thematic differentiators can be summarised in the following manner.

Some aesthetic features are where the aesthetic features are influential because of an artistic quality. These qualities can be enhanced or emphasised through several feature characteristics (whether they are individually used or whether they are applied in combination with others). Respondents identified that subtle artistic characteristics such as changes to lighting in some parts of an image, or areas where the lighting is stronger or more accentuated are both features which change the meaning of each image or passage of interactive digital media. The use of non-symmetrical camera angles and the use of blurring (for example using depth of field) allow an aesthetic feature to thrive using blurred or indistinct object characterisation. Such elements exaggerate the value of the aesthetic feature. Similarly, the use of a blurred foreground or background is capable of amplifying the aesthetic features.

Other aesthetic features can be derived from how an image or piece of interactive digital media may convey information that has value in the form of knowledge. Here the fine details and specific objects that can be seen and understood in an image can be regarded as knowledge and information. In some cases, the knowledge holds interest in the form of an aesthetic feature. In gameplay versions, small and additional pieces of information may contribute to the knowledge that helps to solve a puzzle. Cutscenes are a useful feature that generates additional information. The additional intrigue, driven by curiosity and the desire to win a game, all contribute to the aesthetic qualities of the image.

Aesthetic features can be characterised in terms of an experience. These features are often described by the odd feelings that are best described as mystery, foreboding, or creepiness. Such characteristics can generate emotions such as sadness, excitement, disappointment, engagement, frustration, claustrophobia, or disillusionment.

Aesthetic features that draw users to become more engaged can be characterised in terms of gameplay and viewpoints. Photographic guidelines such as the photographic “*Rule of Thirds*

(RoT)" assist to focus on a specific part of an image, and this can assist in the greater level of engagement by the player. The *Rules of Photography* can be used to augment a part of an image or a part of a digital passage of imagery. The (RoT) is regarded as a useful feature that makes a player become more quickly immersed in a game or drawn to an image. Similarly, camera viewpoints such as the "top-down" view can engage a player to look for an advantage through the desire to be more engaged (or perhaps be motivated to win) a game.

Gameplay is described here as both a drawcard and also an aesthetic feature because it centres on the option within a set of digital media imagery. Choices such as speed, agility, and heighten vision are examples that provide an aesthetic benefit that further serves to engage a player or a viewer to an image or set of images. These are complex aesthetic features that allow a user or a viewer to consider possible and emerging options that provide the opportunity to exercise tactics and strategies.

Provocation and Evocation are two sides of the same coin. They describe the aesthetic features that deliberately stimulate a reaction from a player or a viewer. Provocation describes a stimulus which can be negative (such as anger or revenge) where evocation describes stimuli that connect with pleasantness, satisfaction, pride and contentment. These features are complex aesthetic features because they generate values that are off-centre, quirky, unusual, and different. These are often subtle features but can also be highly obvious and conspicuous as a piece of digital media.

Aesthetics can be useful where they serve the function of realism. In these instances, the aesthetic qualities are described in terms of the effect upon the authenticity of the particular piece of interactive digital media. They can often relate to specific guidelines as used in interactive digital training, but they can also serve to provide specific emphasis on an object, tool, or device that is critical for the digital training. Again, these aesthetic features are complex and often overlap with the *Rules of Composition*. They serve to increase the likelihood of accuracy, factual truth, and validity and truth.

Other aesthetics features describe pleasure and enjoyment. These features are the structures that are popular because they provide a heightened and more specifically engaged experience. Such features can over-rule other rules because they capture the imagination of the plater. For example, the game Stardew Valley has poor graphics but draws together large numbers of people because it is simply fun to play.

One separate aesthetic feature is described as the state of flow. It is often described as the seamless way in which smooth camera movements and scene transitions are collectively organised to ensure that the story, game, or digital expression can be continued. This is particularly applicable to fast-paced games but applies to all forms of digital media and interactive digital media.

Context is used to influence digital imagery on the aesthetic level. It sometimes includes other rules, such as the use of occlusion to show a scene where someone has a partial or unusual view. Other features include shadows, sound effects, storytelling. This includes the use of the rules of composition to affect the rules of composition. It applies across both gameplay and cinematic elements and can be strongly connected with both cinematic and gameplay styles of gaming.

Player Centricity is critical for the growth and sustainability of the user experience. Without plater centricity, many games have unforeseen consequences about the way in which a user or gamer enjoys the digital vision. They can also have influence on interactive digital media which is cinematic. They include complex combinations of other aesthetic features.

The rules of Composition are similarly complex because they can be used in combination. Such features can work independently but are most commonly dependent upon other features used at the same time. This means that sometimes the emphasis is upon narrative ahead of gameplay, although sometimes it is more gameplay than narrative. These rules are particularly important in scenes where the background and foreground can comprise of a number of objects and not just one. There is a visual hierarchy, but it can apply to both cinematic and gameplay arrangements.

Aesthetic features are not static. Instead, they are dynamic and can drive the acceptance of a particular passage of interactive digital media. In combination, they show the value of existing rules on the provision of the user experience, and assist in making the gameplay different and exciting, irrespective of whether the person is playing for the first time or is a returning player. These features relate to the sustainability factors of the game.

Standards for Aesthetics are not uniformly recognised in the same way as the Rules of Cinematography and the Rules of Photography. The responses from research in this thesis show that the majority of people are unconvinced that there is a hard and fast set of rules that cover aesthetics. Instead, many responses point to the need for a collective set of features that have a range of characteristics that can be weighted differently accordingly to different type of interactive digital media, with different expectations in terms of the usage and time expectancy of that interactive digital media. This applies to the critical positioning of cameras, and the generation of camera views and viewpoints. In this sense the use of aesthetics are such dynamically driven features that they need to be used as a starting point but should be flexible enough to survive in terms of repeated usage and ongoing development.

The use of AI in game design is best used where the AI can procedurally generate content and algorithms that emulate the behaviour of key actors and central elements of a game or piece of interactive digital media. They are typically the aesthetic tool of choice for the developer, but perhaps not as important to the game player. AI is held with diffidence by many players because they hold the concern that it may generate specific high-quality viewpoints and camera placement decisions but will also generate predictability around a game.

Conclusion

These collective characteristics and features form a broad range of elements that can be used separately or collectively for a variety of uses. They allow for the generation of different and aesthetically derived choices about camera placement and camera positioning. They do not specifically point to any one optimum camera placement, but instead they give guidance and directional assistance to the range of camera position choices that will create the structure and interaction for the best possible game outcomes.

Chapter 5

A Genetic Algorithm for finding a Range of Optimum Views

This chapter provides an overview of the developed quantitative method used for finding an optimum viewpoint in a 3D Virtual Environment (VE). The chapter consists of the details of the constraints developed and details of a Genetic Algorithm (GA) designed for finding the range of optimum views for three different designs of VE. The technical review of Genetic algorithms (GA) has already been given in Chapter 2 of this thesis.

5.1 Introduction

The algorithm developed for this study to find the range of optimised views for placing a camera in a 3D VE had been formed by means of a specific adherence to the fundamental *Rules of Cinematography* (Roy, 1998). A Genetic Algorithm (GA) has been proposed in this study as a technique for devising the optimisation of camera parameters in the form of position and orientation. The fitness function developed for this GA uses the basic *Rules of Cinematography* for finding the range of optimised views. The details of the rules applied and developed for finding the range of optimised viewpoints is explained below.

The developed quantitative approach in this study is composed of two parts. Firstly, this study describes the development of measurable constraints for virtual camera parameters using a rules-based approach. The camera parameters optimised are position, orientation and field of view (FoV). Secondly, this study describes the development of an optimisation technique such as a GA. In this thesis we have considered five measurable constraints based on virtual cinematography which have been adopted from the work of Litteneker & Terzopoulos (2017). These constraints are given in Table 5.1. and a detailed description of the parameters is given in Section 5.3.

Table 5. 1 Brief description of measurable constraints based on virtual cinematography

	Constraints	Description
1.	Frame Bounds	Target object should be within camera frame
2.	Occlusion	The line of sight between camera and target object should be clear
3.	Shot size	Target object should be included on the screen
4.	The Rule of Thirds (RoT)	Composition rule for a camera screen. Target object should be at thirds line horizontally and vertically
5.	Combined Frame Parameters	All above four parameters are combined as one parameter.

These constraints are designed for a single target point in a VE for a single target object. A Genetic Algorithm (GA) has been developed as an optimisation technique (Goldberg & Holland, 1988) and allows for finding the range of optimised camera placement within 3D VE (PRIMA et al., 2016; Ranon & Urli, 2014). To test this, a VE with a single target object and a single virtual camera has been developed using UE 2020.2.2f. in Visual Studio 2019. This has been developed using C# as an API scripting language for the implementation and optimisation of the camera parameters. Three different Virtual Environments (VEs) with three different characters are implemented and tested for these VEs.

5.2 Optimization Using Genetic Algorithm (GA)

Determining the optimum parameters for manually positioning a camera is a complex task when there is a need to satisfy both technical and cinematography principles of game designs (Nathan, 2020). Such complexity is further accentuated in a 3D VE (Burelli & Yannakakis, 2015; Sharpe, 2019; Ronfard, 2021). Some optimisation based approaches have been developed for finding an optimum solution for a 3D VE camera parameter such as Litteneker & Terzopoulos (2017), Prima et al. (2016), and Ranon & Urli (2014), and in these approaches they have started by considering a single optimum solution. Whilst technical aspects are often integrated into the established principles of cinematography, they relate to elements such as camera angles lighting, staging (Ronfard, 2021).

In this study, a Genetic Algorithm (GA) based optimisation has been developed to evaluate the quantified camera properties given in Litteneker & Terzopoulos (2017) based on principles of cinematography. It does this in order to focus on aesthetic elements in preference to a focus on technical aspects. Using the automatic control of a camera in a 3D game VE, the user is freed from the restrictive practice of adjusting low-level camera parameters. GAs are useful in finding a single optimum and robust solution where there is a wide range of possible solutions (Forrest, 1996; Alam et al., 2020). Specifically, GAs are suitable for complex non-linear models (Lam et al., 2019) such as the optimisation of camera parameters. GAs are population based algorithms developed on Darwin's theory of evolution (Goldberg & Holland, 1988; Holland, 1992).

Optimum high quality solutions can create a Genetic Algorithm (GA) using a process of selection, crossover and mutation (Mirjalili, 2019). This study offers an evaluation of the cinematographic principles such as frame bounds, occlusion, shotsize, and the RoT (Litteneker & Terzopoulos, 2017) for VE camera parameters using GA (see Table 5.1). The algorithm implemented for this study can be used to assist in automatic optimisation of camera parameters, such as, position, and orientation using a Genetic algorithm (GA). The fitness function of such algorithms could be based on the measurable constraints stated in Table 2.1.

5.3 Details of Measurable Constraints

Measurable constraints are needed because it is important to define the fitness function for any attempt to optimise camera parameters, such as, position and orientation, for a Virtual Environment (VE). These measurable constraints can include frame bounds, occlusion, shot size, and the Rule of Thirds (RoT). Whilst there are a number of other constraints that are of importance in terms of constraints, the choice to measure against these 4 fundamental constraints is based on the understanding that these constraints are the most critical in terms of the frame of rules that can influence the possible optimum position of a camera position.

5.3.1 Frame Bounds

Frame bounds, as given in Figure 5.1, demonstrate part (a) with too much head room, and part (b) with no head room. They are illustrated using Figure 5.2, and are important to the task of optimising virtual camera parameters because this parameter provides a guideline as to where to place the head of a character in a frame (Litteneker & Terzopoulos, 2017; Roy, 1998; Ranon & Urli, 2014). The rule for frame bounds states that for any point on the target object that the user wants to see on the screen, it must appear within the boundaries of the frame. In live action photography this property is also known as "headroom" (Roy, 1998).

This parameter also defines the amount of space between the top edge of the frame and the character's head, which plays an important role in defining the screen composition and preventing screen wastes. For example, all third person-camera games rely heavily upon Frame Bounds. One such example is Resident Evil (Sepúlveda, 2019; Capcom & Poland, 1996) because it uses a tracking camera that follows a character.

In cases where there is insufficient "headroom" the result is that users will feel that a character is sliding through the frame. In cases where this is repeated it will result in a character appearing tiny and inappropriate.

(a)

(b)

Figure 5. 1 Shots in Unity Engine (UE) Game view with (a) too much headroom (b) no headroom

The objective function for frame bounds is given in Equation 5.1 and Equation 5.2.

$$f(p) = \sum_{x \in \prod(p)} g(x) \text{........................ Equation 5. 1}$$

Where;

$$g(x) = \begin{cases} (x - x_{low})^2 & x < x_{low} \\ 0 & x_{low} \geq x \leq x_{high} \\ (x - x_{high})^2 & x > x_{high} \end{cases} \text{... Equation 5. 2}$$

In Equation 5.1, "p" represents the point on the target object, which the user wants to see in the frame as shown in Figure 5.3, where "x" represents the coordinates of the camera (x, y and z) for calculating object visibility inside the frame. In Equation 5.1, "Π" indicates the conversion of world coordinates to screen coordinates to check the visibility of a target point on the screen.

Figure 5. 2 Location of a point P on a target object in a scene view in Unity

In Equation 5.2, “x_{low}” represents the minimum and “x_{high}” represents the maximum values of the frame bounds. According to Equation 5.2 if the target object point “p” is $0 < (|x_{low}|, x_{high}) < 1$, then the point “$p$” is within the frame bound. It will produce headroom with the value of $g(x)$ be 0, otherwise $g(x)$ will be a distance measurement between the camera point and the target object point. If the target object is not within the frame bounds, then value of $g(x)$ will be a distance measurement between the target point and a VE camera.

5.3.2 Occlusion

According to the *Occlusion Rule* the line of sight between the target object and the camera should not be obstructed as shown in Figure 5.3. Occlusion is important for optimising VEs because the visibility of a target object is important for rendering 3D Scenes (Litteneker & Terzopoulos, 2017; Burg et al., 2020). For example, third person video games rely heavily upon on ray casting to prevent a character from occlusion by other objects in a scene. The equation for occlusion as given in Equation 5.3 has been used for the estimation of occlusion in a 3D environment.

$$(c, p) = \begin{cases} 1 \; if \; the \; path \; from \; c \; to \; p \; is \; occluded \\ 0 \; if \; path \; from \; c \; to \; p \; is \; unoccluded \end{cases} \quad \text{…………….. Equation 5. 3}$$

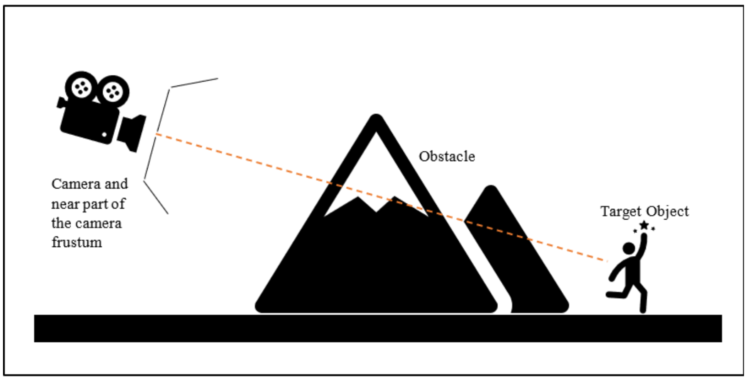


Figure 5. 3 Illustration of an Example of occlusion

According to Equation 5.3 if the path from "c" to "p" is not occluded then the objective function will have a value of 0 otherwise it will have a value of 1. Here “c” represents the camera point in world coordinates and “p” represents the point on the target object in world coordinates. A ray is cast from the camera “c” (origin) to the target object “p” (end), if the object hits the target point, then the line of sight is not occluded. Otherwise, if the ray hits any other object in a VE then the target object is occluded. A tag has been assigned to target the object for occlusion check.

5.3.3 Shotsize

To tell a story, such as in a 3D game or a film, different values of narratives are communicated through different shot sizes. For example, a Medium Shot (MS) usually shows how the immediate environment is depicted by the user. In contrast a Closeup Shot (CS) provides a very intimate view of an object or a character, whilst not providing much detail about the surrounding environment. A Long Shot (LS) size provides more information about the environment around a character. This is also defined as the projection size in literature (Burelli & Yannakakis, 2015).

For example, games developers rely on shotsizes to narrate a story to a user. One such example is Horizon: Zero Dawn (Donaldson, 2016) in which different shot sizes have been used to illustrate the game story.

The Parameter Equation for shotsize is given in Equation 5.4. The Objective Function for shotsizes given in Litteneker & Terzopoulos (2017), are changed by removing an extra theta inside the Arccos function. For Arccos to work the value should between -1 and 1, if theta is subtracted inside Arccos then this value becomes greater than -1 and 1 which is invalid to be calculated by this function. Therefore, an updated equation for shotsize is as below.

$$(a, b, c, \theta) = \left(\theta - arcos\left(\frac{(a-c).(b-c)}{\|a-c\|\|b-c\|}\right)\right)^2 \text{ ... ...Equation 5. 4}$$

Where “a” and “b”, are points on an object as shown in Figure 5.4, “c” is a camera point, and angle “θ” is a vertical FoV of a camera and is constant. The default value for a camera’s FoV is 30 and this value can be decreased or increased if the shotsize is combined with other parameters. The point “a” will determine the upper edge of the object in the frame, such as the head of a character, and point “b” will determine the lower edge of the frame, such as the mid or bottom of a character, as shown in Figure 5.4. If point “a” is at the top and point “b” at the bottom then this will result in a full shot size. However, if point “a” is at the top and point “b” at the mid of the target object then this will result in a medium shot size.

Figure 5. 4 Point a and Point b on the object for measuring Shotsize

5.3.4 The Rule of Thirds (RoT)

The RoT is important to optimising VEs because placing an object of interest at third lines is a true frame composition on a screen (Roy, 1998; Nathan, 2020; Meeder, 2020). For example, the game “Shadow of Colossus” relies heavily upon maintaining the RoT for the player (Suttner, 2016). This game combines two interesting features whereby the camera is controlled by the player, and the camera position, however, the game also aligns with the intersections based on the RoT approach that follows in accordance with this type of optimisation.

In the RoT, the camera frame is virtually divided into thirds both horizontally and vertically (Roy, 1998) as shown in Figure 5.5, so the frame consists of 9 parts. For an ideal image following the rule of thirds the target objects or characters are placed at the intersection of two lines. In the RoT, lines do not exist physically but are placed approximately on the camera frame. Figure 5.6 represents the marking of the rule of thirds on a camera frame. It depends upon the aspect ratio of the camera frames. Different frames with different aspect ratios will give a different marking of the RoT lines on a camera frame.

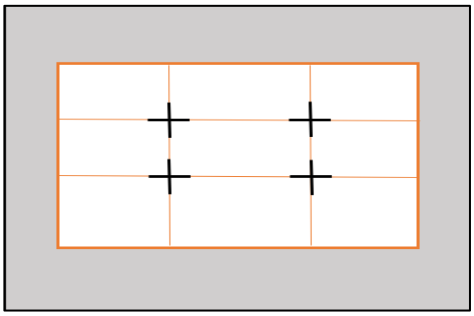


Figure 5. 5 A simple representation for the Rule of Thirds (RoT)

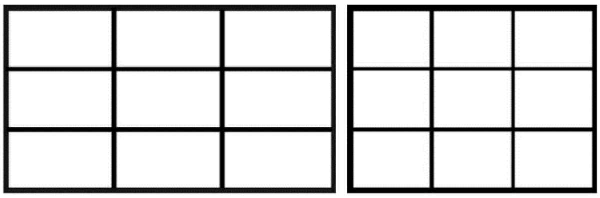


Figure 5. 6 The Rule of Thirds (RoT) Marking for 16:9 and 4:3 frame (Roy, 1998)

There are two equations given in Litteneker & Terzopoulos (2017) for defining the *Rule of Thirds (RoT)*. A non-flat function has been used for the implementation for this project as given in Equation 5.5. The graphical representation of a non-flat function is also given in Figure 5.7 for better illustration.

$$g(x) = \frac{x^4}{x_0^4} - \frac{2x^2}{x_0^2} + 1 \; \ldots \ldots \ldots \ldots \ldots \ldots \ldots \text{ Equation 5. 5}$$

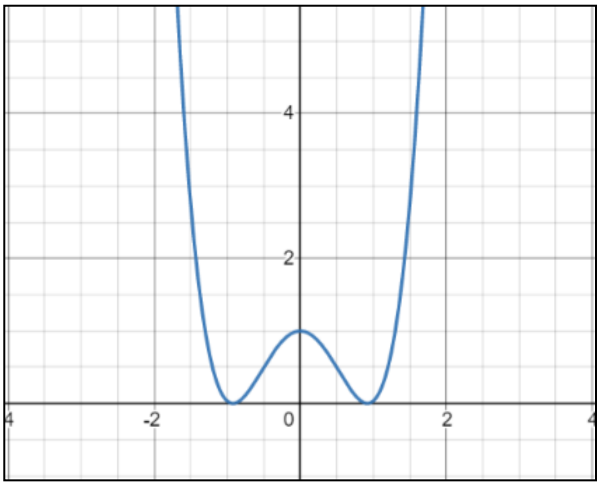


Figure 5. 7 2D plot for the Rule of Thirds (RoT) Given in (Litteneker & Terzopoulos, 2017)

Equation 5.5 represents a non-flat function when represented in a 2D graph. It gives two valleys, and one peak from -1 to 1 as given in Figure 5.7. Since, screen points in unity are between 0 and 1, we say that Equation 5.5 has been changed accordingly as given in Equation 5.6 and in keeping with the graphical representation that is given in Figure 5.8. The equation has been modified in such a way that we get peaks between 0 and 1. If the target object is following the rule of thirds, then $g(x)$ will be zero otherwise the value will be greater than zero.

$$g(x) = \frac{(2x-1)^4}{x_0^2} - \frac{2(2x-1)^2}{x_0^2} + 1 \; \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \text{ Equation 5. 6}$$

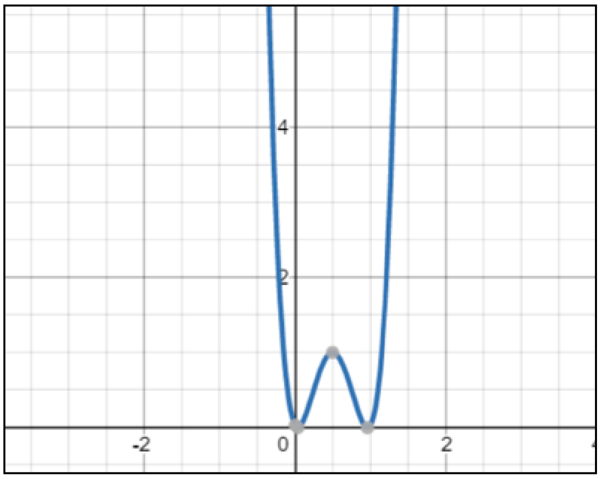


Figure 5. 8 2D plot for the Rule of Thirds (RoT) with new function

5.3.5 Combined Frame Parameters

In this fifth set of parameters the emphasis is on the combination of multiple parameters, rather than the reliance on a single type of parameter. This method has several benefits. The first benefit is that the camera view of the target object, a character in case of game, is clear in having cinematic features (Bourne et al., 2008). An additional benefit is that important objects in the scenes can be highlighted which can capture the user attention (Bares et al., 2000; Mascelli, 1965; Roy, 1998).

In the last set of experiments all objective (or fitness) functions are combined as one objective (or fitness) function and a GA has been used for optimization of the camera parameters. The user specified parameters have been evolved using a GA and the fitness function has been tested systematically with multiple sets of test cases. A Combined fitness function, consisting of the sum of all parameters, can be represented in the form of Equation 5.7 as given in Litteneker & Terzopoulos (2017). The combined fitness function consists of a fitness function for frame bounds, occlusion, shotsize and the *Rule of Thirds (RoT)*.

$$g(x) = \sum_{i=k}^{n} \propto_k f_k(x) \ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 5. 7}$$

Equation 5.7 represents the weighted sum of the related objective functions. In the above equation the value of $\propto$ can be adjusted to either minimize or maximize the influence of one objective function over the other. This is for avoiding unnecessary parameter conflicts. Similarly, the value of theta can be adjusted for the shotsize to avoid the conflict for frame bounds in the case of combined fitness.

5.3.6 Summary of Descriptors

The above descriptors are important in the understanding of GAs because they provide a common frame for the development of GAs. Encoding schemes are important for defining the genotypes of many computational problems, therefore different encoding schemes have been developed. The choice of encoding schemes depends upon the problem under consideration (See Chapter 2, Section 2.7). Genetic operators such as selection determines which array or string will participate in a reproduction process. The crossover determines the genetic recombination of two or more parent chromosomes. The mutation operator on the other hand maintains the population diversity between two generations. All three genetic operators, namely Selection, Crossover, and Mutation, are important in the convergence of a GA and have been repeatedly shown to be beneficial to an optimisation goal (Mirjalili, 2019; Senaratna, 2005; Hassanat et al., 2019).

5.4 The Optimization Method

This section explains the Optimisation Method used in this study. A Genetic Algorithm (GA) for the project has been implemented using Unity Engine (UE) 2020.2.2f, and Visual Studio 2019, with C# as an API scripting language. The purpose of this is to create a range of optimisation views and viewpoints for camera positioning in a 3D VE. A flow chart representing the steps used in Genetic Algorithm (GA) for optimisation process are given in Figure 5.10. The virtual camera parameters are manipulated for capturing an ideal shot in a VE using position parameters, orientation parameters and the Field of View (FoV) of a camera. These parameters are optimised based on the conventions and basic cinematography rules for an ideal shot given in details by Roy (1998) for motion pictures. These conventions can be similarly developed and evaluated for a 3D VE.

A Genetic Algorithm (GA) starts with the initialisation of a population using a random seed. Parameters and operators implemented for a GA have been given in Table 5.2 of this chapter. The input parameters, such as position and orientation, for individuals of a population are taken from the UE simulator. The parameter list obtained from the UE simulator is then used to find the fitness of all individuals in a current population for a current generation. Based on the fitness values, two parents are randomly selected using a tournament selection scheme. The two selected parents go through a process of crossover and mutation for generation of the new individuals of a population which are added to next generation. The process continues until the number of individuals for a current generation become the same as that of the next generation.

The process of selection, crossover, and mutation continues until termination conditions are met.

5.4.1 Genotype Representation

A summary of GA operators implemented for this project is given in Table 5.2. In this Genetic Algorithm (GA) the DNA length for each chromosome (individual of a population) is 5, which means each individual of a population consists of 5 genes as given in Figure 5.9. The first 3 genes represent for position (x, y, and z) and last two for cameras pitch and yaw.

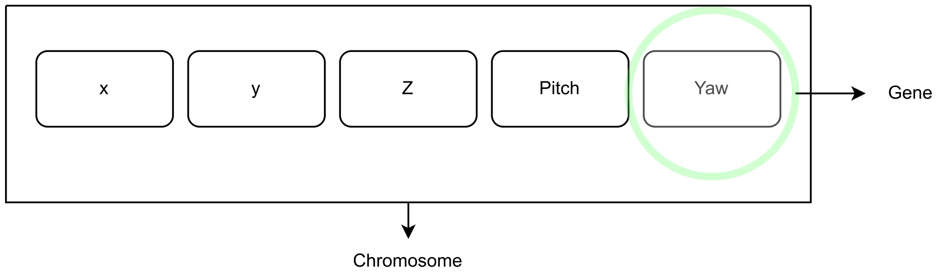


Figure 5. 9 DNA structure for an individual of a population consisting of first three translation parameters and last two rotation parameters of a camera in virtual environment (VE)

The first three genes consist of the translation parameter of a camera in UE. The last two genes consist of rotation parameters (pitch and yaw) for a camera in UE. The real number values have been used for representing each gene of an individual of a population. These five parameter values were optimized by directly evaluating camera in the scene of the UE game environment.

5.4.2 The Viewpoint Optimization

Each parameter explained in Section 5.3 has been used for the optimisation of the camera parameters to find a viewpoint satisfying the constraints in a Virtual Environment (VE). A summary of the GA parameters and operators used is given in Table 5.2. The real value floating point representation has been used for genotypic representation. The first three genes represent translation (x, y, and z) values, and the last two genes represent the rotation (pitch and yaw) of a camera in a game VE. The search space range has been defined for all the five values of a genome. For GAs and other optimisation algorithms the search space is defined so that the processing power can be saved by preventing them to search in a space which is not useful for a problem. A population size of 30 has been used because, after testing with different number of population sizes, it was concluded that a population size of 30 would be sufficient for finding optimum values in this problem. The fitness evaluation consists of four parameters, each tested separately for analysis and the last parameter using a combination where all four parameters were combined. The aspect ratio is kept constant at 1920×1080 for all screenshots captured.

Table 5. 2 Summary of GA operators implemented for the study

Parameters	**Parameters Used in Project**
Representation	Floating Point Representation has been used. 5 Genes in total for a single chromosome (Individual of a population) First 3 Genes defines position, x, y, and z, values of the chromosomes. Last 2 Genes defines rotation, x (pitch) and y (yaw), values of the chromosomes. Position (x, y, and z) value will be limited so that position of a camera remains within the limits of a terrain. Rotation (x, and y) value will be tested for different angles values from 0^0 to 360^0.
Population Size	30-100 (Recommended) 30 has been used in this project
Maximum Generations	300, 1000 0r 2000 1000, 10,000 and 15,000 has been used in this project
Population Model	Generational Model (Lam et al., 2019) Whole population will be replaced by new population.
Fitness Evaluation	An objective function has been defined based on predefined shot parameters in Five Objective functions 1. Frame bounds 2. Occlusion 3. Shotsize 4. The Rule of Thirds (RoT) 5. All parameters Combined
Operators	**Operators used in Project**
Selection	Tournament Selection
Crossover	Crossover rate will be between (0.5 to 1.0), One-point crossover has been used in this project. Crossover rate 0.5
Mutation	Uniform Mutation Mutation rate 0.1
Termination Condition	Fix number of Generations has been used in this project

The flow diagram of the evolutionary process is given in Figure 5.10. The process starts with the population initialization. The initial population is a set of possible solutions for a given problem. The fitness of each individual in a population is evaluated separately. Individuals are sent to a simulator and the parameters are returned by the simulator in response to the individual values that determine the fitness values of the individual. After the fitness evaluation, two individuals are selected as parents, one after the other, for reproduction. The crossover process is used for generating two offspring. Two offspring undergo a process of mutation, where each gene of two offspring is checked for mutation. Depending upon the mutation rate, genes are mutated, and two mutated offspring are created. The final mutated offspring are added as individuals for the next generation. A condition of the number of individuals in the current generation is that it should be equal to the number of individuals in the next generation. If this condition is not true, then the process of selection, crossover, and mutation continues. If the condition is true, then the current generation is replaced by a new generation. This process of creating generations continues until the termination condition is approached.

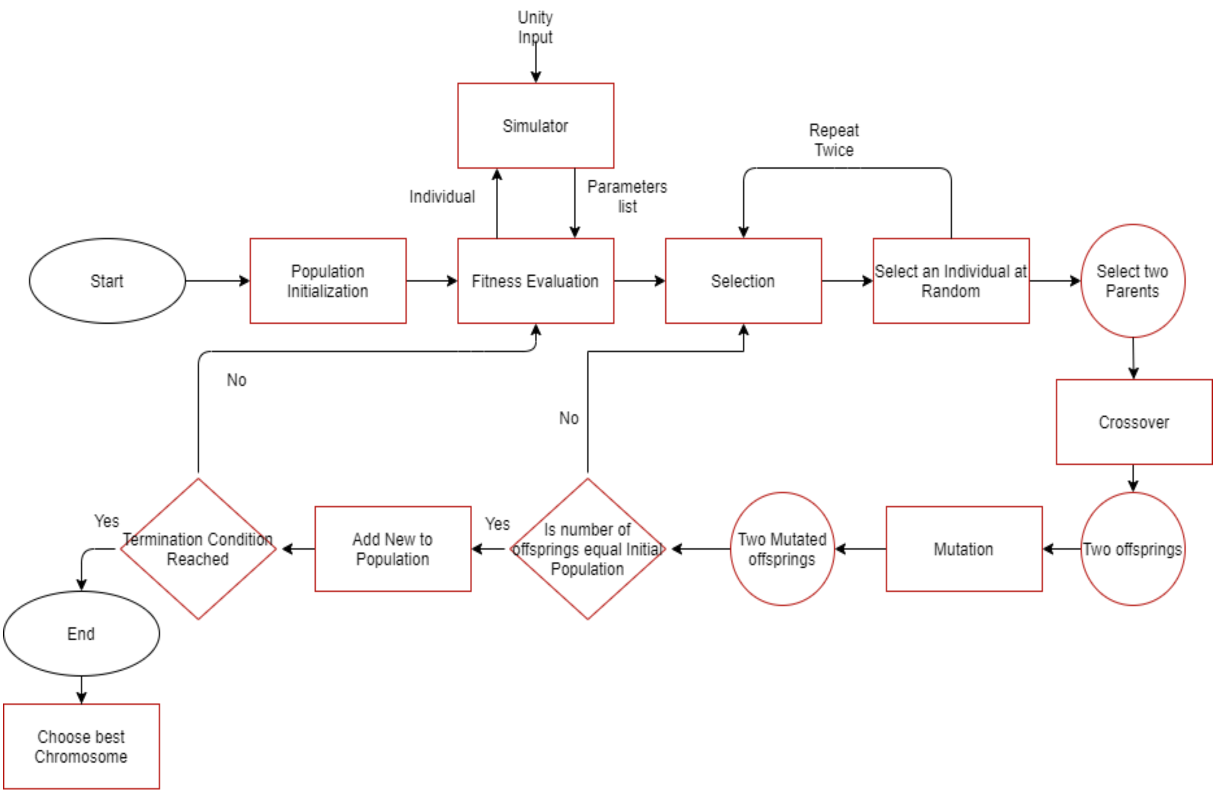


Figure 5. 10 Flow chart for a Genetic Algorithm (GA) implemented

Tournament selection has been used for selecting parents randomly for reproduction (See Chapter 2, Section 2.7). Tournament selection is a preferred method because it is not affected by bias of the fitness values of the individuals of the population and there is no requirement for scaling the fitness values (Goldberg & Holland, 1988; Rajasekaran, 2017; A. Shukla et al., 2015). Two parents are selected for crossover and mutation. One point crossover has been used for generating offspring. In one point, crossover of the gene position is selected randomly, and crossover takes place at a point between chromosomes. Uniform mutation is applied to determine which gene at a random position on the chromosome is mutated. Separate functions are created for mutating genes as the search space for each genes varies. The rate for crossover and mutation has been selected through experiments. A crossover rate of 0.5 and mutation rate of 0.1 has been selected for the problem implemented. The termination condition used for the GA is based on the number of generations. For this problem generations from 500 to 1000 have been used for analysis.

Three VE scenes were used for testing parameters as given in Figure 5.11, Figure 5.12 and Figure 5.13. The first step for the evaluation of parameters was to define the search space for GA. For this purpose two sets of experiments were conducted using two different search spaces. The search spaces have been defined in such a way as to limit the camera view within the area of terrain around the target object. An application of three different scenes was used for the testing of a problem. One scene used a simple terrain with few objects around the target object (Fig 5.11). The second scene was an indoor environment with an open space office environment with walls and corridors (Fig 5.12). The third scene, was a complex VE with mountains, trees, and rocks along with fog renderer (Fig 5.13). The use of three randomly selected environments was applied in order to test against the different scenarios where different parameters were in common usage.

In each of the different environments the individual of the initial population has been randomly generated using fixed seeds of 5, 20 and 100. These seeds have been selected randomly to verify the results obtained. The crossover probability (Pc) is 0.5 and the mutation probability (Pm) is 0.1. The experiment has been executed for 500 to 1000 generations for each seed and results are analysed using a box and whisker plot for initial and final individuals of the population. The analysis also uses Best vs. Average fitness plots for each parameter tested. Experiments were further divided based on shotsize. Two different experiments were conducted, one for a medium shot and other for a full shot. In the medium shot “point a” is at the top and “point b” at almost the middle of a character as explained under shotsize, whereas in the full shot “point a” is at the top and “point b” is at the bottom of a target object.

Figure 5. 11 Virtual Environment (VE) 1 showing scene with a target object in it for experiments conducted

Figure 5. 12 Virtual Environment (VE) 2 showing scene with a target object in it for experiments conducted

Figure 5. 13 Virtual Environment (VE) 3 showing scene with a target object in it for experiments conducted

All the above scenes given in Figures 5.11, 5.12 and 5.13 vary in terrain length, height and width. Different search spaces have been defined based for each scene based on width, height, and length of terrains. Different scenes have been tested, for fitness and with visual confirmation, to check the performance of the developed constraints in different contexts such as indoor and forest (simple or complex) environments.

5.5 Summary

This chapter provides the summary for optimisation methods implemented for finding the range of optimal solutions using measurable constraints. Details of measurable constraints has been stated in this chapter. Details of the implementation of the Genetic Algorithm (GA) has also been provided. Results for the optimisation method are discussed in Chapter 6 of this thesis.

Chapter 6
Findings for a Range of Optimum Views using a Genetic Algorithm

This chapter provides the details of findings, both the visual and the graphical results, obtained by the process of optimisation using Genetic Algorithm (GA). In Section 6.1, results obtained because of optimisation through GA are stated and discussed for each parameter from the computational perspectives. Section 6.2 consists of a discussion of the visual results in context with the findings of the qualitative analysis stated in Chapter 4.

6.1 Findings of Genetic Algorithm (GA)

Two types of findings, graph based and visual results, have been analysed for optimisation through a GA within this work. For this purpose, the use of box and whiskers plots for different VE scenes were tested. This enables a clear picture of the fitness values based on the initial and then final population differences. Such a comparison between fitness values of final population assists in overall analysis of the distribution. Box and whisker plots are given for each parameter separately and for combine parameters. Box and whisker plots were used to identify the distribution of population around the mean. The Best vs. Average fitness plots for each frame parameter show those camera positions that can be considered for optimum selection and help to understand those selections that are unsuitable. These fitness plots are essential for determining the behaviour of evolutionary algorithms like GA.

6.1.1 Findings for Frame Bounds

Box and whisker plots using frame bounds were determined for initial and final population fitness values. They depicted frame bounds for 500 generations through three different VEs given in Figure 6.1. The fitness values were normalized between 0 and 1. From the box and whisker plots it was observed that as the environments became more complex, the distribution of fitness values for the initial values varied greatly. By applying a Genetic Algorithm (GA) it resulted in a convergence with approximately the same distribution. Most of the individuals have fitness values of zero in the final population after 500 generations, excluding outliers. Outliers are the range of optimum values whose values vary significantly from the rest of the population during optimisation. These outlining values are prevented from moving on to the next generation through the process of selection.

Frame bounds were also tested by fixing different random seeds. Note that the frame bounds only check whether the coordinates of a target object lie within the coordinates of a camera frame, even if the target object is positioned behind some other object in a scene. Since we already know that frame bounds alone are insufficient for an optimisation algorithm, the use of frame bounds for optimised visibility demonstrates that in combination this is a useful consideration for improved camera position optimisation.

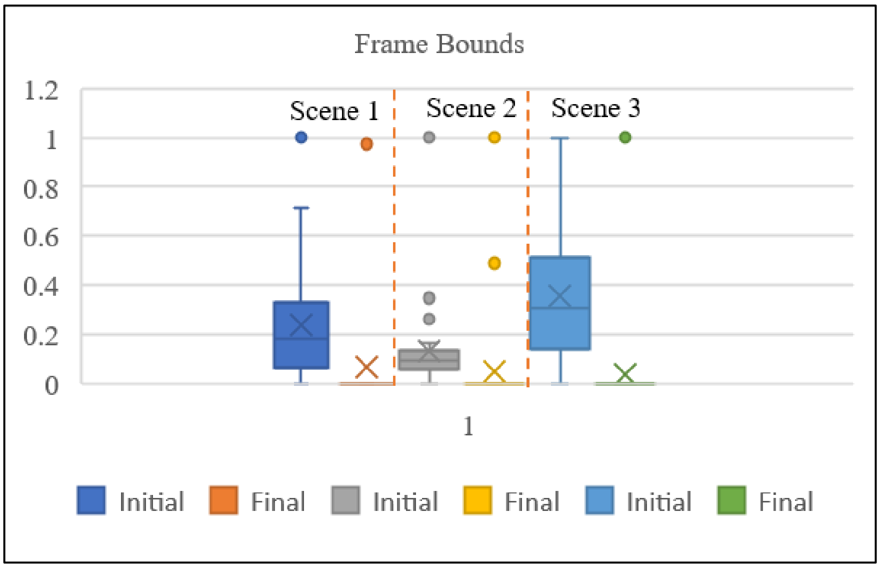


Figure 6. 1 Box and whisker plot for Frame Bounds for three tested VEs for initial and final populations

The Best vs. Average fitness plot frame bounds are shown for the three different VEs and are given in Figures 6.2, 6.3 and 6.4. In Figure 6.2, the evolution removes the individuals with the worst genes immediately through the process of selection. After 45 generations the best fitness values were reduced to zero. In Figures 6.3 and 6.4, although similar type of results was obtained as in Figure 6.2, the worst individuals with very high fitness values still appeared during the evolutionary process, if evolved further these fitness values would have been removed from the population. These worst individuals were not passed to the next generation as the process of evolution continued. In Figure 6.3 there is a peak value of 75.47826 at around 139 generations, which is due to an outlier in the 139th generation. This outlier is dropped in subsequent generations. Another outlier is in the 415th generation as can be seen in Figure 6.4. From the average and the best fitness plots, for all scenes, the best member among the population survived in subsequent generations and stayed the same over generations for frame bounds. Increasing the number of generations may have affected the average fitness, however the best fitness continued to be the same. The remaining results for different seeds tested for frame bounds are given in Appendix E of this thesis.

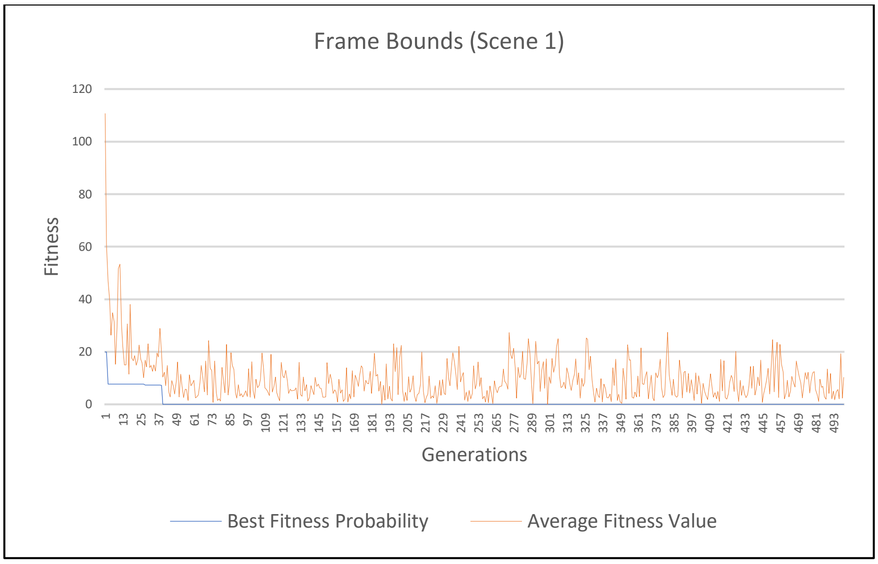


Figure 6. 2 Best vs. Average fitness plot for Frame bounds for 500 Generations for Scene 1

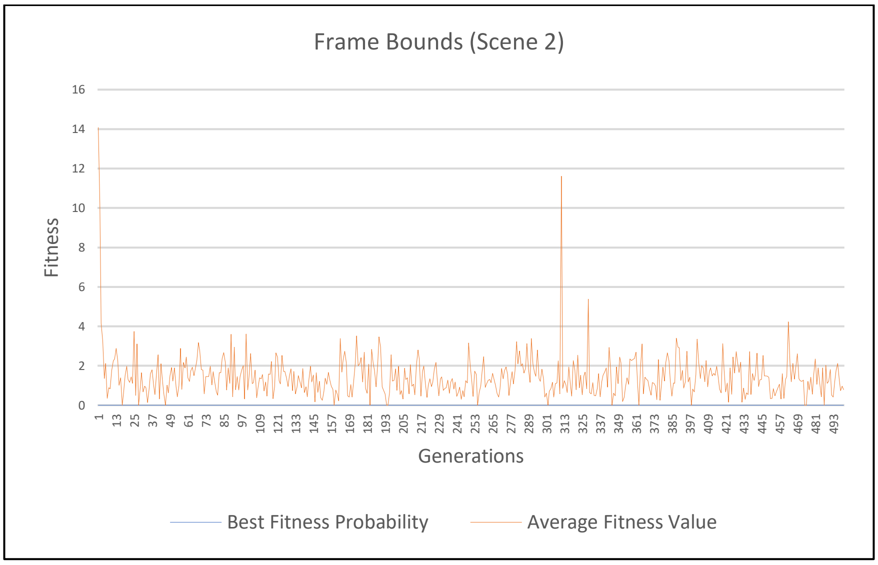


Figure 6. 3 Best vs. Average fitness plot for Frame bounds for 500 Generations for Scene 2

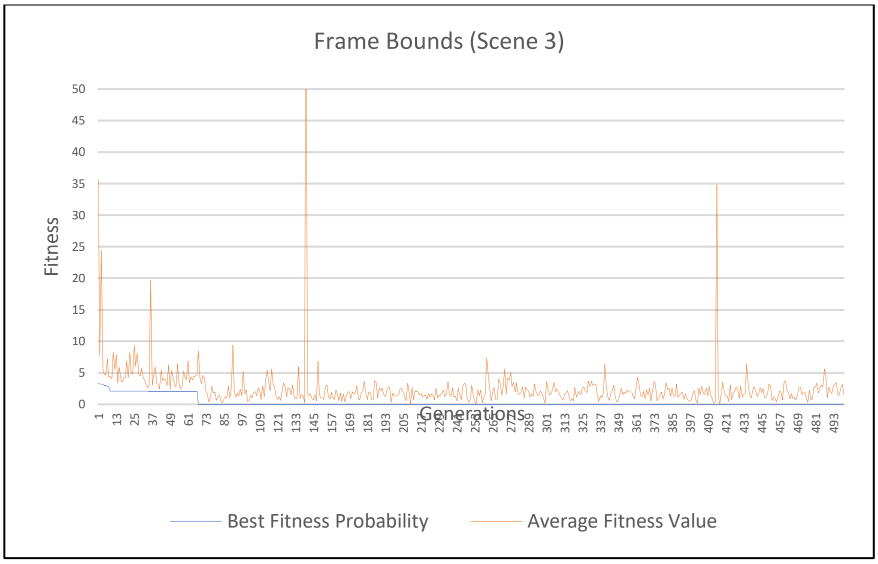


Figure 6. 4 Best vs. Average fitness plot for Frame bounds for 500 Generations for Scene 3

Visual results for frame bounds are given in Figures 6.5, 6.6, and 6.7. The best fittest individuals are presented after 1000 generations. Although the best fittest individual was obtained at the beginning of the evolutionary process it should be noted that still the process of evolution was carried out for 1000 generations to confirm the results. From the visual results it is apparent that even though we can determine that there is some occlusion between the target object and the camera, the frame bounds conditions are still satisfied. This means that frame bounds alone are insufficient for satisfying visibility parameters. Frame bounds do not measure the distance from the camera, they only check the screen coordinates for the target object. For example, in the visual results for Scene 2 and Scene 3 in Figures 6.6 and 6.7, the character's object is within frame bounds but is not visible on the camera screen. Target objects can still be occluded by obstacles such as trees or walls or rocks.

Figure 6. 5 Visual results for Scene 1 for Frame bounds

Figure 6. 6 Visual results for Scene 2 for Frame bounds

Figure 6. 7 Visual results for Scene 3 for Frame bounds

6.1.2 Findings for Frame Bounds + Occlusion

Based on the results above, it was concluded that the frame bounds parameter alone was not sufficient to display a target object on the screen. To further optimize the result the parameter of occlusion was added to the analysis of frame bounds. Occlusion detects any obstacles between the camera and the target object and then enhances the viewpoints accordingly.

Box and whisker plots for frame bounds + Occlusion for 500 generations is shown in Figure 6.8. The Frame bounds were tested for different random seeds. For comparison with different scenes the result of one seed was used. Note that the frame bounds only checked whether the *x* and *y* coordinates of a target object was within the coordinates of a camera frame, whereas occlusion looks for a clear line of sight between camera and target object. The two parameters are important for target visibility on the screen. Variation in an initial population of Scene 1, Scene 2 and Scene 3 can be seen in a figure below. There is more variation in initial population of a Scene 1 and Scene 3 as compared to Scene 2. In final Population all individuals converge to zero value, excluding outliers.

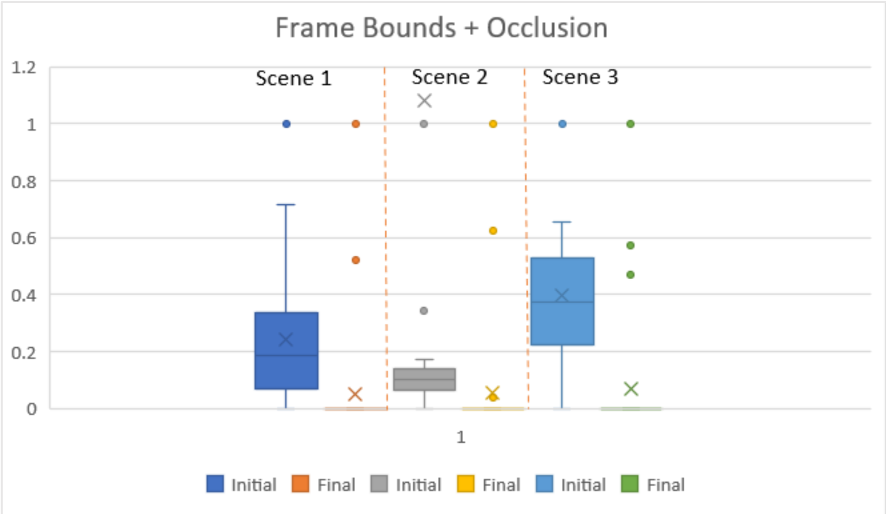


Figure 6. 8 Box and whisker plot for Frame Bounds + Occlusion for three tested VEs for initial and final populations

Best vs. Average fitness plots are given for Scene 1, Scene 2, and Scene 3 in Figure 6.9, 6.10, and 6.11. In Figure 6.9, there were very large fitness values at the beginning of the evolution. As a number of generations were passed, the fitness values were reduced on average for a population. The best fitness value was also reduced to zero after 18 generations, which means, best fitted individual was found in 18th generation. The number of peaks for the average fitness values were also detected, which were due to individuals with very high fitness values. Such individuals were discarded in subsequent generations. Similar observations can be seen in Figure 6.10 for Scene 2. In Figure 6.11, for Scene 3, there were a greater number of peaks for average fitness plot as compared to Figure 6.9, and Figure 6.10. The results are given for only 500 generations for Scene 3, as further evolution took place the worst individuals with very high fitness values, in the previous generations, were discarded. The best fitness values were detected at the beginning of the evolution for Scene 2 and Scene 3, as given in Figure 6.10 and 6.11. Remaining of the results for different seeds tested for frame bounds + occlusion is given in Appendix E of this thesis.

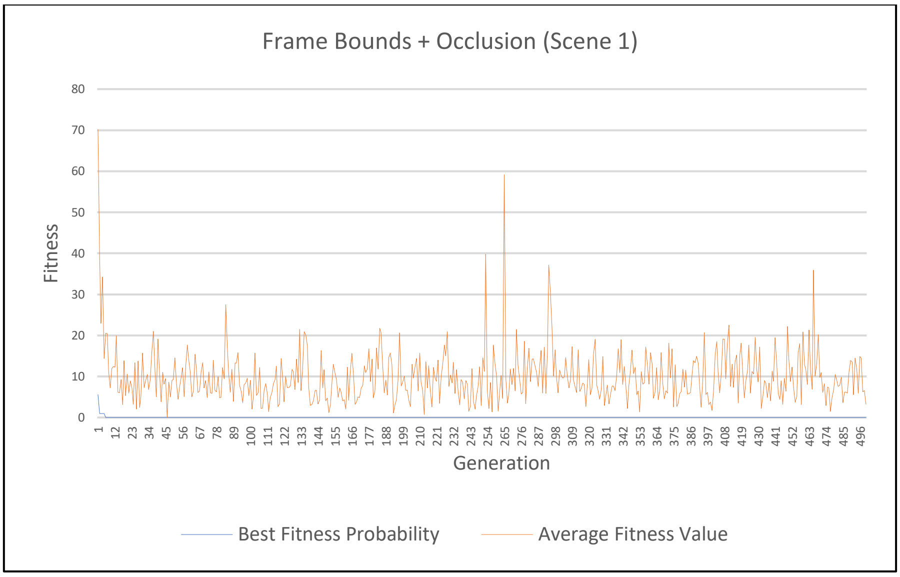


Figure 6. 9 Best vs. Average fitness plot for Frame bounds + Occlusion for 500 Generations for Scene 1

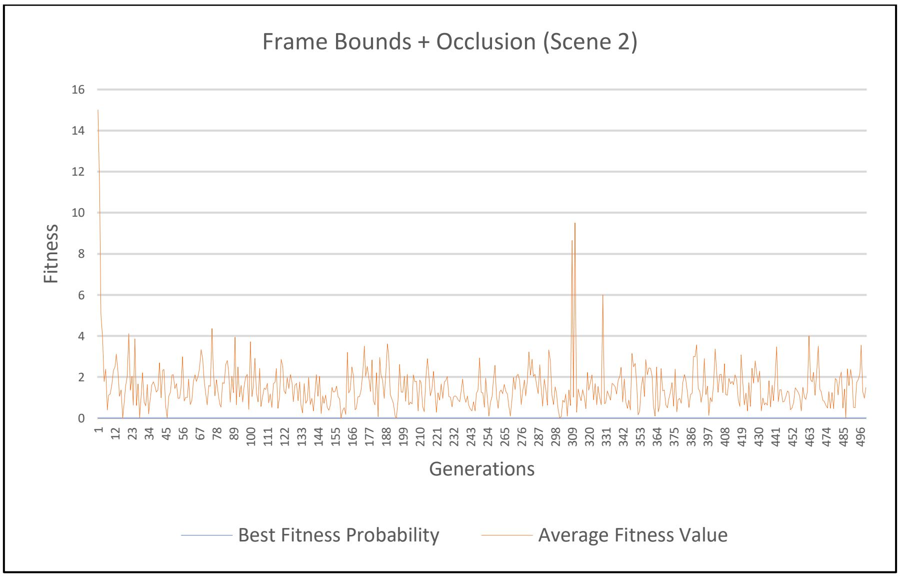


Figure 6. 10 Best vs. Average fitness plot for Frame bounds + Occlusion for 500 Generations

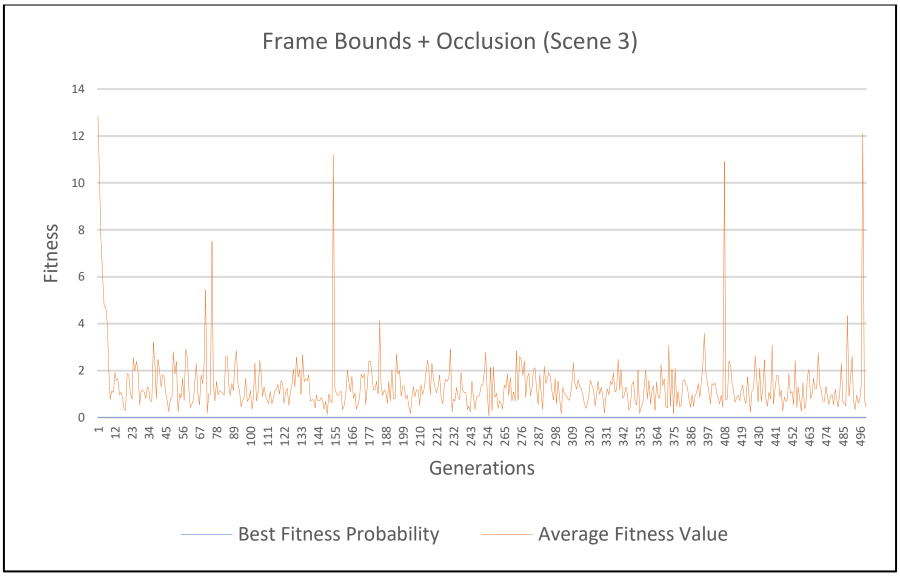


Figure 6. 11 Best vs. Average fitness plot for Frame bounds + Occlusion for 500 Generations for Scene 3

The visual results for the combination of Frame bounds and Occlusion are shown in Figures 6.12, 6.13, and 6.14. They show that in the first VE in Figure 6.12 we get the same result with or without occlusion, however in Figures 6.13 and 6.14 we now see a clearer visualization of the target object. We can conclude that there are some instances where an optimal position can be obtained with or without the parameter of occlusion, but that these are coincidental rather than expected results. Where possible, the use of the occlusion parameter should still be included in this type of combination of parameters.

Figure 6. 12 Visual results for Scene 1 for Frame Bounds + Occlusion

Figure 6. 13 Visual results for Scene 2 for Frame Bounds + Occlusion

Figure 6. 14 Visual results for Scene 3 for Frame Bounds + Occlusion

6.1.3 Findings for Shotsize

Measuring the shotsize shows how much of a target object should appear in the frame. For the analysis of the shotsize parameter two types of shotsizes were analysed, (the Full Shot (FS) and the Medium Shot (MS)). For FS measurement we use Point *a* at the top and Point *b* at the bottom of a character. For MS measurements Point *a* is at the top and Point *b* is at middle of a character. In this constraint the theta values have been changed to observe the effect on the shotsize. Theta is given in Chapter 5, Equation 5.4, and checks if the calculated angle between camera Point (Point c) and Point *a* and Point *b* on a target object equals the theta to get the optimum shotsize. For these different values of theta, they have been tested to see the effect of theta values on a camera's shotsize. The shotsize parameter only measures angles between the camera Point c and Point *a* and Point *b* on the target object. This parameter does not consider whether the target object is in frame or not. To make sure that the target object is visible within the frame, the shotsize parameter needs to be combined with visibility parameters such as the integration with frame bounds and occlusion measurements.

6.1.3.1 Result for Full Shot (FS)

Box and whisker plots are shown in Figure 6.15 for each scene for FS. The Objective function has been checked for different theta values such as 15, 30, 45 and 60. It was observed that if the value of theta in an objective function was kept equal to the FoV of the main camera, the optimum viewpoint visually was hard to obtain until the *x* rotation search space was increased from 0 to 360 (rather than 0 to 90).

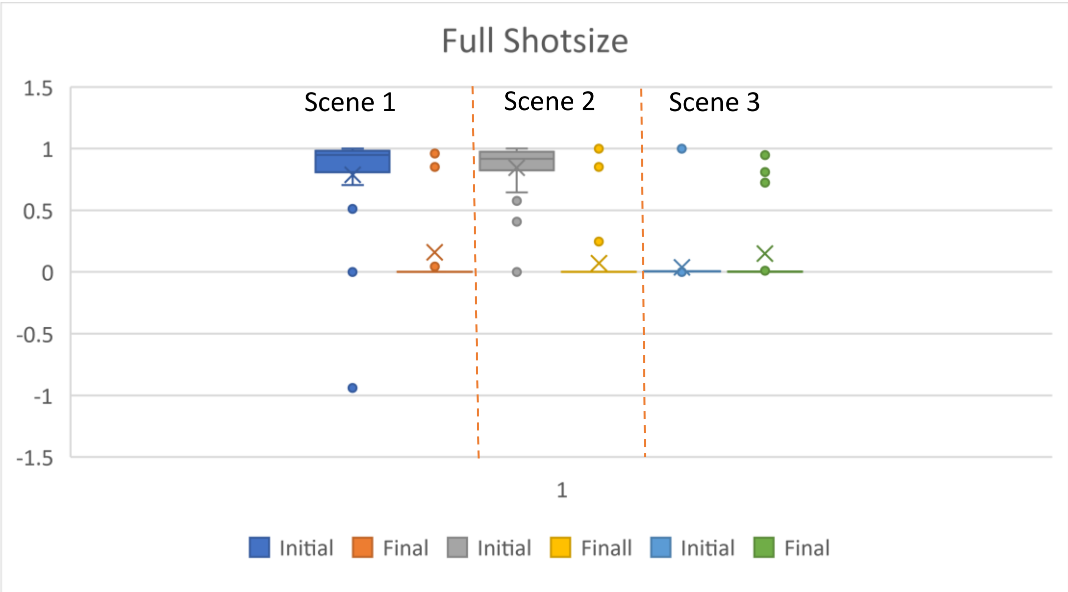


Figure 6. 15 Box and whisker plot for Full Shot (FS) for three tested VEs for initial and final populations

The search space of 0 to 90 for x rotation was initially used because we wanted to have an upright optimum value for a target object instead of an upside-down value. If 0 to 360 was selected for *x* rotation, then an upside-down image was also able to be selected as the best individual. If theta is equal to the main camera's FoV than the camera position was very close to the target object, making it impossible to capture an optimum camera viewpoint. Figure 6.17 shows a scene where the camera is so close to the target object that it effectively looks right through the target object and the shot does not visually show the target. The Theta value should be less than the FoV of the main camera to obtain an upright viewpoint of a target object for any Shotsize.

Figure 6. 16 Scene 1 (fitness 0.5390406, theta equal FoV, Gen 2000, x rotation 0 to 360) Best viewpoint have been used for the results

Figure 6. 17 Scene 2 (with theta half of cameras FoV, fitness 0.0000112562, Gen 2000, x rotation 0 to 90)

Figure 6. 18 Scene 3 (with theta equals to cameras FoV, fitness 0.5622796, Gen 2000, x rotation 0 to 90)

6.1.3.2 Result for Medium Shot (MS)

For a MS, Point *a* was at the top and Point *b* was at middle of a character. In a Medium shot we want the top half of a character to occupy the screen or camera frame. Analogous results to those obtained for the FS results were also obtained for MS results. If a camera's FoV is the same as that of the theta in the shotsize function, it becomes difficult to guarantee the inclusion of the target object in the frame as given in Figure 6.20. Even after applying the visibility parameters of frame bounds and occlusion it is hard to get an ideal shotsize of the target object. This may also result in the unnecessary parameter-based conflict between frame bounds and shotsize results. This occurs because using the shotsize measurements the constraint does not directly aim to include the target object within the frame, but instead considers the angles between the target vectors.

It is not always guaranteed that we only get an upside-down camera viewpoint of the target object. Upright viewpoints were also obtained for x rotations (For example: x rotation ranging from 0 to 360). This is the case even though there was still a chance of getting an upside-down viewpoint if the x rotation of a camera was not fixed to 0 to 90 degrees in Unity as given in Figure 6.19. These results show that the retention of a full range (360 degrees) of freedom does not necessarily result in an optimum camera position.

Figure 6. 19 Scene 1 (fitness 0.004648, theta equal FoV, Gen 2000, x rotation 0 to 360) Best viewpoint have been used for the results

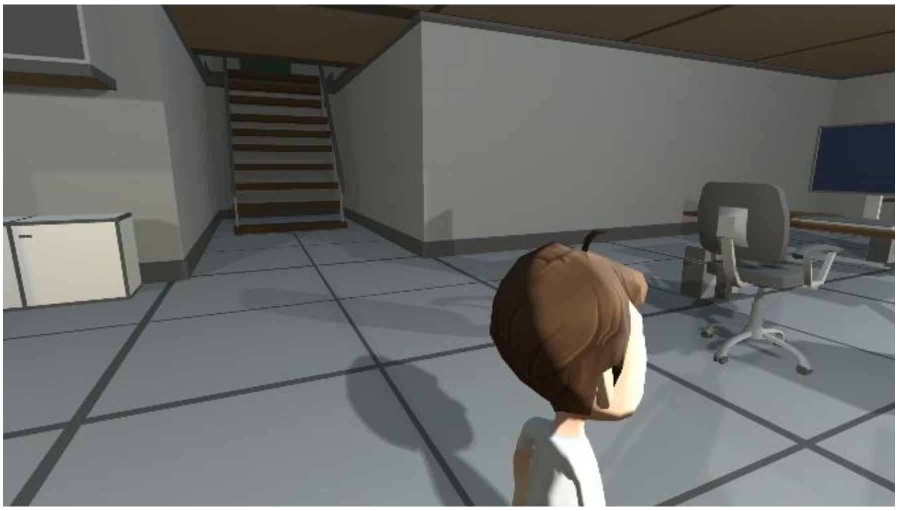


Figure 6. 20 Scene 3 (with theta equals to cameras FoV, fitness 0.5622796, Gen 2000, x rotation 0 to 90)

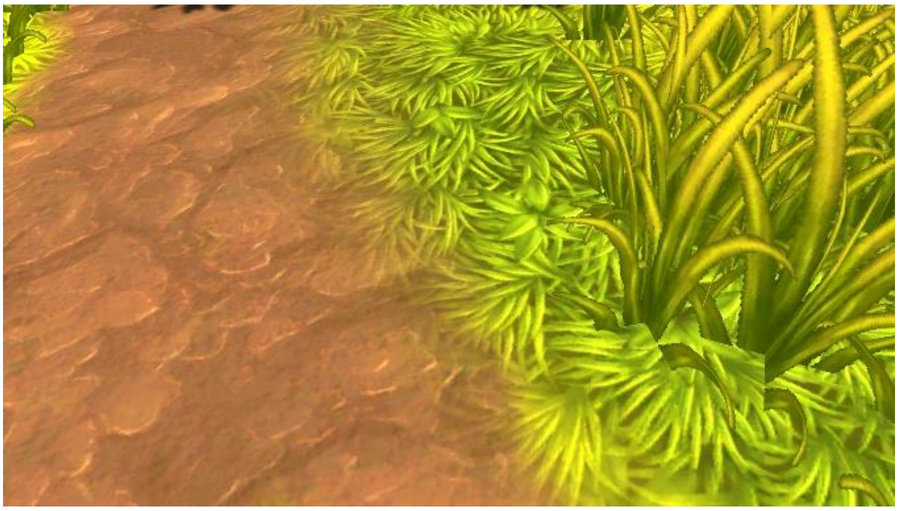


Figure 6. 21 Scene 3 (with theta equals to cameras FoV, fitness 0.5622796, Gen 2000, x rotation 0 to 90)

The graphical results for Best vs. Average fitness plots for different scenes are given below in Figures 6.22, 6.23, and 6.24. The Best vs. Average plots for the FS and MS follows an analogous pattern. On this basis only one set of Best vs. Average fitness plots for all scenes has been added and discussed here. From Figure 6.22, we can observe that very high Average fitness values and Best fitness values occurred in early generations. As the process of evolution continued, the average fitness values were reduced along with best fitness values. After the 250th generation the Best fitness is reduced to zero as this can be seen in Figure 6.22. The remaining results for all seeds tested for this parameter for three scenes are given in Appendix E of this thesis.

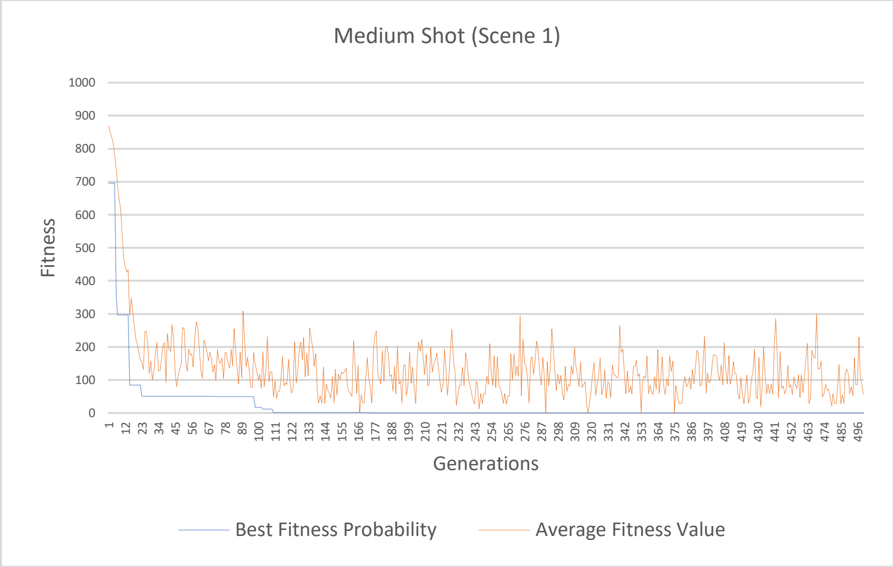


Figure 6. 22 Best vs. Average fitness plot for Scene 1 for Medium Shot (MS) for 1000 Generations

From Figure 6.23, the average fitness was reduced from a very high value of 814.1198 to a low value of 77.42135 after 500 generations. In contrast, the best fitness values were reduced from 525.9709 to 0.000003373749 after the same number of generations. When the evolution is continued further, the results obtained show that the minimum value obtained was not zero but slightly above zero. It is possible that further analogous results can be obtained if the gene values are discretised or quantized. A similar pattern shows for the plot in Figure 6.24 for Scene 3.

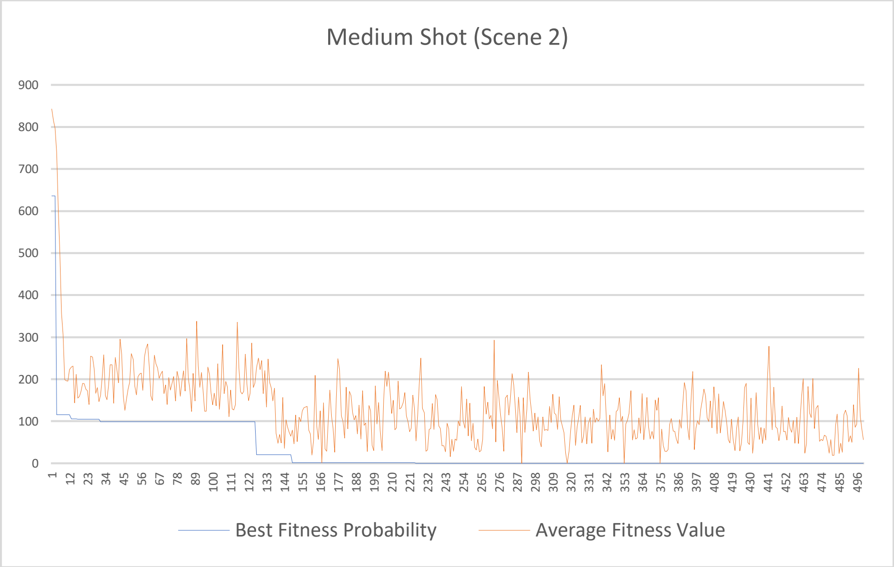


Figure 6. 23 Best vs. Average fitness plot for Scene 2 for Medium Shot (MS) for 1000 Generations

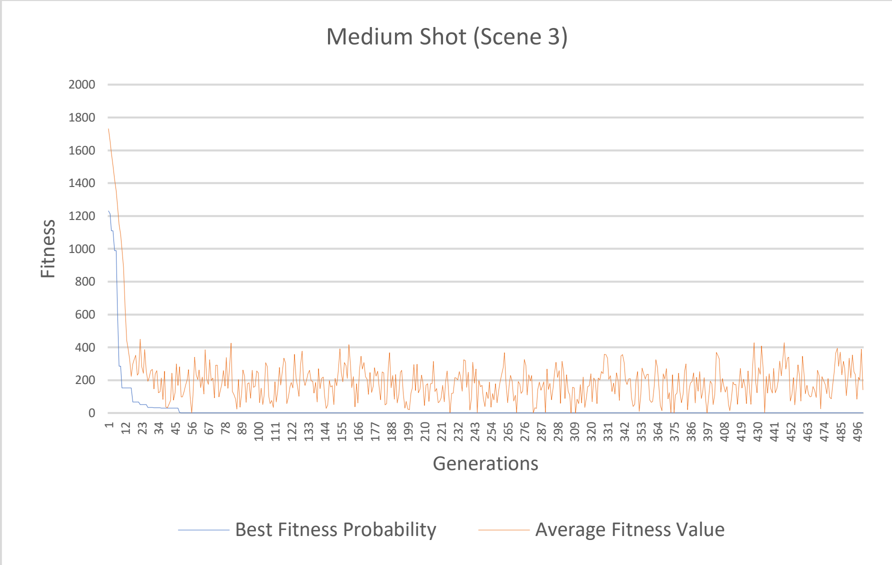


Figure 6. 24 Best vs. Average fitness plot for Scene 3 for Medium Shot (MS) for 1000 Generations

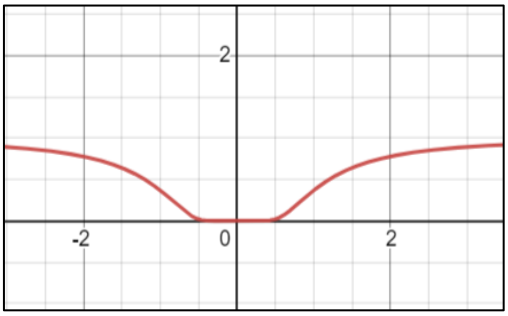
6.1.4 Findings for the Rule of Thirds (RoT)

When measuring with the *Rule of Thirds (RoT)* we examine Point *p* on the top of the character. For these results we analysed these results to determine whether point *p* lies at the intersection of thirds lines (2 vertical and 2 horizontal).

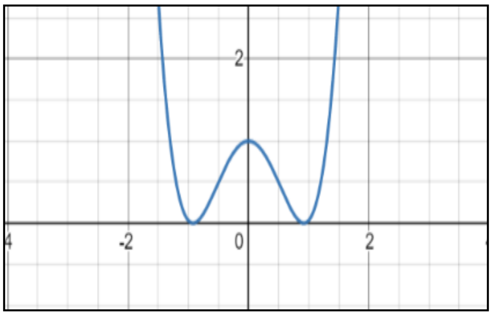
From the box and whisker plots given in Figure 6.26, the variation of the fitness values between initial and final populations of the three tested scenes are given. The plot shows that there was more variation in the fitness values of Scene 1 as compared to the fitness values of Scene 2 and Scene 3.

In addition, the fitness values detected for the initial population were very large as compared to the fitness values after 500 generations. These results showed that large fitness values shrank the initial fitness plot for Scene 3 during the normalization of data. The largest value for the initial population for Scene 3 was 8.5×10^{22}. We attribute this result to the use of a non-flat function in the analysis.

The function for the *Rule of Thirds (RoT)* is called a non-flat function because it is differentiable at x=0 and around its neighbour, whereas a flat function is not differentiable at x=0, given in Figure 6.25.



(a)



(b)

Figure 6. 25 Illustrates (a) A flat Function (b) A non-flat Function

The shape of a flat function is flat at 0, whereas for a non-flat function the shape in changing at 0 (rising or falling). Therefore, the differential of a non-flat function exists at zero as compared to a flat function.

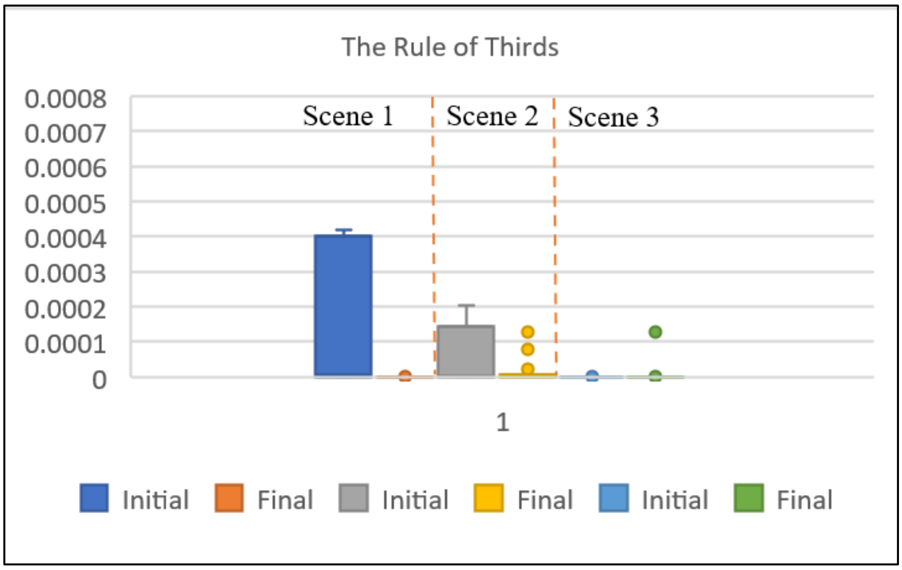


Figure 6. 26 Box and Whisker plot for the Rule of Thirds for 500 Generations

The Best vs. Average fitness plots for the RoT for Scenes 1, 2 and 3 are given in Figures 6.27, 6.28 and 6.29. Logarithmic scale for the fitness axes has been used to present the results. This is because their average fitness values were very large as compared to the best fitness values, and the best fitness values were not clear on the plot. From the average vs. best fitness plot, we can see that the best fitness values reduce to approximate zero values, rather than to exact zero values. The Average fitness values also reduce in the subsequent generations as the process of evolution continues. Average fitness values vary with the process of evolution, but best fitness (once obtained) continues to be the same throughout the evolution process. The Best fitness achieved for Scene 1 was in the 350th generation, which was 0.001855731, which continues to be the same in the evolution process. For Scenes 2 and 3, the best fitness values were achieved earlier as compared to best fitness values of Scene 1.

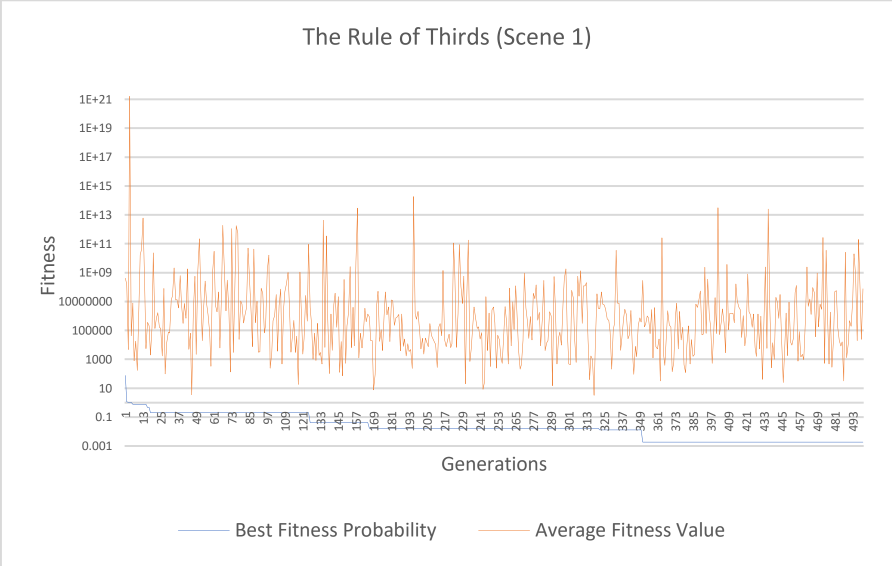


Figure 6. 27 Best vs. Average fitness plots Scene 1 for the Rule of Thirds (RoT)

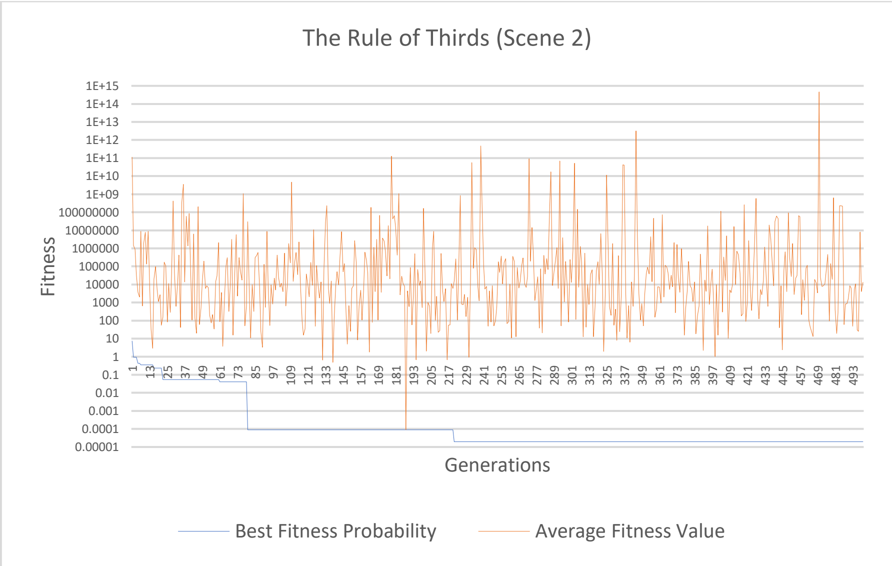


Figure 6. 28 Best vs. Average fitness plots Scene 2 for the Rule of Thirds (RoT)

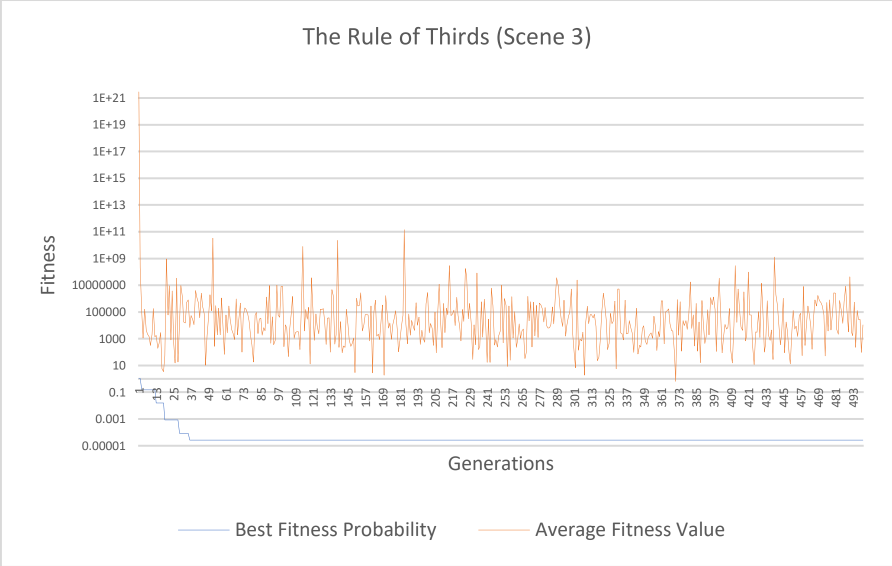


Figure 6. 29 Best vs. Average fitness plots Scene 3 for the Rule of Thirds (RoT)

Looking at the visual results of the *Rule of Thirds (RoT)*, there were two things that need to be considered. Firstly, if the RoT was applied, it was important to convert the world coordinates to screen coordinates, since the RoT is a composition rule for a viewpoint of a frame. Secondly, an occlusion check was important for the target object's visibility on the screen.

If the target object is not visible, then the composition rule cannot be applied. From Figure 6.30, the target object is at the intersection of lines at the right top intersection marked with the red circle. The target object is hidden behind the intersection lines as the size appears to be small.

In terms of clarity and distance this does not provide a very good viewpoint even though it follows the RoT. This is because better results will occur where there is a larger portion of the screen taken up by the target object, and in these results, we can see that the surrounding environment takes up the majority of the screen, with only a very small portion of the screen devoted to the target object.

The visual results for Scene 2 and Scene 3 are of greater interest. They are given in Figures 6.31 and 6.32, representing the effect of choosing a search space based on an optimization algorithm. The remaining results for different seeds tested are given in Appendix E of this thesis.

Figure 6. 30 Visual results for the Rule of Thirds (RoT) for Scene 1

Figure 6. 31 Visual results for the Rule of Thirds (RoT) for Scene 2

Figure 6. 32 Visual results for the Rule of Thirds (RoT) for Scene 3

6.1.5 Findings for All Parameters Combined

In a Combined Frame we draw measurement parameters from all of the previously discussed frame parameters. In this combination we blend *Frame Bounds, Occlusion, Shotsize*, and the *Rule of Thirds (RoT),* as one single objective function. The Optimized viewpoint, satisfying the above-mentioned constraints, has been obtained using a Combined Frame parameter. It was observed from testing the individual parameters that the target objects visibility (*Frame Bounds + Occlusion*) is an important parameter. This is because we want to ensure that the target object is visible in the screen wherever possible. Here the results demonstrate a combination that satisfies the aesthetic benefits by showing how a combination (in this case *Frame Bounds and Occlusion*) can improve the visual perception but not from the viewer's point of view.

The target object's visibility showed a different set of results once combined with other parameters for analysis. The combination of all four parameters was tested to see the effect of this blended approach. The combined parameters were tested for different Seeds (5, 20, and 100), for different shotsizes (Such as Full Shot (FS), and Medium Shot (MS)), and for different Thetas for the shotsize. The combined parameters were also tested for different weightings of the four parameters according to Equation 6.1.

$$g(x) = \sum_{i=k}^{n} \propto_k f_k(x) \quad \ldots\ldots\ldots \text{ Equation 6. 1}$$

This blend of parameters was also analysed for different numbers of generations such as 1000, 10,000, and 15,000. A selection of the best optimised results has been given here for analysis.

Best and Average fitness plots for the combined parameters are given in Figures 6.33, 6.34, and 6.35. The Fitness scale has been converted to a logarithmic scale. This change is useful because whilst the fitness values for the Average fitness values are high, the Best Fitness line becomes obscured. By using the log of the Fitness scale, the resultant plot becomes clearer. From the plots, the Average fitness values observed were very high whilst the average fitness values were reduced in subsequent generations, as the process of evolution continued. Similar results can be observed for the Best fitness values in the plots. Based on results from the plot, the Best fitness values do not reduce to zero for the combined parameters however they record an approximate zero value (just above zero).

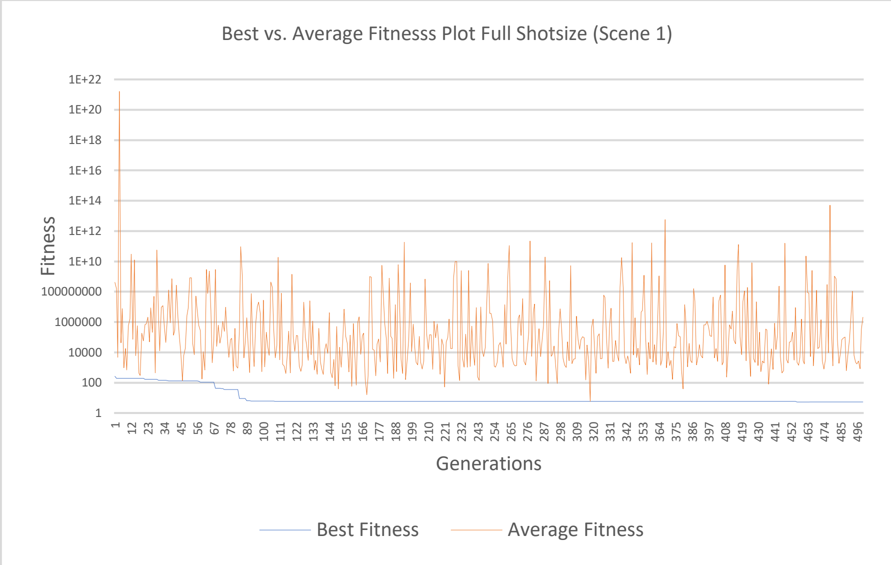


Figure 6. 33 Best vs. Average fitness plots Scene 1 for the Combined Parameters

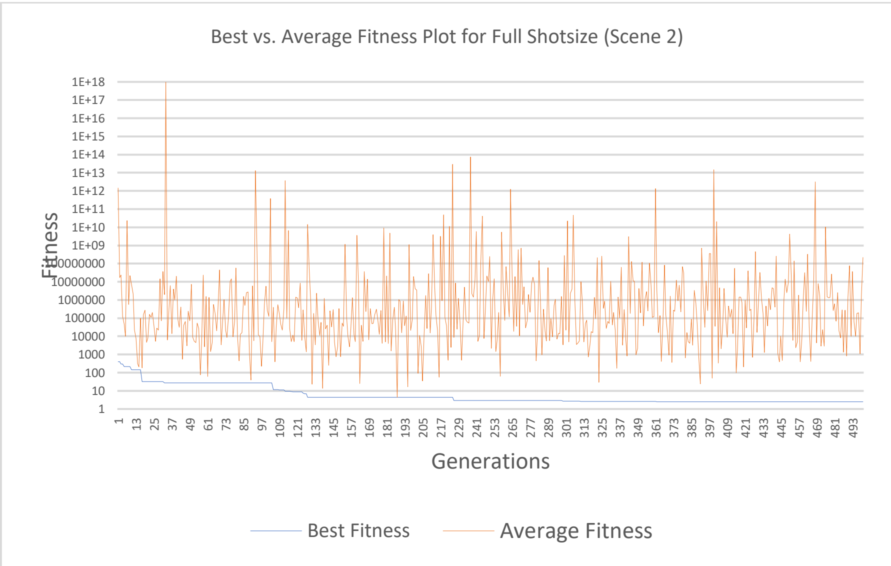


Figure 6. 34 Best vs. Average fitness plots Scene 2 for the Combined Parameters

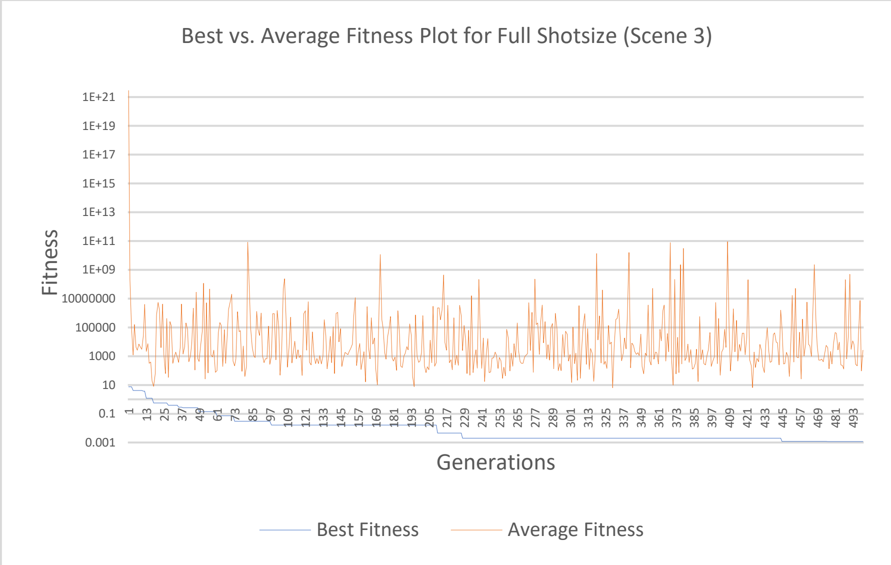


Figure 6. 35 Best vs. Average fitness plots Scene 3 for the Combined Parameters

The visual results for combined parameters are given in Figures 6.36, 6.37 and 6.38. The visual results have been added for the Full Shot (FS) and for the theta half of the cameras FoV. From the results of all parameters in combination a result is obtained which visually shows an aesthetic improvement. These results show an improvement in terms of the rules-based optimisation, but not in terms of the aesthetic values of the visual results. The remaining results for different seeds tested are given in Appendix E of this thesis.

Aesthetic parameters, based on the cinematography principles such as *Headroom, Occlusion, Shotsize, and the Rule of Thirds (RoT)*, show an enhanced quality in terms of visual appearance. This improved quality applies to the target object on the screen. The visual findings given above provide an exemplar set of viewpoints that can be used by the designer of a VE, but to define their aesthetic qualities, additional features are required for such views.

6.2 Variations in Weighted Values

Up to this point, the findings for these combined parameters have been determined by equal weightings across each of the four parameters. By varying the weighting by which these parameters are applied, we can obtain greater aesthetic results. For example, if the search space for the x-rotation of a camera is not limited to 0 to 90, then the upside-down viewpoints can also be selected as optimum viewpoints by the algorithm (as already explained in Shotsize).

The combined parameters were also tested for different weights for each parameter. From this type of variation, there was only conflict between *Frame Bounds* and *Shotsize*. To resolve conflict, we chose to either reduce the weighting of the Shotsize parameter in the Combined parameter testing or reduce the theta value. Both variations were conducted, with more visually enhanced results being obtained after reducing the theta values to half of the cameras FoV (as seen in Fig 6.36).

(a) *(b)*

Figure 6. 36 Visual results for the Combined Parameters for Scene 1. (a) With equal weights for all parameters and theta equals to camera's FoV. (b) With equal weights for all parameters and theta reduced to 150 for Shotsize.

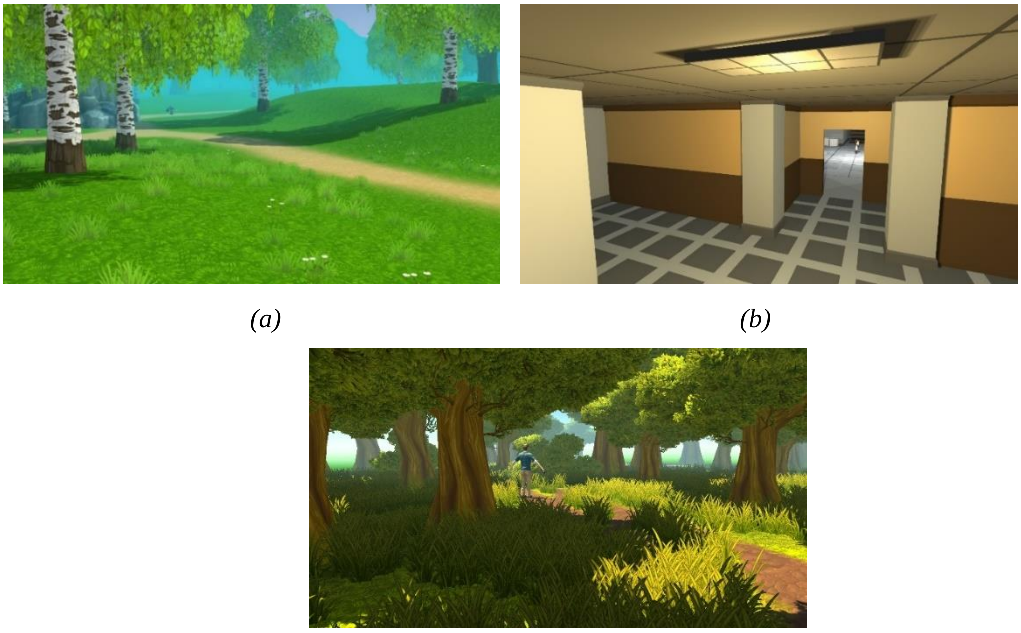
Some basic viewpoint constraints, analysed in this research, provide the basis for framing a target object using gameplay within a cinematographic approach. Visual language is used to build up the story within a game in a more effective way. The choice of frame offset, shotsize, and composition rules (like the rule of thirds) is one way in defining the choice of views, but for aesthetic considerations more than visual constraints are required.

Following this rules-based approach to optimised aesthetic values, it is possible to obtain more than one way to form a suitable image composition. To look for an optimum viewpoint manually based on these constraints is time consuming and requires human effort. If we a have set of optimum values to choose from, then we can considerably reduce the effort and cost of manually selecting the individual shots.

6.3 Considerations for Rules-Based Aesthetics with Reference to Qualitative Analysis Findings

The visual results, obtained after the application of optimisation technique, show that even after following the rules and constraints all visual results might not be useful, and some changes will be required according to the context of the story provided for a designing a game. Views obtained because of rules-based optimisation method might be beneficial in one scenario but not practical for the other. This is important in terms of positioning a camera in a 3D VE. Therefore, there is a need to define the aesthetics of views to get the relevant viewpoints according to the game story. For example, looking at Figure 6.37, there are two rules that have been applied for these viewpoints. Rule one, "Frame bounds", the character should remain within the bounds of the frame, and rule two, "Occlusion", there should be a clear line of sight between the character and the camera. Both of these rules are followed correctly in captured frames and are optimised according to GA, but the character is too far away from the camera.

The characters in Figure 6.37, Part a, appear as a shadow for the first VE (Scene 1). In the second VE (Scene 2), Part b, the character can be seen through a corridor, standing in a room, a kind of indoor scene, but too far away from the camera. Likewise, the character, in Part c, can be seen behind and under the tree in the third VE (Scene 3), still far away from the camera. Such viewpoints might not be useful during gameplay, but they can be useful for use in the opening scenes of the game. These can be used for presenting an introduction to a story for a game for a player to understand the gameplay. Such views can be as a part of the cinematic overview. These views might not be usable if there is a scene where you want to show a character in conversation with another character or in a combat. In such cases closeups, over the shoulder or a top view might be suitable.

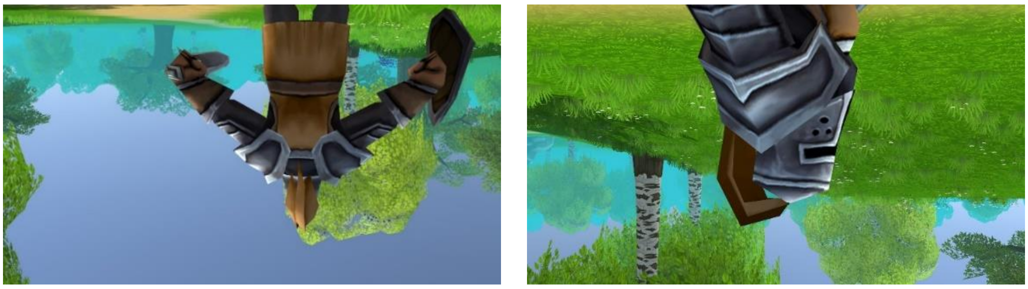


(a) *(b)* *(c)*

Figure 6. 37 Visual results for Scene 1 (a), Scene 2 (b) and Scene 3 (c) for Frame bounds and occlusion

Views that have been optimised using three rules, that is *Frame Bounds, Occlusion*, and *Shotsize* are given in Figure 6.38. These rules have been combined to capture the close shots of the character in a 3D VE. There are two types of shotsizes applied in this figure. One is the FS and the other is the MS of the character. Both optimised viewpoints are upside down. In the following views, not only is the character upside down but all the surroundings around the character are also upside down. From these two shots we can see that although the rules have been applied and satisfied by views, there still remain shots below that might not be beneficial for gameplay. Showing a character upside down during a game might not be a player centric view and it will provide the player with an uncomfortable feeling, making the game less immersive and engaging.

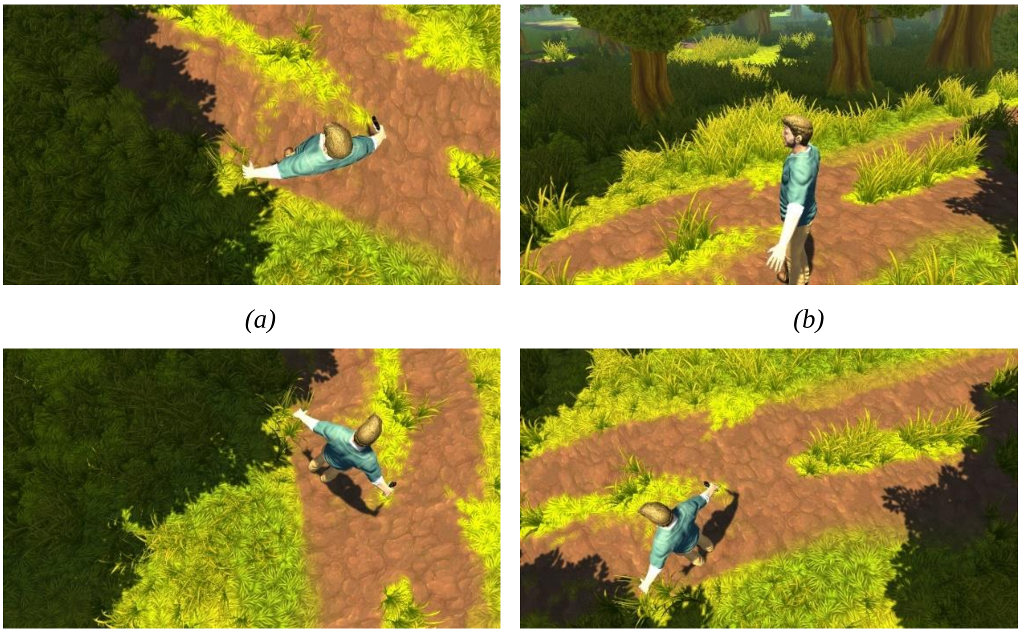
This means that just applying the rules blindly will not result in an aesthetic view, but there is a need of additional features based on the context of a gameplay. One way could be, in such scenarios, to bound the one of the rotation parameters of the camera to get the up-right views instead of upside-down views. The rotation parameter of the camera that needed to be bounded is the rotation around *"x-axis"* to get the upright viewpoints. During this study for further application of optimisation through GA the rotation parameters around x-axis was restricted in order to get the upright views.



(a) (b)

Figure 6. 38 Visual Results for Scene 1 for Frame bounds, occlusion, and Shotsize (FS and MS)

Viewpoints obtained through optimisation using a GA for the third VE (Scene 3) are given in Figure 6.39. Two rules have been followed for these views. The frame bounds and occlusion. The views given in Figure 6.39 looks like a top-view or a god like view for the given scene. Such a "god like view" is beneficial when the information of the surroundings is available. In Figure 6.39, Part (a), (c), and (d), a very narrow view with no information for the surroundings is on display. Such views might not be beneficial for the user as he or she will not be able know anything about the surroundings, which is important for performing tasks and playing a game in a 3D VE. In such cases views might be optimum according to the rules but not beneficial for a gameplay. Alternatively, part (b) of the figure is somewhat reasonable as we can see the surroundings around a character with some trees. In this viewpoint we can see a path on which a character is standing. In this viewpoint we can understand the story that a character is moving on a path to reach a destination. The direction in which a character might be moving is also visible in this view. The main difference between this view and the other three views is that the gun in the hand of a character is visible. This might be important if it has a context of a shooting game, and in this scenario a wider view might be more beneficial if the character has to kill an enemy.

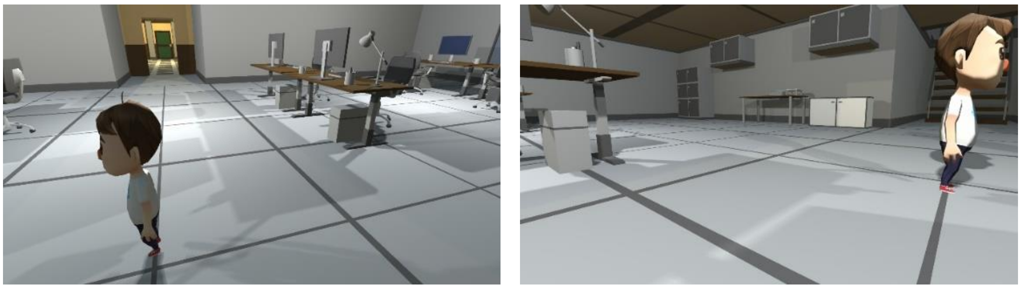


(a) (b)

(c) (d)

Figure 6. 39 Visual Results for Scene 3 for Frame bounds, and occlusion

Views following three constraints are given in Figure 6.40. Three rules used are *Frame Bounds, Occlusion,* and *Shotsize* (FS). All rules have been followed correctly in these optimised views accordingly. Visually in both views, the character is too close to the bounds of the frame. In such views if a character has to perform a certain task than the player is unable to see what is in front of the player. So, in this case the rule requires modification or an additional requirement to show the space in the forward direction of a character. If the character's forward direction is too close to the bounds of the frame than such views will have a claustrophobic feel and the user, or a player might not be able to play a game without knowing what a head of a character is. In such cases rules should be redefined in order to get the accurate view to show a space in the direction the character is facing. For example, moving the character a little further away from the frame bounds and getting a wider view if a character is in conversation with another character, or if a character wants to see in a forward direction for a gameplay.



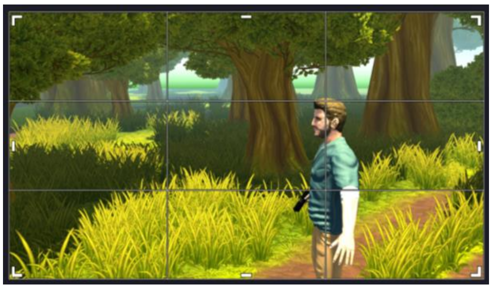
(a) *(b)*

Figure 6. 40 Optimised viewpoints for Scene 3 (optimised parameter FS)

The views given in Figure 6.41, Scene 1 (a), Scene 2 (b), and Scene 3 (c), represent the application of the *Rule of Thirds (RoT)* along with *Frame Bounds* and *Occlusion*. The RoT is used for highlighting what is important on the screen and where to look once the scene is started. In all these three viewpoints the importance of character with respect to the surroundings can be seen. In all three scenes information about the surrounding VE can be clearly seen. The character is clearer in Scene 3 (c) of Figure 6.41, and even the gun can be seen in the hand of a character. This conveys information about the context of the game and the viewpoint. A character has to move through the environment carefully to reach the destination and kill enemies on his way. There might be a need to change views from FP to TP and vice versa, based on the context of gameplay.

The view in Scene 2 (b) shows that the character has been watched behind the wall, and it conveys the feeling of foreboding or creepiness. This view also conveys the information that this game may be a spying game, in which a character has been carefully observed behind the wall. This scene might be useful for a cutscene to explain the background and understanding what next task could be waiting for a player to be performed during a gameplay. Scene 1 (a) on the other hand does give some information about the environment and the character but still the character is too far away from the screen, and it seems like some part of the terrain has been cut-off in this viewpoint. This viewpoint can be adjusted to get the better view, according to the storyline of a game.

(a) *(b)*



(c)

Figure 6. 41 Optimised viewpoints for Scene 1 (a), Scene 2 (b), and Scene 3 (c) (optimised parameter the RoT)

Viewpoints given in Figure 6.42 follows the rules of frame bounds, occlusion and shotsize. These viewpoints could be used as a third person views during a gameplay, especially when the character is moving across the terrain. View for Scene 2 (a) is a nice viewpoint from the perspective of a TP gameplay. A full view of the room can be clearly seen and directions in which a character can move are clear. However, the view of Scene 3 (b) requires a little wider view if the character, if character has to fight an enemy, or a player need to see the direction of enemies from where it is coming. This view might be useable if the player has a task of just navigation through a VE. If the character has a fight to do, then a wider view might be suitable in that particular scenario.

(a)

(b)

Figure 6. 42 Optimised viewpoints for Scene 2 (a), and Scene 3 (b) for Shotsize

6.4 Conclusion

Rules can be used as a starting point for the game design, but a clear aesthetic definition is required for its usage for an enhanced user experience. For example, in a Third Person (TP) game, during gameplay, a closer view from the back of a character might be useful, or for a strategic game a god like view might be useful. In addition, there are other features that needs investigation for defining a range of optimised views, such as audience type, game genre, story and so on.

Applying only the composition rules such as the *Rule of Thirds (RoT)* might not be sufficient to improve engagement in a singular sense, but where other factors were considered, an advantage could be obtained through the combination of various aesthetically engaging mechanisms. This is especially clear in interactive digital media and digital games, where there can be many options available on how a specific camera view is selected for a particular gameplay. Choosing the right view for a portion of gameplay can make the experience more immersive and engaging for a user because it helps in building a story.

Rules can be changed, modified or even broken if the view obtained are not according to the aesthetic requirement of a game or a digital media. But this requires the justification of why these rules were modified or broken. Rules can be broken if there is a need to improve user experience or provide the user with the experience that results in better user engagement and aesthetic experience. This will require the number of factors to be considered such as application they have been applied for, user's type and gameplay.

From the above given visual results it can be concluded that the defining aesthetics for finding an optimised viewpoint will require additional factors such as the context of the story, gameplay and application amongst others for an optimised viewpoint. The application of rules without any logical considerations for finding an optimised viewpoints is not a good approach, as it will still result in creation of viewpoints that most of them will not be useful in a context they have been optimised for. The understanding of aesthetics for defining a view can make the application of rules more defined and usable in the field of visual designs of digital medias like games.

6.4.1 Impact of the findings on a range of optimum views using a GA

A range of camera views, satisfying the measurable constraints, were generated using GA. Extensive testing was carried out to obtain the visual results, as described in Appendix E of this thesis. From this generated range of camera views, it was determined that the exclusive application of the *Rules of Cinematography*, without any specification of context, could not satisfy the aesthetic criteria required to generate these views. This finding has significant impact, because it is part of the proof that supports the earlier suggestions from the scoping literature review and the qualitative roundtable discussions.

These previous chapters have demonstrated the need for a richer and deeper set of aesthetic characteristics to satisfy all of the needs of an interactive digital media application. which strongly point to the need for a broader set of aesthetic features as part of the process that determines optimised positioning for important elements such as camera positions and camera viewpoints.

The testing using GA demonstrated a set of conditions that support the idea that aesthetic characteristics require a much greater set of features that n those which have been historically referred to in the *Rules of Photography* and the *Rules of Cinematography*. It has become clear, that after implementing these rules using GA, it is visually and algorithmically demonstrated that optimisation characteristics require a greater set of variables if we are to create meaningful interactive digital media that allows for interactive influence from automated camera selection software.

This chapter shows that in a range of tested scenarios in interactive digital media and digital games, choosing the right view for a portion of gameplay is not always supported through the historical adherence to rules of cinematography and photography. Clearly the use of aesthetic features can make an interactive digital media experience more immersive and engaging. This is vital for a user because it helps in building a story. If there is a disconnect between the chosen camera view and the game story, then the user experience can be strongly affected through a deliberately chosen visual experience that is contrary to the expected aesthetic nuance that may be aligned with the story.

This chapter demonstrates seven areas where the attempt to generate an optimum position is unable to meet the required conditions to support the adherence to just the rules of cinematography and photography. The first area is shown in terms of frame bounds – where the results demonstrate that frame bounds alone are insufficient for satisfying visibility parameters. The second area of unmet conditions is described in terms of the combination of frame bounds and occlusion, where the results show that there are some instances where an optimal position can be determined regardless of whether the parameter of occlusion is considered. A third area of difficulty is demonstrated when considering shotsize parameters, where the parameter does not consider whether the target object is in the frame or not. In such a scenario, the shotsize parameter needs to be combined with visibility parameters such as the integration with frame bounds and occlusion measurements. A fourth issue is demonstrated in terms of where the camera is so close to the target object that it effectively looks right through the target object and the shot does not visually show the target. A fifth challenge was seen in scenarios where it was possible to generate upside down visuals of the target object. In a sixth issue this chapter showed that if the target object is not visible, then the composition rule cannot be applied. Finally, in the seventh demonstration of a problem the chapter explains that some visual findings given can provide an exemplar set of viewpoints that work for a given VE but require additional features to include the decision choice with the inclusion of aesthetic characteristics.

This study is important because this study highlights the importance of aesthetics on choosing a range of camera views in accordance with aesthetic criteria defined through the game story and gameplay. It provides sufficient evidence to support the need for a broader range of aesthetic values as part of a system that can assist in the generation of optimised camera positions and viewpoints.

Chapter 7
Rationalisation of the Chosen Research Approaches

This chapter states the justification for the elements which were brought together in a single framework that defines aesthetic features. The chapter draws its reasoning from the Literature review, Qualitative analysis, and Quantitative analysis. The collected information enabled this study to demonstrate an instrument that incorporates aesthetic features and allows them to be systematically considered against interactive digital media constructs, such as games. It draws the main body of evidence from an appropriate range of knowledge and expertise, and it demonstrates that the historical reliance upon the rules of photography and the rules of cinematography are individually insufficient as tools to appropriately drive decisions in interactive digital media.

7.1 The Role of the Literature Review in defining the research method

At the beginning of this study a literature review was used to establish the early information and data on how aesthetics has been defined for different art medias such as photography, cinematography, games and 3D VEs Designs. In the course of applying these previously identified rules of cinematography and rules of photography, it became clear that the optimisation that was based on the inclusion of aesthetics would need to involve a deeper understanding of the principles and guidelines for the use of aesthetics in other digital media, and interactive digital media that includes 3D VEs. The literature review carried out for this study returned to gather a more informed selection of literature in order to satisfy the greater needs of the proposed investigations into optimised camera positions. Consequently, a further review in the form of a scoping review was undertaken to more accurately describe the aesthetic features in a contemporary sense to allow the appropriate application to interactive digital media including games and 3D VEs.

7.2 Reasoning behind the Qualitative Analysis

The Qualitative analysis was carried out because the literature clearly identified that aesthetics is widely described as a collective rather than singularly definable components and that they occur in variable circumstances. As such, aesthetic analysis requires qualitative elements to sufficiently address the broader collective values of the area being investigated. It is important that the main research question draws from studies that specifically address the key differences in order to provide a rich and descriptive answer to the challenge of aesthetics in interactive digital media, whilst allowing for these variables to be applied within a set of rules and frames that provide a meaningful set of answers. So, in order to answer research questions and fill gaps these aesthetic features highlighted by the literature review were covered by the Qualitative Analysis examination of this study.

The purpose of the study was to investigate the area of choosing aesthetically optimized views for camera placement within interactive digital media. To achieve this goal, it became necessary to follow an approach that drew from both a quantitative data set and a qualitative process that enabled the inclusion of a rich, deep set of aesthetically derived interactive digital media features.

7.3 Reasoning behind the Quantitative Analysis

In Quantitative analysis, a Genetic algorithm (GA) based optimisation has been developed to evaluate the quantified camera properties given in Litteneker & Terzopoulos (2017) based on principles of cinematography. GA was used because GAs are useful in finding a single optimum and robust solution where there is a wide range of possible solutions (Forrest, 1996; Alam et al., 2020). Specifically, GAs are suitable for complex non-linear models (Lam et al., 2019) such as the optimisation of camera parameters. GAs are population based algorithms developed on Darwin's theory of evolution (Goldberg & Holland, 1988; Holland, 1992).

This study was important because this study highlights the importance of aesthetics on choosing a range of camera views in accordance with aesthetic criteria defined through the game story and gameplay. It provides sufficient evidence to support the need for a broader range of aesthetic values as part of a system that can assist in the generation of optimised camera positions and viewpoints.

7.4 Validation from a novel Framework

One of the challenges that highlighted from the Literature, qualitative and quantitative study of this study was that aesthetic characteristics have (in the past), been driven by a past set of rules that were originally designed to describe images and artistic contributions of the 20th century but are inadequate in the contemporary understanding of images and visual objects that now proliferate interactive digital media (Ratheeswari, 2018; Goethe, 2019; Turja, 2020).

Past rule sets such as the rules of photography have served a purpose in assisting imagery that is to be presented in optimised form based upon existing technology, norms, and values. These rules are no longer sufficient by themselves, and further additional aesthetic parameters require consideration. The collective of characteristics described in the framework are part of the work in future-proofing the future conceptualisations of aesthetics. This research has developed a broad set of aesthetic features and has applied them to a framework for the purpose of defining the aesthetic characteristics of interactive digital media especially in the area of digital games.

The developed framework provides a valuable connection between the historically established features that are used in the rules of cinematography and the rules of photography, and the modern appreciation of technical capability that allows for aesthetic elements that are derived from features and characteristics that are more modern and contemporary in nature. It is a product of this thesis that has evolved from the literature review, qualitative research and quantitative research. It demonstrates the confluence and union of a very wide variety of interactive digital media attributes that pertain to aesthetic values that can be recognised in a range of interactive digital media and Virtual Environments (VEs).

7.5 Summary

This chapter summarises the justification, reasoning, and validation of three different research procedures, that is, the scoping literature review, the qualitative analysis and the quantitative analysis used as a part of this study. This has led to the conclusion that these studies were critical in combination with each other, since they systematically helped in answering the main research question, and incorporated the different considerations that emerged from the answers to the research sub questions that were investigated in this study.

Chapter 8

Defining the Characteristics and Parameters of Aesthetics for an Interactive Digital Media Framework for games.

This chapter brings together a range of qualitative, quantitative, and literature-derived elements that provide strong evidence in support of a framework that defines aesthetic features. The chapter draws upon the combination of existing rules, and existing practices, together with a dataset of modern and contemporary opinion from industry and academia. The collected information enables this study to demonstrate an instrument that incorporates aesthetic features and allows them to be systematically considered against interactive digital media constructs, such as games. It draws the main body of evidence from an appropriate range of knowledge and expertise, and it demonstrates that the historical reliance upon the rules of photography and the rules of cinematography are individually insufficient as tools to appropriately drive decisions in interactive digital media.

This chapter proposes an aesthetics framework for interactive digital media. It does so by means of a framework instrument that provides a pathway to the application of aesthetic features that allow interactive digital media to define parameters for the purpose of AI generated interactive digital media, such as the optimised selection of camera positions and viewpoints in interactive digital media games.

One of the challenges to the research questions within this thesis is that aesthetic characteristics have (in the past), been driven by a past set of rules that were originally designed to describe images and artistic contributions of the 20th century but are inadequate in the contemporary understanding of images and visual objects that now proliferate interactive digital media (Ratheeswari, 2018; Goethe, 2019; Turja, 2020).

Past rule sets such as the *Rules of Photography* have served a purpose in assisting imagery that is to be presented in optimised form based upon existing technology, norms, and values. These rules are no longer sufficient by themselves, and further additional aesthetic parameters require consideration. The collective of characteristics described in this chapter are part of the work in future-proofing the future conceptualisations of aesthetics. This research has developed a broad set of aesthetic features and has applied them to a framework for the purpose of defining the aesthetic characteristics of interactive digital media especially in the area of digital games.

A modern-day application of the guiding conditions for aesthetics is required to converge with previously unrealistic camera angles, viewing expectations, and viewing conditions. Where in the past a camera could not be positioned in the sky without support, the technology of interactive digital media allows for an endless array of variable conditions for cameras, camera angles, motion, and control.

The ability to include controls that can pass from a director to an operator, to a game player, and to an observer, illustrate the challenge for interactive digital media. Controls can now be predetermined, programmed, and rapidly changed. They are dynamic, flexible, and subject to a freedom of range and motion that has not previously been recognised or elevated in terms of impact and significance.

The results and descriptions below show a redefined set of aesthetics features that are shown as a collective of characteristics, controls and parameters. Older rules and values continue to anchor many of the expected choices for camera positions and camera viewpoints, whilst technology changes and digital applications permit and pre-empt the need for a reorganisation of aesthetic elements. The collective of objects that have been researched and analysed are presented below for discussion, reformation, and application.

8.1 Player Centric Aesthetically Weighted Framework (PCAWF)

A Framework for choosing a range of aesthetically optimised viewpoints is provided in Figure 8.1. The framework has been named as the "Player Centric Aesthetically weighted framework" (PCAWF). The evidence that has been collected as part of this research study collectively demonstrates the need for a framework that can assist with the various aesthetic features that characterise interactive digital media, with specific application to digital games. This framework provides both a visual explanation of the types of aesthetic features as well as the parts of an interactive digital media product and the various treatments that apply to it before it can be used. Once in use, the PCAWF framework can be dynamically re-applied, allowing for changes in development, storyline, player, viewer and application.

The framework consists of four important pillars for defining an aesthetically optimised view. These four main factors are the storyline, the user state, the gameplay, and the knowledge application type. There are also sub-factors associated with these main factors. Each of these factors and sub-factors are capable of influencing a range of aesthetic views or viewpoints for the camera placement in a 3D VE. Their explanation is given in description below.

Player Centric Aesthetically -Weighted Framework (PCAWF)

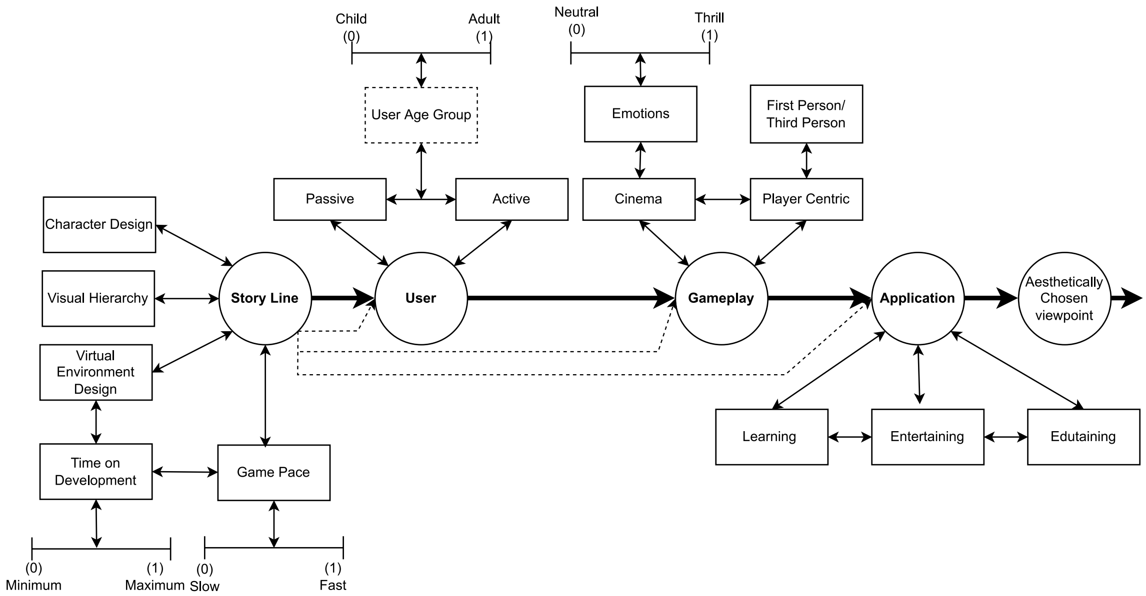


Figure 8. 1 Framework for making range of aesthetic choices for an optimised camera view

8.1.1 Storyline

The main factors that affect the choice of aesthetic viewpoints are given in Figure 8.2. Aesthetic choices can be determined in this framework as a set of ranges rather than as a single best possible choice. The evidence from the GA testing using the rules of photography described in chapter 6 clearly showed that attempts to find an optimum camera position were problematic. Such evidence suggests that a more pragmatic approach was to use an instrument (such as a framework) that would allow for a range of optimised camera positions rather than a single position.

In combination with a rich and varied set of aesthetic choices, the application of a framework allows for a storyline to be started. More importantly however, is that it can also be altered dynamically throughout each digital experience according to the user (Silvennoinen, 2021) and the player choices that can be influenced and driven by aesthetic options and choices. The storyline is the first principal factor that is used to define the range of aesthetic viewpoints. The storyline remains a key element in any digital media composition and is supported by a range of features, that provide the critical factors for the initial attraction and engagement of a user/ developer/ game player, or viewer of media.

The sub-factors associated with the storyline are character design, visual hierarchy, and VE design (Yao et al., 2019). The VE design depends upon the game pace that ultimately defines the time required for the design and development. The sub-factors associated with the user states are active, and passive audiences. Other factors also include the recognition of users and their age ranges. Other sub-factors that are associated with knowledge applications consider the range of emphasis across the three main variables of learning, entertaining and edutaining (a combination of both learning and entertaining applications) (Lutfi et al., 2019). The sub-factors associated with gameplay (Goethe, 2019) are player-centrism (Bayrak, 2020), and cinematic styles.

The selection of other main factors is also dependent upon the storyline, as this is the first step in defining aesthetics for any interactive digital media especially games. There are five sub-factors that are dependent on the storyline for their aesthetic description. These sub-factors are character design, visual hierarchy, VE design, the time for development and the game pace (Atkinson & Parsayi, 2021). Each of the sub-factors are connected (at different locations) along a standardised process that begins with defining the storyline, then defines the user, then the type of gameplay, and then the application of the experience. They are described in Figure 7.2.

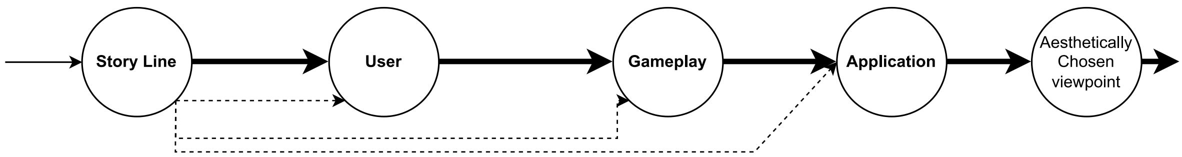


Figure 8. 2 Framework with main factors for choice of an aesthetic viewpoint

The first two important sub-factors, as given in Figure 8.1. These are the character design and the Virtual Environment (VE) design factors. Both of these two sub factors are important in creating an association between the game story and context. If the aesthetically influenced description of a character and VE are not aligned according to the description given in the story than this will adversely affect the user experience, and the value of the immersion will be lost from the game. A player understands games by looking at the character design and game surroundings. It is a way of establishing a context for a player when the player is new to a game.

8.1.1.1 Time, Development, and the Pace of the Game

The aesthetics for defining the VE design is also described by the story line. This sub-factor is affected by two other sub-factors that is “Time on development” and the “Game Pace”. The effect of these two sub-factors, is represented through a scale in a framework. The scale for time development and game pace have been represented between 0 and 1. This scale shows that the time spent on development can be changed from minimum (0) to maximum (1) depending upon the game pace. For example, if it is a fast-paced game than less time is required for designing the environment because a user will take less time in looking around the environment and the surroundings during a gameplay. On the other hand, if it is a slow-paced game than more time will be required. This is because a user will spend a significant time in looking around the surroundings while playing. Hence, we can say that the time spent on game development is inversely related to game pace. If the game is a fast-paced game, such as racing games, then the time spent on the development is reduced. If the game has a slow pace but is based around strategy and tactical decisions, then the time spent on the development may be much greater.

When a designer wants to show a user what is important on the screen, the sub-factor of visual hierarchy is used. The story describes the aesthetics of visual hierarchy. In this scenario the rules and guidelines such as the *Rule of Thirds (RoT)* or golden ratios can be applied.

The application of these rules enables the player to focus what is important in a current viewpoint. An example of such as a viewpoint is given in Figure 7.4. This is a screenshot of a game known as Forbidden Horizon (Cardy, 2022). There are two important things in the view. The first is the main character, and the second is the machine (the enemy). The main character is represented as a warrior and has been moved to the left side so that the player can see the machine while shooting an arrow. If the character is at the centre of the screen and if the camera view is that much close to a character, then it is hard to see the direction to fire an arrow. A narrow view with a character in the centre would be blocked by the character during a gameplay. In such scenarios, careful consideration for the application of rules of composition, mentioned in Chapter 5, need to be carried out. Such views should be chosen, and the rules should be applied in a way that could be helpful in a gameplay and that can improve user experience. The variable application of rules, guidelines and aesthetic features combine to form a range of choices and options that require an instrument that interprets the application of these components. The PCAWF is one such instrument that defines the needs of digital media and the gap that has evolved over time that must include a wider selection of aesthetic characteristics.

The sub factors that are figuratively connected with the Storyline, the User choices, the type of Gameplay, and the media Application have been collated and derived from three specific parts of this thesis study (See figure 8.1). The first part demonstrates that some areas of aesthetic broadening needed to be outlined in the scoping review literature that was studied and annotated at an earlier stage of the thesis development, when it was becoming clear that the use of existing rules of photography and cinematography are inadequate to meet the demands of modern digital media. The second part revealed that through a selection of experts drawn together to discuss aesthetic attributes on different formats of digital media it was clear that most of the interviewed experts held established views that indicated a broad set of aesthetic features that were not adequately covered by the rules of cinematography and / or the rules of photography. The third part demonstrated a strong body of evidence through the use of Genetic Algorithms (GAs) and the visual analysis of their outputs that the traditional rules of photography and cinematography were inadequate on their own, and that there were in fact many additional aesthetic features that deserved to be included. These three evidence-driven parts in this study provide the reasoning behind the formation and development of an aesthetically featured digital media framework.

Figure 7. 1 Screenshot of Forbidden Horizon Adapted from (Cardy, 2022)

8.1.2 User State, Type and Age Group

The second significant pillar that defines the aesthetics framework is the understanding that interactive digital media can be defined by the type of user who is interacting with such type of digital media. The user makes decisions that determine specific dynamic changes that can be applied to a piece of interactive digital media.

The choice of gameplay is dependent upon the state of the user. It can range between being in an active state or being in a passive state. The storyline typically provides the details about when and where the user acts as an active user and when and where the user acts as a passive user. If the user is passive then the user's current status is that of a passenger, and that user is regarded as not actively playing a game. During that time the user is either looking at a recap of his or her gameplay or learning by watching other person playing a game. If a person is learning by watching (Ferguson et al., 2020), then in such scenarios cinematic views are suitable and the *Rules of Cinematography* can be applied in this type of gameplay. In the cinematic views the user interaction and freedom are limited as the control is taken away from the user when the user is in passive state.

In contrast to this, if the user is in an active state and the camera control is in the hand of the player then at that time a player-centric camera view is suitable for the gameplay. For example, if it is a shooting game, then a first-person view might be advantageous. On the other hand, if a player needs to see the surroundings or the direction of the enemy approaching then a third-person view may provide a better option in terms of gameplay. The application of rules such as the *Rule of Thirds* (RoT) can be applied in the third-person game view but with a limited usability in first-person view. In modern games in the current format there is a mechanism provided to switch between different views depending upon the user's state.

There are different purposes for which active and passive viewpoints are created depending on the application. Take for example, the use of a Virtual Reality (VR) application. VR applications are sometimes used for training and learning purposes. In an educational VR application users learn in two ways. A user can learn either by performing tasks themselves (learning by experience) or by observing others performing tasks (learning by watching). If it is learning by experience, then a *point of view* camera view from a players perspective approach is most suitable. If it is a form of learning by watching, then a view other than the first-person view may be suitable for the user. For VR based interactive experiences sometimes a user can become a passenger to understand the information that has been conveyed through such applications. They can always revert to a more active user at a later stage.

The way that a story is narrated and the choice of objective aesthetic factors such as colour and complexity, is also dependent upon the age group of the user. A scale has been applied for defining the age group of the user for whom the game has been designed for. The scale could be used to determine the approximate age group of users for the application. If the game is designed for children, then it might be bright, and colourful having less complexity. On the other hand, if the game has been designed for adults then the choice of colours for the adult game will be chosen accordingly. Adult games might be more complex and may demonstrate a complex functionality. The choice of different aesthetic camera views would also be defined by the age factor. The distinctions drawn here are not meant to be regarded as absolutes, but rather they are examples used to demonstrate different choices, selections and options that can be applied and that illustrate the variation in users and the interpretation of a storyline. They can be vastly different from user to user, and their characteristics are highly variable based on a range of human qualities.

8.1.3 Gameplay

The third factor that is important in choosing an aesthetic viewpoint is “Gameplay”. The choice of gameplay, to some extent, is described by the storyline. The storyline helps the designer to make a choice for either cinematic or player-centric gameplay. The choice between two different gameplays would ultimately result in planning whether the rules of cinematography can be applied for the chosen view or not. The choice of what constitutes the right gameplay is important for an enhanced user experience. If a view selected is not player-centric and there is a conflict of camera settings between user preferences and a gameplay, then it will affect the overall experience of a user.

Providing multiple views to the user can help in overcoming this problem by providing them with multiple options suitable for a chosen gameplay. The key element (and an aesthetic attribute in its own right) is choice. The ability in interactive digital media and games to change and deviate from chosen environments to another area is instructive in demonstrating the value of different attributes, and the choice on when to include them (if at all).

When a player is playing a game there may be a need to switch between cinematic and player-centric views. This change in views is defined by gameplay (see Figure 7.4). Cinematic viewpoints are required when there is a need to narrate the story or to explain an introduction of a scene to a player. Sometimes cinematic viewpoints are used to illustrate the summary of a play after a gameplay. Cinematic views are mostly used when the user’s state is passive. In such camera views the *Rules of Cinematography*, such as *Shotsize*, and the *Rule of Thirds (RoT)* amongst others, can be applied.

On the other hand, in player centric viewpoints the camera control is in the control of a player. Player-centric views are required when the player is playing a game. For a player-centric approach multiple viewpoints are required for a player to choose according to the gameplay, such as First-Person (FP) and Third-Person (TP) views. Principles like *Frame Bounds*, and *Occlusion* are important to keep a character on the screen, whereas rules such as the rule of thirds are optional for a player-centric view.

There should be a seamless or smooth switching between the two cinematic and player centric views. If the switching between two different game conditions is not smooth it will adversely affect the overall game experience of a user, and there is a chance that user might not use the same application again.

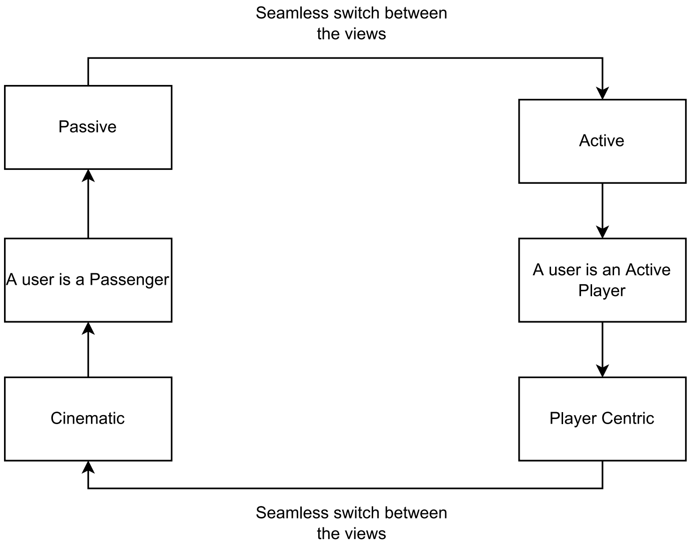


Figure 8. 3 Flow diagram to show switch between different views

The range of emotions can be expressed through cinematic views. A scale has been shown on the framework to represent the range of emotions for choosing cinematic viewpoints based on gameplay. The range of emotions vary from "neutral" to "thrill". The choice of emotions will be dependent upon how the story need to be narrated to a user/player.

Gameplay can be both player-centric and cinematic. That combination ultimately depends upon what is the user's state at that time that the digital media is on use. A user can be in an active or a passive state in different scenarios. If a user is an active user than the view presented to the player should be player centric. This is because the user needs to actively control the camera in an appropriate manner to suit the gameplay of the game. In player centric mode there should be a choice of multiple viewpoints from which a user can choose according to the situation such as FP or TP.

The choice of a cinematic view will be dependent upon the type of emotions that need to be generated for a user. Then viewpoints can be selected from the range of emotions to narrate the story to a user or a player or an audience. Emotions can vary from "neutral" to "thrill" based on the storyline. For example, the viewpoint given in Figure 8.4 can be used for generating the feeling of creepiness. The image in Figure 8.4 conveys secrecy and observation. In the image half of the viewpoint has been covered by the wall, and it seems like the character has been observed secretly by someone behind the wall.

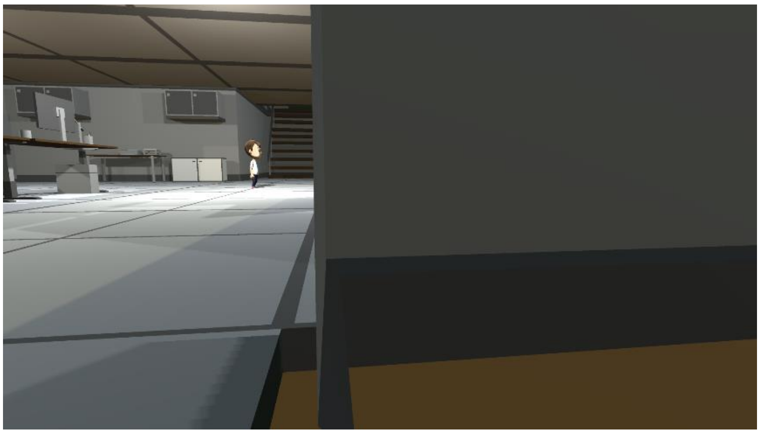


Figure 8. 4 An optimised viewpoint for Scene 2

The choice of a gameplay between player-centric and cinematic would be defined by the current user state. If the user's state is active than a player-centric gameplay would be more effective. If the user's state is passive than a cinematic view perspective would play a more significant role in defining the aesthetic of a chosen viewpoint. The application of rules, such as cinematography and photography, are defined by the choice of a specific type of gameplay.

8.1.4 Application Type

The choice of a viewpoint is also dependent upon the application it has been chosen for, such as an application for entertainment, learning, or a combination of both, that represents a form of edutainment (Anikina & Yakimenko, 2015; Ardani et al., 2018; Hanif, 2020).

If the application is just for entertainment then the cinematic and player centric views will be two different types of views that would be considered for the application. If the application is a learning tool then realism as an aesthetic factor will be important. An example of such an application is in training users on how to use a forklift using VR based application. On the contrary, if the application is an edutainment application, then a combination of cinematics, player-centricity, and realism will be applied, depending upon the scenario and the age group it has been designed for. The choice of aesthetic factors is dependent upon the application it has been developed for.

In some cases applications are created purely for educational purposes such as a learning simulator for a forklift. In such scenarios one important aesthetic factor is realism. The angles and the viewpoints chosen should resemble the real-world scenarios. This type of application is mostly apparent in Virtual Reality (VR) where the application requires the FP view. In such applications the position of a person's head should be according to the person's height, as this is important from the real-world perspective. Along with the positioning of the head in VR, the positioning of buttons and levers should also resemble a real time forklift. This is because when the person uses such equipment in real life, he or she will have an idea of how it was used in the simulator. The application of the rules of cinematography might not be that beneficial unless the user is a passive user.

If the game is purely for entertainment purposes, then the choice of gameplay will define the choice of a viewpoint for the application. It can be player-centric or cinematic depending upon the storyline and the user states. Here the applications of rules of cinematography and photography will be important in the context of the story they have been applied for. On the other hand, if the application has been developed for both educational and entertainment purposes than the balance between the application of rules and cinematography should be developed for a better user experience.

The factors explained for the given framework would help in defining the range of aesthetic viewpoints for development of digital medias especially video games. The choice of a viewpoint and the placement of a camera in a 3D VE will be affected by the four main factors explained above. In addition, sub-factors associated with these four main factors would be beneficial in further defining the reason for choice of an aesthetic view for the camera in a 3D VE. In addition, various aesthetic factors such as objective influencing factors of aesthetics like colours and themes can also be defined using this framework.

8.2 How Pillars of the PCAWF Framework Were Established

From the literature review it was found that a view of a Virtual Environment (VE), for any real time game environment or any other real time applications, is represented through a camera. The most important factor for defining the aesthetics measures applied to these camera behaviours depends upon the game genre it is applied for. Aesthetics and gameplay overlap in the sense that an aesthetically engaging view of a game world is important for the purpose of understanding the game virtual world, which then in theory improves gameplay. The multiple concepts of gameplay given in Table 8.1 were derived from the literature review.

Gameplay Types
First Person (FP)
Third Person (TP)
Cinematic
Hybrid (FP+TP)

Table 8. 1 Types of Gameplay

8.2.1 Non-uniform recognition of rules

From the qualitative analysis it was found that the standards for aesthetics are not uniformly recognised in the same way as the *Rules of Cinematography* and the *Rules of Photography*. The responses from data collected in this thesis show that the majority of users and developers are unconvinced that there is a hard and fast set of rules that cover aesthetics. Instead, many responses point to the need for a collective set of features that have a range of characteristics that can be weighted differently accordingly to different type of interactive digital media, with different expectations in terms of the usage and time expectancy of that interactive digital media. This applies to Player Centricity, which is critical for the growth and sustainability of the user experience. Other aesthetic features pointed out were state of State of Flow, and Context.

The participants emphasize the importance of a compelling storyline to create a captivating narrative and evoke emotional responses from players. They also highlight the significance of innovative and balanced gameplay mechanics to ensure player engagement and long-term enjoyment. Players express the desire for immersive experiences that adapt to their preferences and skill levels, enabling them to progress and personalize their gameplay. This was further supported by the experiments conducted to prove the most effective algorithmic approaches (Quantitative Analysis) of this study.

A range of camera views, satisfying the measurable constraints, were generated using GA. Extensive testing was carried out to obtain the visual results. From this generated range of camera views, it was determined that the exclusive application of the rules of cinematography, without any specification of context, could not satisfy the aesthetic criteria required to generate these views. This finding holds significant impact, because it forms part of the proof in support of the earlier reasoning developed jointly from the scoping literature review and the qualitative roundtable discussions.

8.3 Summary

This chapter describes the detailed elements of a proposed framework that has been created for choosing a range of aesthetic views in digital media. It can be used for choosing a range of optimised locations for the placement of a camera in the 3D VE of an interactive digital game. The framework was created using the findings of the qualitative analysis, carried out for this study. The importance of the four main factors storyline, users' type, gameplay, and application types have been highlighted using this framework. These main factors are also dependent on the various important sub-factors for making an aesthetic choice. The reasons for when and where to apply rules, such as the rules of photography and cinematography, are factors that have been explained in this chapter. This framework can be used for defining aesthetic factors for other interactive digital media such as websites, mobile applications, virtual reality, and a range of interactive digital media.

The PCAWF framework provides a valuable connection between the historically established features that are used in the rules of cinematography and the rules of photography, and the modern appreciation of technical capability that allows for aesthetic elements that are derived from features and characteristics that are more modern and contemporary in nature. It is a product of this thesis that has evolved from the literature review, qualitative research and quantitative research. It demonstrates the confluence and union of a very wide variety of interactive digital media attributes that pertain to aesthetic values that can be recognised in a range of interactive digital media and Virtual Environments (VEs).

Chapter 9

Discussion of Major Findings, Final Analysis, and Research Answers

This chapter discusses the major findings of this research study through the combination of the three different pathways that have led to a collective analysis of the research components of this thesis. It allows the research to be explained in terms of the key answers to the questions that are raised in this thesis. The discussion below provides a means by which we can characterise the research journey in terms of the pathway by which the major findings were reached. At the same time, this chapter explains the findings as they apply to the research questions and to the thesis in general.

9.1 Discussion of Major Findings

In this study the main research question was followed by three sub-research questions. The main research question was as follows: RQ1. ***"How can a range of aesthetically optimised views be obtained for a 3D VE of an interactive digital media such as games?"***.

This was further investigated by three sub-research questions which were:

SQ1. ***"How can aesthetics be defined for digital media and what criteria can be followed for applying aesthetics across such media?",***

SQ2***. "What measurable constraints can be developed for the camera positioning parameters in a 3D VE?",*** *and*

SQ3***. "How can an approach incorporating aesthetic measurements be developed for finding an optimised range of camera parameter in a 3D VE?"***

9.1.1 Summary of Approaches

To answer these research questions four approaches were used. Firstly, a scoping literature review was carried out. The scoping literature review facilitated the understanding of how aesthetics had been defined in the past. It provided clarity in understanding the modern perspectives of aesthetics for digital medias and interactive digital medias. The second approach used roundtable discussions to obtain a qualitative analysis of opinions from a group of industry and academic experts. This included views from the experts in the field of digital media and interactive digital medias such as game designers, developers, player, and users. This thesis study included expertise from scholars, researchers, practitioners, and industry experts from the area of digital media, interactive digital medias and games. Thirdly, this study undertook the development and testing of an evolutionary algorithm. This algorithm incorporated the rules of composition as they are stated in relation to the rules of photography and cinematography, as a fitness function for optimisation of camera parameters in a 3D VE. The thesis used this algorithmic testing as a way of investigating the sustained suitability of the existing rules of cinematography and photography in terms of aesthetic values. The inclusion of the GA investigation in chapter 6 provides the study with valuable information in two important ways. In the first instance the thesis used the application of a genetic algorithm to test whether the *Rules of Cinematography* and the *Rules of Photography* would be sufficient in terms of aesthetic characteristics to definitively show that they could assist with the determination of an optimum camera position in interactive digital media.

It is a significant finding of this research that the rules of cinematography and photography are inadequate (on their own) for the purpose of successfully finding a location for the optimum camera position and camera viewpoint in a interactive digital media, such as, game. This information is supported by information from the scoping review as well as the expert opinions from digital media and interactive digital medias experts. It is a clear finding of this research that aesthetic characteristics are variable and can be found in a range of areas that are applied to interactive digital media (and in particular digital games).

This study developed and established a framework for defining the range of aesthetic views that can be applied to interactive digital media. These aesthetic features provide the basis for the advancement of human-based computerized systems for defining a range of aesthetic views for application within 3D VEs. It is a major finding of this research that the application of a framework (PCAWF) depicts the multivariable areas where aesthetic characteristics can impart a significant influence upon a piece of interactive digital media. This research finding has been described in terms of the interaction of four major elements within the PCAWF framework that define a pathway of application for aesthetic features and their interactions. The four key areas of application are the storyline, the user state, the type of gameplay, and the application. The application of this framework, in conjunction with the greatly improved understanding of widespread aesthetic features represents a novel interpretation of interactive digital media aesthetics.

A scoping literature review was carried out for this study which revealed different perspectives of aesthetics regarding various types of interactive digital media. From the literature it was found that the objective and subjective factors such as colour, symmetry, order and complexity, and statistical features amongst others, play an important role for defining aesthetic properties of artifacts. Objective features, such as, statistical features also laid a foundation for the development of the computational methods for assessment of aesthetics of other digital media such as digital photographs.

A set of preliminary experiments were conducted which extracted the statistical features (the deep learning features) of a photo quality dataset. This led to the publication of a paper that showed that the quality features of photo types were based on image categories and the context of each photo (Maqbool & Masek, 2021). This enabled the researcher to establish the need for a more feature-broad range of characteristics that would provide clarity and nuance to digital media in a variety of constructs and contextual variations. This was an important step in demonstrating a clear understanding of aesthetics from a rich collection of considerations.

Interactive digital media, such as, websites or web interfaces required an additional aesthetic factor, in the form of interactionism. Interactionist perspectives were shown to delineate the relationship between aesthetics and the perceived usability for interactions in interactive digital media. For digital media that focused on a gaming element the aesthetic factor was strongly related to camera placement. Camera placement was considered as an important aesthetic factor for better user engagement and immersion. Game-based camera placement was affected by the game type and the game genre, which was ultimately defined by the combination of aesthetic factors that could be applied to a wide cross-section of interactive digital media. To further investigate and analyse the aesthetic factors for interactive digital media such as games a qualitative analysis was undertaken.

9.1.2 Defining a broad set of aesthetic features

The qualitative study in this thesis was originally supported by key reference points that were found in the scoping literature review. These initial findings from the literature-based qualitative analysis pointed towards the fact that characterising aesthetics on one fixed criterion was not definable. Standards for aesthetics are not uniformly recognised to the same level of structure as the rules of photography and cinematography. Aesthetics includes a broader set of constructs and is inclusive of perspectives and attributes that are subjective and idiosyncratic. The responses recorded from the expert roundtables showed that many people remain unconvinced of the existence of clear distinct rules and rubrics that cover aesthetics. Instead, many responses pointed towards the need for a collective set of features that can define the range of characteristics that can be applied based on the type of interactive digital media designed and developed for any given user. This includes the expected usage and anticipated time of each interactive digital media experience. Importantly, this applies to the critical positioning of cameras, and the generation of camera views and viewpoints. In this sense the use of aesthetics are such dynamically driven features that they need to be used as a starting point, however they should be flexible enough to survive in terms of repeated usage and ongoing development. To further test these features, an algorithmic approach was developed using measurable constraints for this study.

9.1.3 Testing measurable aesthetic constraints using Genetic Algorithms

An optimisation method using Genetic Algorithm (GA) was developed using four measurable constraints defined for digital photography and cinematography. The four measurable constraints used were *Frame Bounds*, *Occlusion*, *Shotsize*, and the *Rule of Thirds (RoT)*. The visual results, obtained after the application of the optimisation method, showed that even after following the rules, there were visual results that were not always useful, and some changes were required according to the context and the story provided for defining aesthetics.

Similarly, applying only the composition rules such as the RoT is not always sufficient to improve engagement in a singular sense, but where other factors are considered, an advantage could be obtained through the combination of various aesthetically engaging mechanisms. This was especially clear in interactive digital media and digital games, where there can be many options available on how a specific camera view is selected for a particular gameplay. Choosing the right view for a portion of gameplay can make the experience more immersive and engaging for a user because it helps in building a story.

9.1.4 Factors that influence a holistic framework

From the study it was found that there was no single factor that defined these important differences. This study determined that there are four main factors that include the storyline, the user state, gameplay, and the knowledge application type that are used in combination for defining aesthetics for digital media such as games (see Chapter 8 Figure 8.1). These multivariable factors are key inclusions in the recognition of a Player-centric aesthetically weighted framework (PCAWF). There are also sub-factors associated with these main factors. The sub-factors associated with the storyline are character design, visual hierarchy, and VE design. The VE design depends upon the game pace that ultimately defines the time required for the development of a VE design. The sub-factors associated with the user states relate to whether they are active, passive, as well as a recognition of each users' approximate age group. The sub-factors associated with knowledge applications are described as learning, entertaining and a combination of both (edutaining). The sub-factors associated with gameplay are player centrism, and cinematic styles. These factors and sub-factors are responsible for providing the range of aesthetic views or viewpoints for the camera placement in a 3D VE.

9.2 Final Analysis

The challenging part for developing a games-like environment is the non-availability of any standardised systems. There are uniform standards for films cinematography and also for digital photography but not interactive digital media such as games, especially from the perspective of camera placement in a 3D VE. Currently the use of film cinematography has been applied in games to enhance user experience and engagement. The challenge that defines this study is the difficulty in creating a balance between the cinematography and gameplay aesthetics, because of the non-availability of well-described rules. This study provides evidence of the required attributes for defining the criteria that inform the range of aesthetic views for optimised camera placement in a 3D VE.

Guidelines such as the rules of photography and cinematography can be used as a starting point and an initial set of parameters. However, in order to find the range of aesthetic views or viewpoints from a combination of factors, this study presents the PCAWF framework (in Chapter 7) as a means of shaping and steering each media element towards a defined set of aesthetic features. The combination of features including the storyline, the user state, gameplay, and knowledge application type are critical for the definition of an appropriate aesthetically informed choice. Each factor consists of sub-factors for further elaboration for defining a range of aesthetic views or viewpoints. Using a combination of all or some of these factors is central for the pursuit of aesthetic criterion for choosing the range of viewpoints.

9.3 Research Answers – the key findings.

From the study it has been found, both from a quantitative and a qualitative perspective, that there is no single optimised position. Instead, the incorporation of aesthetic features demonstrates the need to consider each component within interactive digital media as part of a range of possible features, and therefore a range of possible camera positions. From this study it was found that the aesthetic characteristics of a view or a viewpoint are not defined by a single feature or factor. A combination of features and factors is required to define a range of aesthetic viewpoints for an enhanced user experience. Boundaries need to be set for defining the user experience based on the need to connect with the PCAWF framework. This study defines these criteria. It demonstrates their influence through a framework which provides steering and guidance in the determination of an optimised range of camera positions and viewpoints.

Chapter 10
Conclusion and Future Work

This chapter forms the conclusion to the results and findings that inform the research questions underpinning this body of work. The study answers the research questions asked at the beginning of this thesis. It provides a methodology which explains the means by which a mixed application of quantitative and qualitative approaches was used. It demonstrates the optimisation factors that influence aesthetically based camera position choices. This chapter also identifies the major limitations of this thesis, and future work that will evolve from this study.

10.1 Conclusion

This study has been carried out to answer the following main research questions. The principal research question was as follows: **How can a range of aesthetically optimised views be obtained for a 3D VE of an interactive digital media such as games?**

This research question queries several points within a single principal question. The question is seeking answers to optimised views, and within that question it suggests that one possible answer is that there is a single optimised camera position for different aspects. The findings of this thesis, both from a quantitative and a qualitative perspective show that there is no single optimised position. Instead, the incorporation of aesthetic features demonstrates the need to consider each component within interactive digital media as part of a range of possible features, and therefore a range of possible camera positions. This is a central finding. It demonstrates the significance of using a range of optima rather than a single optimum position.

From the study it was found that the aesthetic characteristics of a view or a viewpoint is not defined by a single feature or factor. A combination of features and factors are required to define a range of aesthetic views or viewpoints for an enhanced user experience. These elements are key in determining the value of these findings. They demonstrate the need for a wider set of rules, guidelines and definitions if the future of interactive digital media aspires to evolve automated systems that can intelligently determine elements such as the perfect camera position or the perfect viewpoint. This study finds that there are many aesthetic characteristics that go well beyond existing rules and guidelines and require a highly nuanced allocation of guiding principles to find a usable method of applying aesthetic features for the purpose of realism and authentic interpretations of an interactive digital media such as digital games.

The combination of features including the storyline, user, gameplay, and application type are critical to defining the reason for making an aesthetic choice. The selection of a range of aesthetic views or viewpoints is affected by four main sub factors and sub-factors associated with the main factors.

Boundaries need to be set for defining the user experience based on the need to connect with aesthetic criteria. This study defines these criteria.

The principal research question was further examined through three sub questions as follows:

Sub Question 1: How can aesthetics be defined for digital media and what criteria can be followed for applying aesthetics across such media.

This study concludes that the defining characteristics of aesthetically influenced choices within digital media are multi-variable and irregularly weighted. These characteristics were identified through a mixed methods approach which developed a framework that provides a pathway for the inclusion and omission of varying aesthetic factors. The range of aesthetic factors has been described in Chapter 4 and in Chapter 7 and is further discussed in corroborated terms in Chapter 8. The PCAWF framework demonstrates how aesthetically influential characteristics can be followed and the choices that can be applied to a digital media selection.

Sub Question 2: What measurable constraints can be developed for the camera positioning parameters in a 3D VE?

Measurable constraints, stated in Chapter 5 and Chapter 6 of this thesis, can be performed against the selection of an optimised range of camera positions in terms of some, but not all, aesthetic elements. This study showed that whilst it was possible to show algorithmically that camera positions could be chosen based on frame bounds, occlusion, shot size and the rule of thirds, the inclusion of other characteristics are both limiting and restrictive of an algorithmic selection of optimum camera ranges. These other characteristics are directly connected with multivariable factors within the storyline, user activity, cinematic or player centric gameplay, and the combinational application of educational or entertainment-oriented information.

Sub Question 3: How can an approach incorporating aesthetic measurements be developed for finding an optimised range of camera parameter in a 3D VE?

This study concludes that the full range of multi-variable aesthetic criteria provide a range of parameters for the selection of optimised camera positions, as given in Chapter 8. This is achieved by using the Player Centric Aesthetically Weighted Framework (PCAWF). The described criteria can be applied as filters and screens that shape and guide the optimised range of choices for camera positioning. The framework acknowledges a selection of photographic, cinematographic, player centric, knowledge-based and story-based factors.

This study informs the future of digital media interaction by providing clarity and reasoning behind the aesthetic decision-making inclusions that are integrated into automatically generated vision by providing a framework for choosing range of aesthetic viewpoints in a 3D VE of a game. The study identifies critical juxtapositions between photographic and cinema-based media aesthetics by incorporating qualitative rationales from experts within the digital media field. This research will change the way AI generated interactive digital media chooses visual outputs in terms of camera positions, field-view, orientation, contextual considerations, and user experiences. It will impact across all automated systems to ensure human-values, rich variations, and extensive complexity in the AI-dominated development and design of future digital media production.

10.2 Limitations of Study

Some limitations were encountered during data collection. During data collection it was analysed that the there was an overlap between the academic and industry professionals such as people working in game design and development in academia were also involved in game design and development for industry, for most of the participants. The use of more than 5 focus groups including 32 participants collected data from a broad range of industry and academic respondents. The number of respondents used was 32, and this defines the number at which it was felt that the response variations had reached saturation, and that there was little benefit in pursuing beyond the original focus group participants. It is possible that a larger group of respondents may have revealed other additional criteria.

Another limitation that was recognised became apparent through responses from some participants in the expert roundtables. Two of the respondents (out of 32) declared that they felt that their answers were incomplete because they were not specifically involved in the development of digital media or in games. It is possible that some respondents were incomplete in some answers in cases where participants were used that did not have digital media development experience.

One possible limitation is included here that recognises that when the genetic algorithms were created using measurable constraints, the research study only used the four constraints of *Frame Bounds, Occlusion, Shotsize,* and the *Rule of Thirds (RoT).* This was deemed to be a sufficient number and type of constraint, and it was determined that since these four constraints were unable to include other aesthetic features into a single optimum, the inclusion of other rules such as the 30-degree rule and the continuity rule would not show any additional aesthetic characterisations. It is possible that these exclusions are a limitation. It is possible that the study could be further enhanced by testing and applying other rules of composition and measurable constraints as given in (Roy, 1998).

10.3 Impact of Study

This study provides a framework (PCAWF) for finding the range of aesthetic views and viewpoints for placing a camera in a 3D VE. Placing a camera in a 3D VE is a time consuming and laborious task for directors and designers of interactive digital medias like game and films. The developed framework of this study facilitates designers and developers by highlights the important factors for finding the range of aesthetic views and viewpoints. The developed framework has the scope to be used for other digital media besides games and films, although there are other factors and constraints that can be considered.

This study forms the basis for an understanding of aesthetics that can be used to influence choices regarding camera viewpoints in digital media. It draws from the perspectives of experts and users from academia and industry with an emphasis on evaluating the application of rules of composition. This includes the rules of photography and cinematography. This study confirms that the application of rules alone, without consideration of the context it has been applied for, are insufficient for the purpose of creating an aesthetic experience for a user.

This study lays the foundations for the development of an automated aesthetics-based assessment system. Such a system will reduce the time and effort needed to create an aesthetically informed VE experience. The inclusion of multi-variable aesthetics factors are critical elements in the development of optimised digital media.

10.4 Future Work

The future work for this study may include the implementation of a framework for testing and evaluating digital media parameters and for reducing the time taken in the selection and placement of camera positions. The framework developed in this study emphasizes the importance of four main factors, that is storyline, user's type, gameplay, and application type, for defining the range of aesthetic views and viewpoints for an interactive digital media like games. This framework can also be modified and enhanced for development of other types of interactive digital media applications such as designing a website or mobile based applications. In such applications the gameplay might be skipped but other factors such as storyline, user's type and application type may be considered for making aesthetic decisions.

The future study also includes testing of each individual factors, given in a developed framework, for implementation and evaluation on different interactive digital media such as websites, and mobile application. This implementation for evaluation might also include the testing for non-interactive digital media applications.

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Appendix A

Preliminary Experiments for the Aesthetic Analysis

A.1 Preliminary Experiments for the Aesthetic Analysis of 2D Images

Preliminary experiments for aesthetic analysis of 2D images have been developed and tested using three pre-trained VGG16 (Simonyan & Zisserman, 2014) convolution neural network. The developed approach for image aesthetic analysis based on image categories shown in Figure A.1. During the experiments every image category of the CUHK-PQ database has been (Luo et al., 2011) considered separately for image aesthetic analysis. The approach for aesthetic analysis consists of two basic steps: First, feature extraction using three pre-trained VGG16 convolution neural network, and Second, classification of extracted feature vectors using J48 (Bhargava et al., 2013) and SMO (Cortes & Vapnik, 1995) classifier. Experiments are further divided into two parts, training phase and testing phase. In training phase classifier are trained separately for each image category whereas in the testing phase image categories are tested using trained classifiers. VGG16 convolution neural network has been used for feature extraction because it provides a good generalization for various image classification tasks and datasets (Simonyan & Zisserman, 2014), where more accurate results can be obtained as compared to other available deep neural networks (Simonyan & Zisserman, 2014).

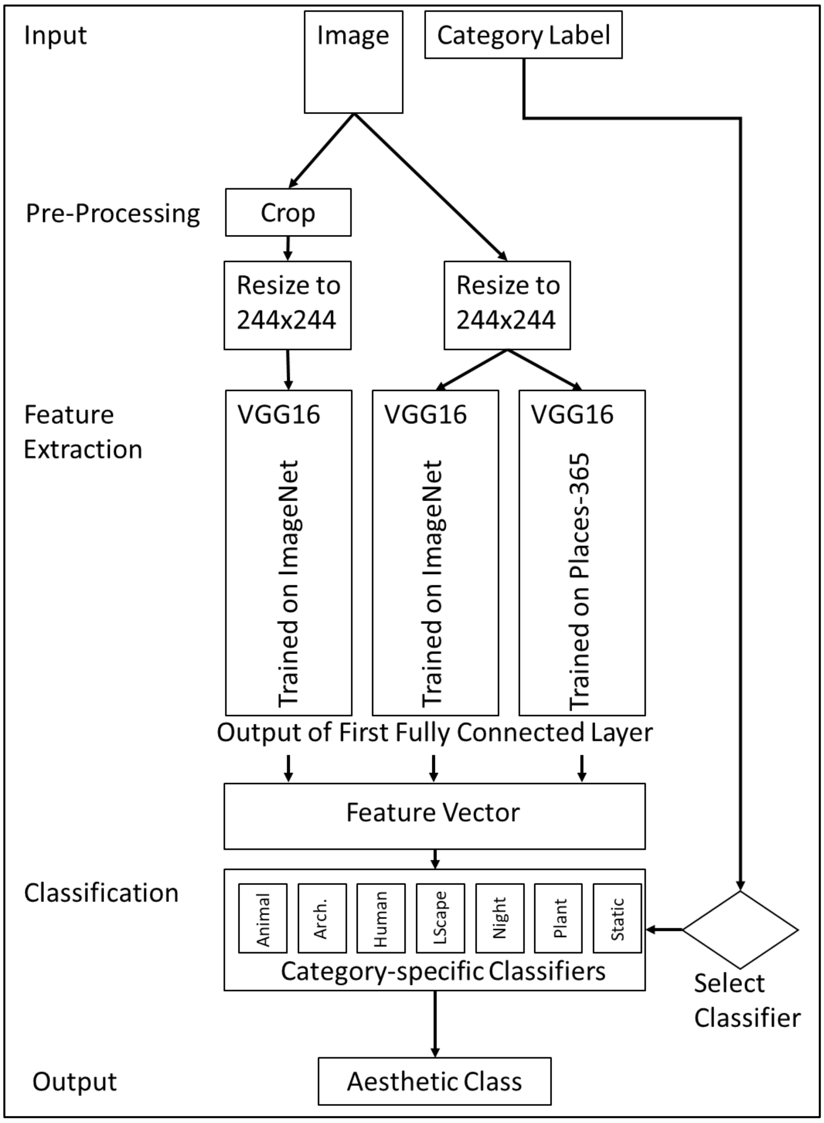


Figure A. 1 Developed approach for aesthetic analysis of images based on image categories (from the Conference Paper)

A.1.1 Feature Extraction

An image is given as input to three pre-trained VGG16 deep neural networks, two of deep neural networks were trained on the ImageNet dataset, and third one trained on the Places-365 dataset. The VGG16 deep neural network processes an input image, and from the first fully connected (FC) layer of the network three different features are extracted, namely Global features, Local Features and Scene-aware features. Details of deep learning features extracted are;

- **Global Features**

The pre-trained VGG16 deep neural network has been used for extracting the Global features. The VGG16 deep neural network is trained on 1.2 million images of the ImageNet dataset (Deng et al., 2009) for image classification. An effective set of features is extracted by given each image of the dataset as an input to VGG16 deep neural network. An image size 224×224 is fixed for input to the

VGG16 deep neural network. Top layers of the VGG16 deep neural network are convolutional layers, and the last three layers are fully connected layers. The Global features were extracted from the first fully connected (FC) layer of the VGG16 network. The length of the feature vector was 4096 for each image.

- **Local Features**

The Local features also play an important in the analysis of image aesthetics. For the Local features instead of giving the complete image as an input, an image centre is cropped with ratio of 0.62. The central part of the image is selected because the user mostly focuses on the centre of an image. These cropped images are then given as an input to the VGG16 convolution neural network pre-trained using ImageNet dataset (Deng et al., 2009) for image classification. The features are extracted in a similar way as global features by giving 224×224 images as input and extracting features from the first fully connected layer of the VGG16 convolution neural network. The length of the feature vector is 4096 for each image, which is saved for further processing.

- **Scene Features**

The Scene features or Scene-aware information also play an important role in analysing the contents of images for aesthetic assessment (X. Fu et al., 2018). VGG16 convolution neural network trained using the Places-365 dataset (Zhou et al., 2018) has been used for feature extraction. The pre-trained VGG16 scene recognition convolution neural network was given the complete image as an input with the image size of 224×224. The first FC has been used to extract the feature vector of length 4096, which was used for further processing.

A.1.2 Classification of Feature Vector

Images given as input are classified as a high aesthetics image or low aesthetics image using the classifier trained on each image category separately. Classifiers J48 and SMO are trained on each image category separately, and also trained by combining all image categories together. These trained classifiers are then tested for detail analysis of image aesthetics for each image category separately.

- **Dataset**

The CUHK-PQ dataset (Luo et al., 2011) has been used in this work. The CUHK-PQ originally (before the addition of another category "Yiwen" (Y. Luo & Tang, 2008)) consists of 4517 high-quality images and 13,156 low-quality images which are divided into 7 categories based on the contents of the images (W. Luo et al., 2011). The distribution of high-quality and low-quality images for each category is represented in Table A.1.

Table A- 1Distribution of High-Quality and Low-Quality images for CUHK-PQ database (from conference paper)

Image Categories	High-Quality Images	Low-Quality Images
Animals	947	2224
Architecture	595	1290
Human	678	2536
Landscape	820	1947
Night	352	1352
Plant	594	1803
Static	531	2004

A.1.3 Results of Experiments

Results for the classification accuracy of J48 and SMO classifier are shown and compared using the box and whisker plot represented in Figure A.2.

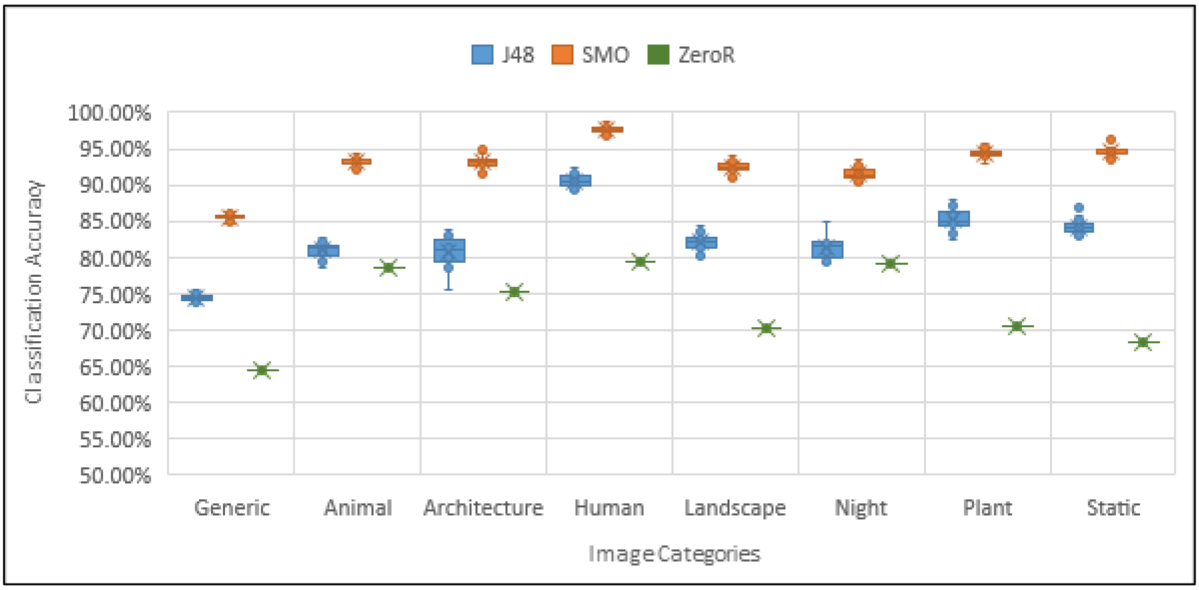


Figure A. 2 Box and Whisker Plot representing the classification accuracy for J48 and SMO classifier for Generic Classifier and image categories classifier separately (from conference paper)

Values for the ZeroR are used for establishing the baseline for J48 and SMO classification algorithms. The ZeroR is the simplest classification method which always chooses the majority category as a baseline (Nasa & Suman, 2012). The results of the J48 and SMO classification algorithms are compared with the ZeroR to determine the validity of the trained classifiers as a classifier that does not work better than the ZeroR is not considered for further testing of data. Results for the classifiers are summarized in Table A.2 and further discussed for understanding.

Table A- 2 Summary of Mean and standard deviation for all feature type (from conference paper)

Image Category	Classifier	Classification Accuracy (Mean and Standard deviation)
Generic	ZeroR	64.55%
	J48	74.56% ± 0.44%
	SMO	85.57% ± 0.34%
Animal	ZeroR	70.63%
	J48	81.05% ± 1.04%
	SMO	93.15% ± 0.58%
Architecture	ZeroR	68.44%
	J48	80.83% ± 1.84%
	SMO	93.12% ± 0.79%
Human	ZeroR	78.46%
	J48	90.57% ± 0.83%
	SMO	97.74% ± 0.43%
Landscape	ZeroR	70.40%
	J48	82.07% ± 1.13%
	SMO	92.39% ± 0.79%
Night	ZeroR	79.34%
	J48	81.21% ± 1.39%
	SMO	91.54% ± 0.89%
Plant	ZeroR	75.22%
	J48	85.24% ± 1.44%
	SMO	94.27% ± 0.73%
Static	ZeroR	79.06%
	J48	84.25% ± 0.95%
	SMO	94.69% ± 0.59%

The Box and Whisker plot have been drawn by taking thirty different values which are generated using thirty random testing and training sets for each image category for the combined Global , Local , and Scene. An output of the classifiers J48 and SMO were recorded thirty times to plot the Box and Whisker plot. The value of ZeroR remained constant whereas values with slightly varying classification accuracies were recorded for the J48 and SMO classifiers. The following box plot shows that the average accuracy for the "Generic" classifier, consisting of combined features for all the image categories, for J48 classifier is 74.56% and for SMO classifier is 85.57%. For "Animal" category J48 classifier gives the mean value around 81.05% and for SMO classifier 93.15% has been recorded. In the same way the mean classification accuracy for "Architecture" category for J48 classifier is 80.83%, and for SMO classifier it is 93.12%. Highest mean classification accuracy is recorded for "Human" category which is 90.57% for J48 classifier and 97.74% for SMO classifier whereas the mean classification accuracy for "Landscape" for J48 is 82.07% and for SMO it is 92.39%. Similarly, the mean classification accuracy for "Night" is 81.21% for J48 classifier and 91.54% for SMO classifier and the mean accuracy for “Plant” and “Static” for J48 classifier is 85.34% and 94.27%, whereas for SMO classifier the mean classification accuracy for the similar categories is 94.27% and 94.69% respectively. From the Box and Whisker plot we can see that the results for SMO classifier are significant. Moreover, when image categories are considered separately the classification accuracy increases for the individual categories. Therefore, better results can be obtained if image category based aesthetic analysis is carried out.

The importance of image categories and extracted feature type on the classification of images based on aesthetic quality has been analysed in this research article. Three different features were also tested during the analysis and the important role of features in the aesthetic quality of images were assessed. From this study, it is concluded that the image category consideration plays an important role in the aesthetic analysis of images and type of feature chosen also affect the classification results of data. Global features and Local features both cover most of the information from the images for aesthetic analysis, but Scene features also play an important role in separating images of high aesthetic value from low aesthetic values.

Appendix B

Model File Formats Supported by Unity3D

Model file formats supported by Unity3D Game Engine in given in Table C.1 of this appendix. The table has been adopted from (Haas, 2014) and also from https://docs.unity3d.com/2020.1/Documentation/Manual/3D-formats.html. This Unity document contains all the information regarding the file formats supported. Two different types of files unity support for importing meshes and animation. First is Exported 3D file formats, like ". fbx" or ".obj", and second is proprietary 3D also known as DCC (Digital Content Creation) application files, like ".max" or ". blend". There are both advantages and disadvantages of files formats used in Unity 3D.

Table B. 1 3D Package Support for Unity3D Game Engine

	Tool	Meshes	Textures	Animations	Bones
".mb" and ".ma"	Maya	×	×	×	×
".max"	3D Studio Max	×	×	×	×
".jas"	Cheetah 3D	×	×	×	×
".c4d"	Cinema 4D	×	×	×	×
".blend"	Blender	×	×	×	×
".lxo"	Modo	×	×	×	×
Autodesk FBX	Autodesk FBX	×	×	×	×
COLLADA	COLLADA	×	×	×	×
Carrara	Carrara	×	×	×	×
Ligthwave	Ligthwave	×	×	×	×
XSI 5.x	XSI	×	×	×	×
Sketchup PRO	Sketchup PRO	×	×		
Wings 3D	Wings 3D	×	×		
".3ds"	3D Studio	×			
".obj"	Wavefront	×			
".dxf"	Drawing Interchange Files	×			

Image Formats	Photoshop ".psd" and ".tiff" are imported
	JPEG, PNG, GIF, BMP, TGA, IFF, and PICT are amongst others
Supported Audio and Video Formats	MP3, Ogg, AIFF, WAV, MOD, IT, S3M, and XM amongst others Video MOV, AVI, MPG, MPEG, and MP4VIDEO amongst others.
Other supported formats	.html or .txt files format can be referenced during runtime

Appendix C

Information Letter and Consent Form for Qualitative Study

C.1 Information Letter

Chief Investigator: Hira Maqbool
School of Science
Edith Cowan University
270 Joondalup Drive
JOONDALUP WA 6027
[redacted]

EDITH COWAN UNIVERSITY AUSTRALIA

Participant Information Letter

Project title: Aesthetic standards for Digital Medias

Approval Number: 2020-03468-MAQBOOL

Principal Investigator: Hira Maqbool, Supervisor Dr. David Cook

An invitation to participate in research

You are invited to participate in a project titled "Aesthetic standards for Digital Medias" which seeks to gather a range of different views and perspectives about the ways in which digital media is perceived in terms of Aesthetics. You are being asked to take part in this project because you are either a user, a gamer, a developer, a teacher, or an academics involved in Digital Media. This research project is being undertaken as part of the requirements of a PhD at Edith Cowan University.

Please read this information carefully. Ask questions about anything that you do not understand or want to know more about. Before deciding whether or not to take part, you might want to talk about it with a relative or friend.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:

- Understand what you have read
- Consent to take part in the research project
- Consent to be involved in the research described
- Consent to the use of your personal information as described.

What is this project about?

This research concerns people who use, play with, develop, or teach using digital media. It aims to find standards about the incorporation of aesthetics that can be applied to the use of Digital Media. This study is designed to gather a range of different views and perspectives about the ways in which digital media is perceived in terms of Aesthetics. This is a broad concept that has many different ideas but has no universally accepted definition. Almost everybody has a different appreciation of what they see and how they interact with digital forms of media. This study seeks to understand the importance of aesthetics. It will take views collected from knowledgeable participants from both industry and academia in the interaction with a broad range of digital medias.

This study looks at two important perspectives about aesthetics using digital media. The first area looks at the industry understanding of aesthetics with developing technology and considers various standards that are used in industry. The second area considers a theoretical understanding of developing technology and asks about the professional importance of aesthetics through formal pathways. Together these two perspectives of research will provide a fresh, clear snapshot of the way in which aesthetics standard are applied. This study seeks to combine industry and academia in terms of these important aesthetic perspectives.

What does my participation involve?

Your participation in this research project will involve attending a single roundtable discussion. There will be two round table discussions and you will be invited to one or other of these. The roundtable discussion is aimed to understand different perspectives of aesthetics. Each discussion will provide a set of constraints that will allow participants to discuss different views about aesthetics in digital media. Roundtables are held in relaxed environments where people can swap and share recollections, perceptions, and thoughts about the way they understand digital media aesthetics. Questions are open ended and the responses should be in the form of a discussion with others.

If you decide to participate in these roundtable discussions, you will not be personally identified in the study or final report. Your identity will remain confidential. The roundtables will take approximately 60 - 90 minutes and will require you to attend a location (Either Mt Lawley campus or Perth CBD), where one of the roundtable discussions will be held. All participant responses will be de-identified to ensure confidentiality. All responses will be coded and will contribute to a data collection of research, so no individual responses can be drawn to associate with any individual or sub-group of the overall data collection. No individual identifiable responses will be made available. The information will be stored in a secure environment (ECU has an encrypted cloud storage facility) and will only be accessible by the Research team. All your responses will be de-identified and any information provided will only be used for the purposes of this research. The roundtables will be conducted by a moderator who will not be in possession or know any identifiable information about any of the participants. All recorded data and information will be stored and removed according to ECU Policy.

Do I have to take part in this research project?

Your participation in this research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at any time before the final results are made publicly available.

If you do decide to take part, you will be given this Participant Information Letter and Consent form to sign and you will be given a copy of the information letter to keep. Your decision to take part, or to take part and later withdraw, will not affect your relationship with the research team and another partner involved in this study.

Your privacy

By signing the consent form, you consent to the research team collecting and using personal information about you for the research project. Any information obtained in connection with this research project that can identify you will remain confidential. All responses will be coded and will contribute to a data collection of research, so no individual responses can be drawn to associate with any individual or sub-group of the overall data collection. No individual identifiable responses will be made available. The information will be stored in a secure environment (encrypted cloud storage) and will only be accessible by the Research team. Your responses will be de-identified and any information provided will only be used for the purposes of this research. The roundtables will be conducted by a moderator who will not be in possession or know any identifiable information about any of the participants. All recorded data and information will be stored and removed according to ECU Policy. Your information will not be used for similar future research.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, except where requested for specific reasons, and then you will be asked to provide written consent.

In accordance with relevant Western Australian privacy and other relevant laws, you have the right to request access to the information about you that is collected and stored by the research team. You also have the right to request that any information with which you disagree be corrected. This study adheres to the guidelines of the ethical review process of Edith Cowan University. You are free to discuss your participation in this study with the Chief Investigator (contactable on [redacted]). If you would like to speak to an officer of the University not involved in the study, you may contact the Ethics Officer on 63042170. Please retain a copy of this information sheet for your future reference.

All data collected will be kept in accordance with ECU's Data Management Guidelines and any other records will be stored as required in ECU's Records Management Policy. Electronic data will be stored on a secure Microsoft SharePoint site provisioned by ECU's IT Services. The data will be de-identified and retained for a minimum of 7 years for time required for your project depending on the data collected and destroyed, if appropriate at the end of the retention period.

Possible Benefits

This research may not provide benefit to you personally but may provide benefits for people with working in industry of educational games and human computer interaction field in the future.

Possible Risks and Risk Management Plan

There are no known risks to participating in this research project.

What happens when this research study stops?

We will advise you of the outcomes via the contact details you provide. We also intend to publish the results and data in research journals and repositories and present them at research conferences locally, nationally and internationally. Your name or any other identifying information will not be included in any of the datasets, publications or presentations.

Has this research been approved?

This research project has received the approval of Edith Cowan University's Human Research Ethics Committee, in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)*. The approval number is *2020--MAQBOOL*

Contacts

If you would like to discuss any aspect of this project, please contact the following people.

Chief Investigator **Supervisor (if applicable)**

Hira Maqbool
PhD Student
Edith Cowan University
[redacted]

Dr. David Cook
Supervisor
Edith Cowan University
[redacted]

If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Independent Person
Research Ethics Support Officer
Edith Cowan University
P: 6304 2170
E: research.ethics@ecu.edu.au

If you wish to participate in this research, please sign the Consent Form and return to [redacted]

Sincerely,

Hira Maqbool

Chief Investigator

C.2 Consent Form

Chief Investigator: *Hira Maqbool*
School of Science
Edith Cowan University
270 Joondalup Drive
JOONDALUP WA 6027
Email: [redacted]

Participant Consent Form

Project title: Aesthetic standards for Digital Medias
Approval Number: 2022-03468-MAQBOOL
Principal Investigator: Hira Maqbool, Supervisor Dr. David Cook

I, ___________________________________ have read the Participant Information Letter.

By signing this consent form, I acknowledge that I:

- have been provided with a copy of the Participant Information Letter, explaining the research study
- have read and understood the information provided
- have been given the opportunity to ask questions and have had questions answered to my satisfaction
- can contact the research team if I have any additional questions
- understand that participation in the research project will involve:

- This research project will involve roundtable discussions that are aimed to gather thoughts about various perspectives of aesthetics.
    - The roundtable discussions will discuss aesthetics in digital media.
    - The roundtables will take approximately 60-90 minutes and will require you to attend a location where one of the roundtable discussions will be held (Either Mt Lawley Campus ECU or Perth CBD).
    - The roundtable will have the discussion recorded, and then transcribed into text. This will the removal of all identifying names and objects. This ensures that the data is collected under anonymous conditions.
- understand that the information provided will be kept confidential, and that my identity will not be disclosed without consent
- understand that I am free to withdraw from further participation at any time, without explanation or penalty
- freely agree to participate in the project
- The data collected for the purposes of this research project may not be used in further approved research projects without my consent.
- The data collected may be used only for the purposes of this research project.

I agree to have my conversations digitally recorded

Yes ☐ *No* ☐

Participant name: ______________________________

Signature: ____________________ Date ____________

Approval to conduct this research has been provided by the Edith Cowan University's Human Research Ethics Committee, approval number 2022-03468-MAQBOOL, in accordance with its ethics review and approval procedures.

Appendix D

List of Constructs for Qualitative Data Analysis

Appendix D states the details of constructs used for data gathering in qualitative part of this study. Figure D.1 is the introductory presentation slide used for roundtables. This slide sets the background for the need to conduct qualitative analysis. Details of the constructs used for gathering data for this part of the study are stated below from Section D.1 to Section D.11.

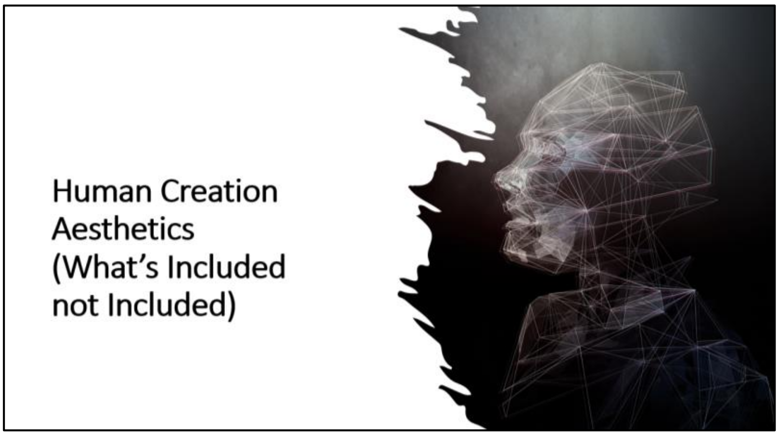


Figure D. 1 Introductory slide for the Qualitative study

D.1 Construct 1 (Appx D, C1)

The presentation slide for Construct 1 is given in Figure D.1. Construct 1 was related to the aesthetics in general. The question on this slide asks participants to choose between Figure 1 and Figure 2 based on their aesthetic preferences. Participants were also encouraged to comment on the reason for choosing between pictures. The question that was asked from participants was "This slide is about aesthetics in general. Two images are of the same objects. If one is more aesthetic than the other – which one, is it? And why?"

Figure D. 2 Presentation slide for Construct 1 of Qualitative Analysis

D.2 Construct 2 (Appx D, C2)

Presentation slide for construct 2 is given in Figure D.3. Construct 2 was about importance of user experience in design and development of the digital media applications. The question stated on the slide was “This slide asks you to think about being a user or being a developer. Which is more important when it comes to the inclusion and engagement with aspects that are aesthetic? Is it more important to include at the development stage or is it more important to allow the user to choose his or her interaction? And why?”

Figure D. 3 Power point slide for Construct 3 of Qualitative Analysis

D.3 Construct 3 (Appx D, C3)

Construct 3 is based on the Rules of Composition. First few slides were presented to provide the brief introduction to the Rules of Composition. The presentation slides for Construct 3 are given below from Figure D.4 to Figure D.8. The first three introduction slide included a simple explanation for rules of composition such as frame bounds, occlusion, Shotsize and the Rule of Thirds. The question stated on the slide was “Is there a room to consider aesthetics from the point of Rules of Composition (Framebounds, Occlusion, Shotsize, and the Rule of Thirds). Both two images (Figure 1 and Figure 2 in Figure D.8) follow the Rule of Thirds-but which one is better and why?”

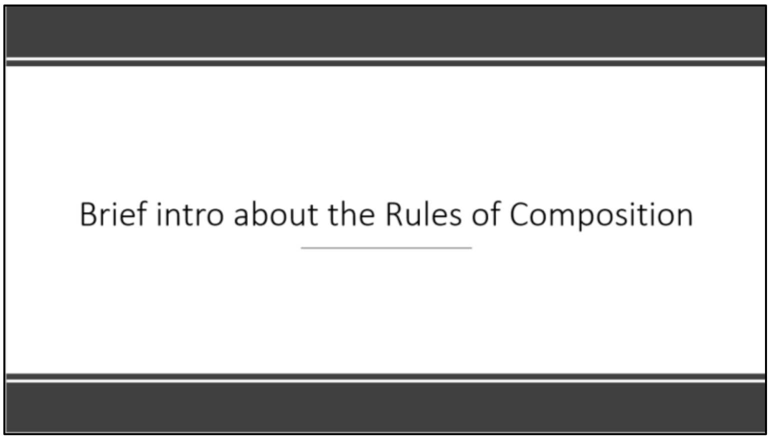


Figure D. 4 Introductory slide to the Rules of Composition

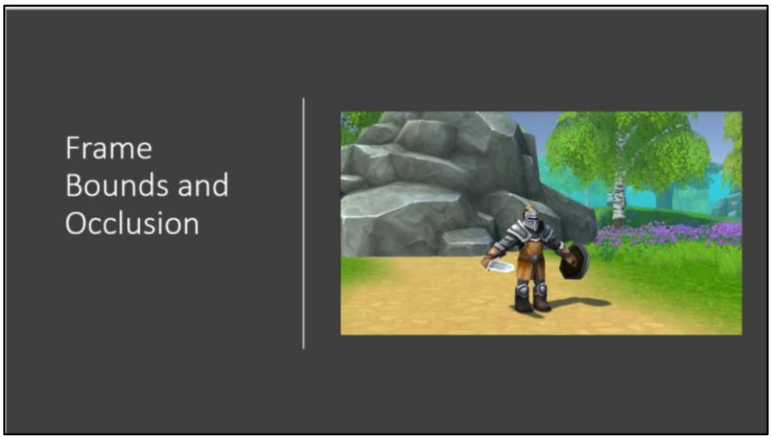


Figure D. 5 Introductory Slide for Frame bounds and Occlusion

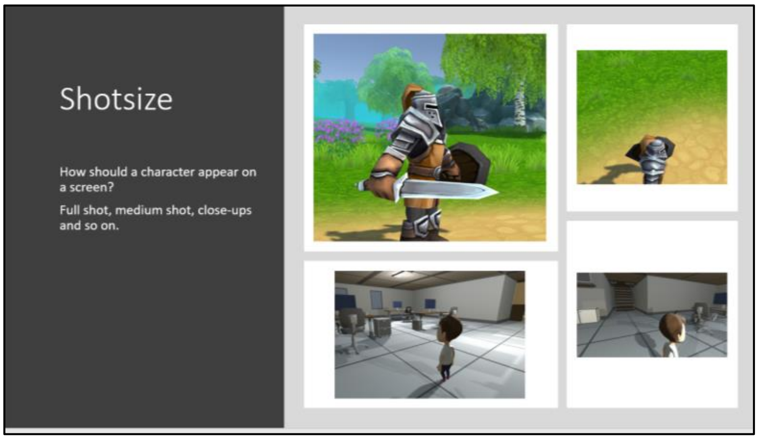


Figure D. 6 Introductory Slide for Shotsize

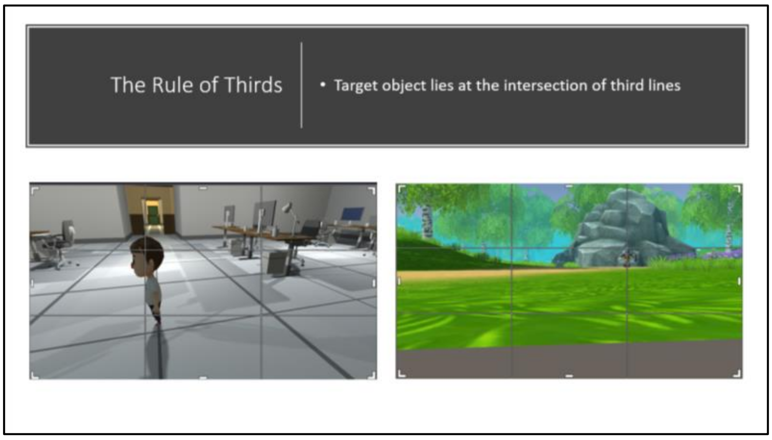


Figure D. 7 Introductory Slide for the Rule of Thirds

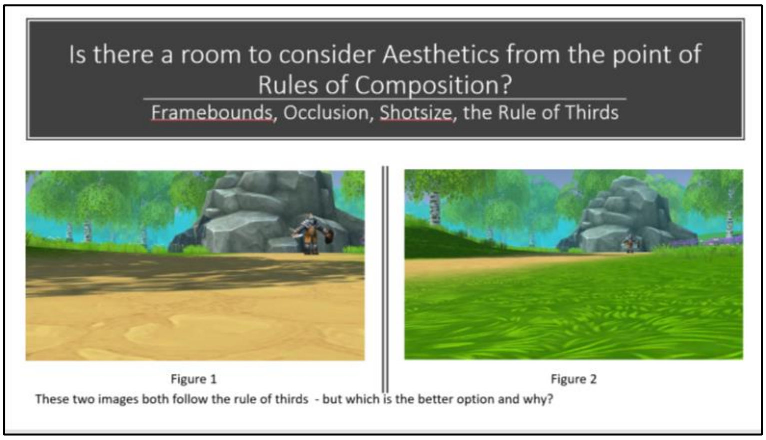


Figure D. 8 Power point slide for Construct 3 of Qualitative Analysis

D.4 Construct 4 (Appx D, C4)

Construct 4 was also based on the rules of composition. The presentation slide for construct 4 is given in Figure D.9. The question stated on the slide for construct 4 was "In this slide the Field of view (Fov) has been reduced in order to get the character within frame. Can we throw out the rules of composition for the sake of an improved Aesthetic? Or does this lead to chaos and disorder if we do this throughout a sequence of video or gameplay? Why?"

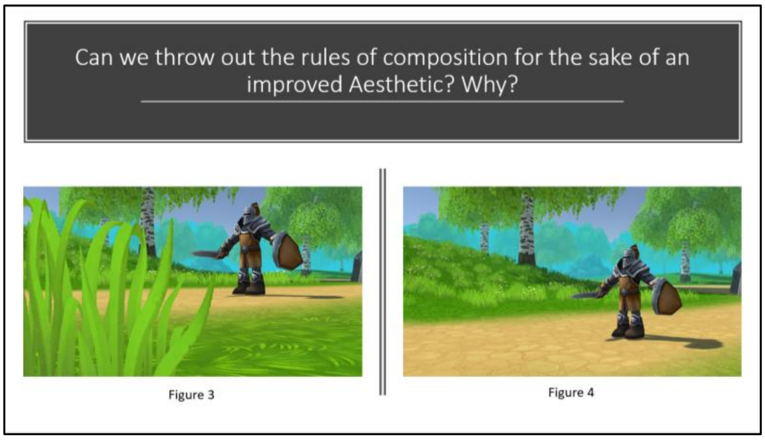


Figure D. 9 Power point slide for Construct 4 of Qualitative Analysis

D.5 Construct 5 (Appx D, C5)

Presentation slide for construct 5 is given in Figure D.10. This slide asks participants about time spent on incorporating aesthetic elements in the video composition. The question for construct 5 was "Both slides show a target object – but one has a narrow field of view – whilst the other has a wide field of view. Should designers deliberately choose to add aesthetic qualities to increase engagement and satisfaction, or should the gameplay drive the type of engagement? Can developers spend too much time in incorporating aesthetic elements into video composition? And why?"

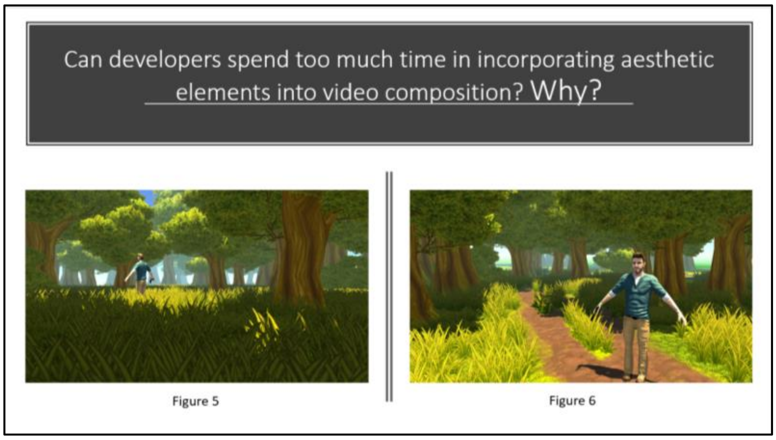


Figure D. 10 Power point slide for Construct 5 of Qualitative Analysis

D.6 Construct 6 (Appx D, C6)

Presentation slide for construct 6 is given in Figure D.11. This construct was based on placing multiple target characters on the screen. This construct asks participants to comment on aesthetics for a multiplayer game. The question for construct 6 was "When there are multiple target objects on the screen, what level of Aesthetic detail is better for engagement? If we follow the rules of composition – the image on the left should be followed. Do you agree with these rules – or are there other factors where aesthetic elements are in play? And why?"

Figure D. 11 Power point slide for Construct 6 of Qualitative Analysis

D.7 Construct 7 (Appx D, C7)

Presentation slide for construct 7 is given in Figure D.12. Construct 7 consisted of a small 30 second YouTube (www.youtube.com) video clip. A part of the video clip was taken from (Brown, 2019) video. He describes different aspects of camera aesthetics based on game genre and type. Different examples of cameras setting were described in this video. The question for construct 7 was "What are the most challenging areas in game design? Is it game camera design for aesthetics? And why?"

Figure D. 12 Power point slide for Construct 7 of Qualitative Analysis

D.8 Construct 8 (Appx D, C8)

Presentation slide for construct 8 is given in Figure D.13. Construct 8 also consists of a small 30 second video clip from YouTube (www.youtube.com) from (ChalkBites, 2020). This video is a virtual reality (VR) based training simulator for training people for Forklift operation. The question for construct 8 was "Aesthetic composition rules for training simulator will work? and why?"

Figure D. 13 Power point slide for Construct 8 of Qualitative Analysis

D.9 Construct 9 (Appx D, C9)

Presentation slide for construct 9 is given in Figure D.14. This construct was about placing a camera in a 3D VE. The question that was asked was "If we are placing a camera in a 3-dimensional area-what might be the best place for it to be positioned?

- Should it be player centric? or
- Should it be according to the industry standards of aesthetics? or
- Should it follow the rules of cinematography? or
- Does it require a combination of choices?"

Participants were also asked to name any known industry standards, if they know any or anyone has followed any standards.

Figure D. 14 Power point slide for Construct 9 of Qualitative Analysis

D.10 Construct 10 (Appx D, C10)

Presentation slide for construct 10 is given in Figure D.15. Construct 10 asks participants to discuss the type of challenges they have faced during game design and development. In case of gameplayers, the participants were asked if they had faced any challenges as a gameplayer.

Question asked for construct 10 was "Past years have meant changes that have been introduced in the way digital games have been designed. Thinking about the way we are optimizing camera aesthetics

- What are the challenges faced by the designers of games?
- What are the most challenging areas to these changes?
  - Using cinematography?
  - Developing player centric approach?
  - Designing industrial standard of aesthetics? or
  - being able to show them on demand?"

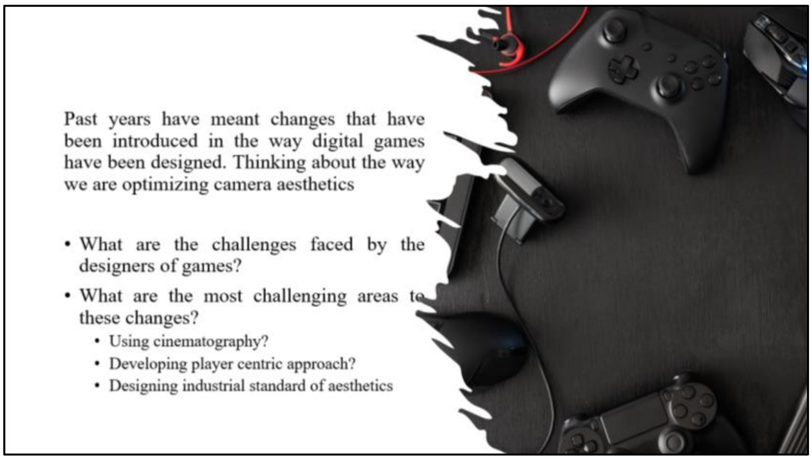


Figure D. 15 Power point slide for Construct 10 of Qualitative Analysis

D.11 Construct 11 (Appx D, C11)

Presentation slide for construct 11 is given in Figure D.16. This was the last construct used for data gathering in a qualitative part of the analysis. This construct asks participants to provide their opinion on incorporating Artificial Intelligence (AI) for placing a camera in a 3D VE. The question asked for construct 11 was "From the point of view of camera placement, that is an AI driven. One of the reasons is that AI currently doesn't understand the relevance of aesthetics. Based on this how AI might be looking for an optimum camera position on any given situation? Do you have any comments that comes to mind?"

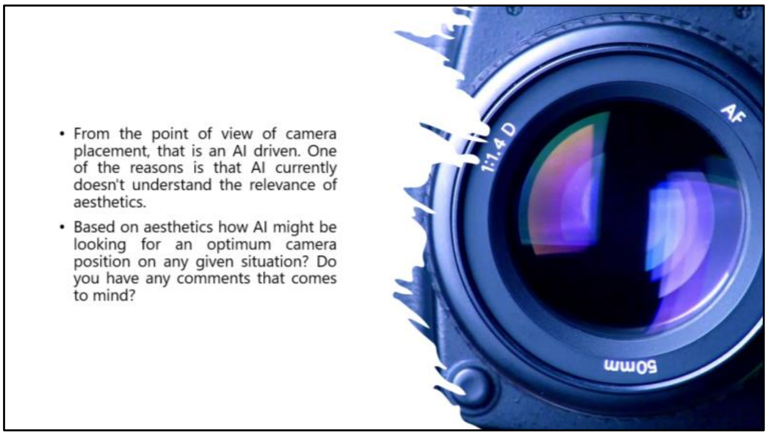


Figure D. 16 Power point slide for Construct 11 of Qualitative Analysis

At the end of each roundtable participants were asked if they want to give any final comments on this discussion. They were also asked to give their opinion on the constructs used for the interviews and give any concluding remarks.

Appendix E

Collection of all Visual and Graphical Results of the Different Seeds for Genetic Algorithm (GA)

This appendix states all the visual and graphical results for the Genetic Algorithm (GA) implemented. All results for the GA were not discussed in Chapter 6. In Chapter 6 some of the results were added for discussion. Rest of the results obtained for different seeds used for generating optimized images for GA and VEs tested are given in this appendix.

E.1 Visual and Best vs. Average fitness plot Results for Frame Bounds

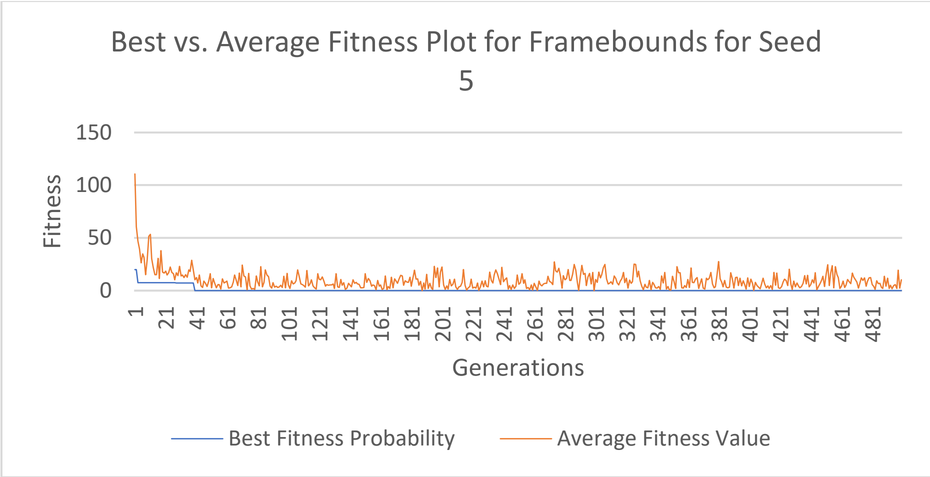
Section E.1 of this appendix stated the results for Frame bounds implemented using GA. Results stated here are for three different seeds tested for GA. These three seeds were 5, 20, and 100. Results were generated for three different VEs. Visual results along with best vs. average plots are given below.

E.1.1 First Virtual Environment (VE)

E.1.1.1 Results for Seed 5

This section states the results for frame bounds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.1. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)

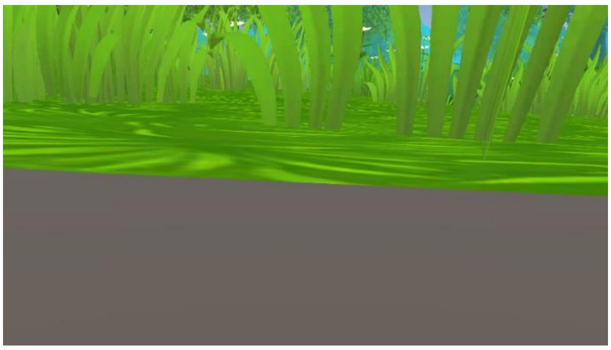


(b)

Figure E. 1 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE 500 generations for Framebounds (Seed 5)

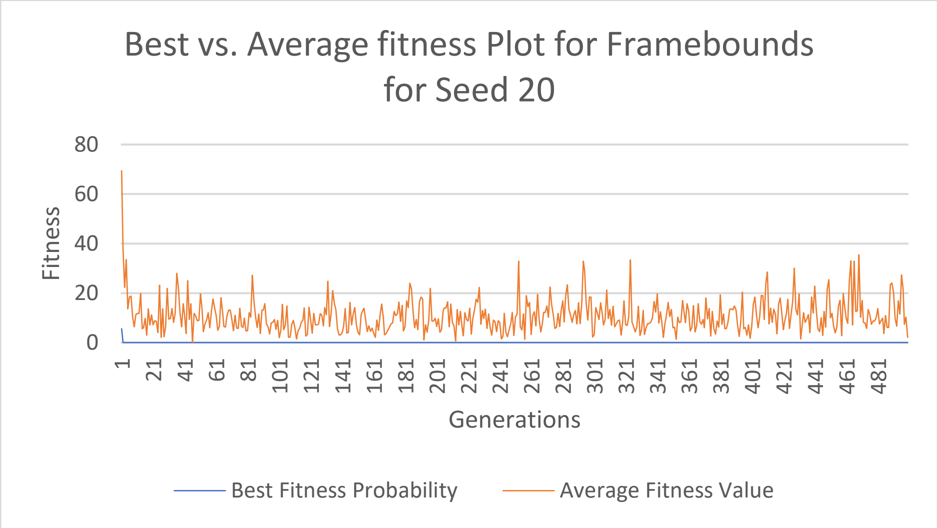
E.1.1.2 Results for Seed 20

This section states the results for frame bounds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.2. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.



(a)

(b)



(c)

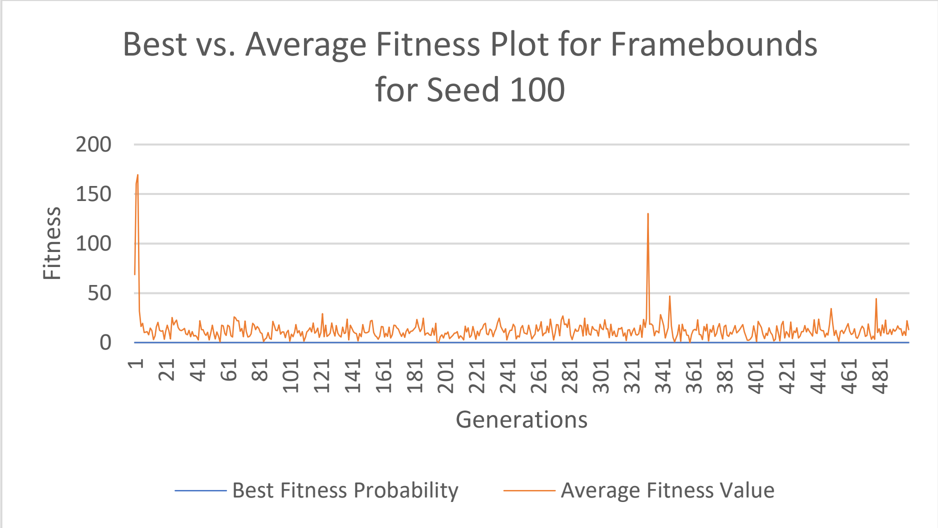
Figure E. 2 Visual Results (Figure a, and Figure b) and Best vs. Average Fitness plot (Figure c) for first VE for Framebounds. (Seed 20)

E.1.1.3 Results for Seed 100

This section states the results for frame bounds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.3. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

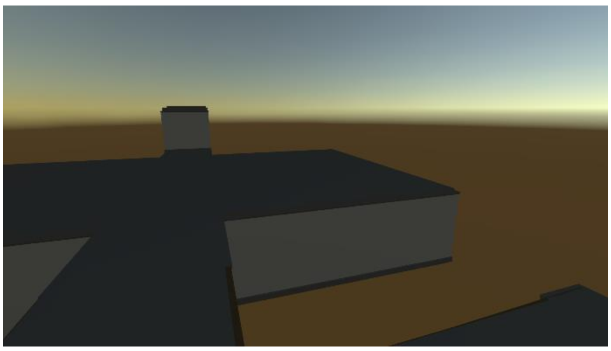
Figure E. 3 Visual Results for Frame bounds for first VE (a and b). Two different optimum viewpoints according to fitness function given in Equation 5.1 and 5.2. Part c best vs. average fitness plot for first 500 generations (Seed 100)

E.1.2 Second Virtual Environment (VE)

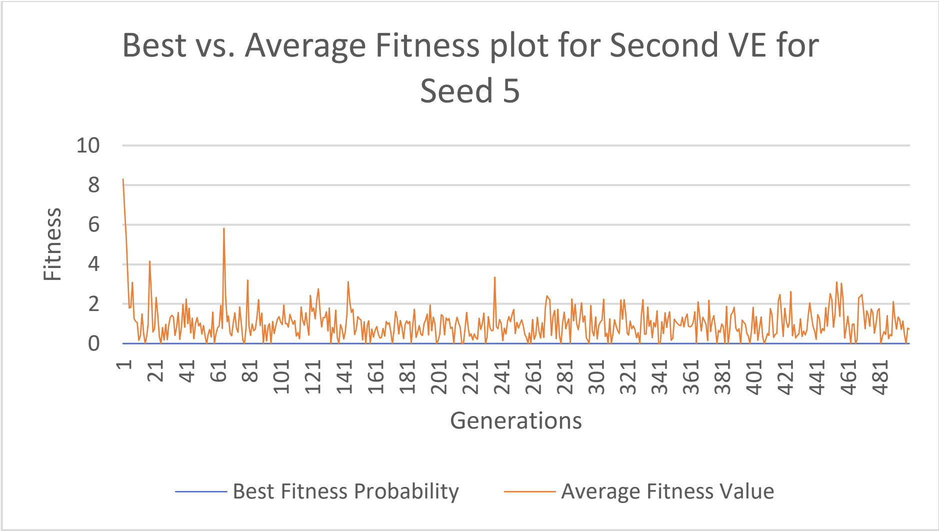
Following are results for Frame bounds for VE two. From Figure E.4 (Part a) although the conditions for Frame bounds are satisfied still the character is not visible in the frame. So, condition of Frame bounds alone is not sufficient to get the viewpoint of character within that camera frame.

E.1.2.1 Results for Seed 5

This section states the results for frame bounds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.4. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



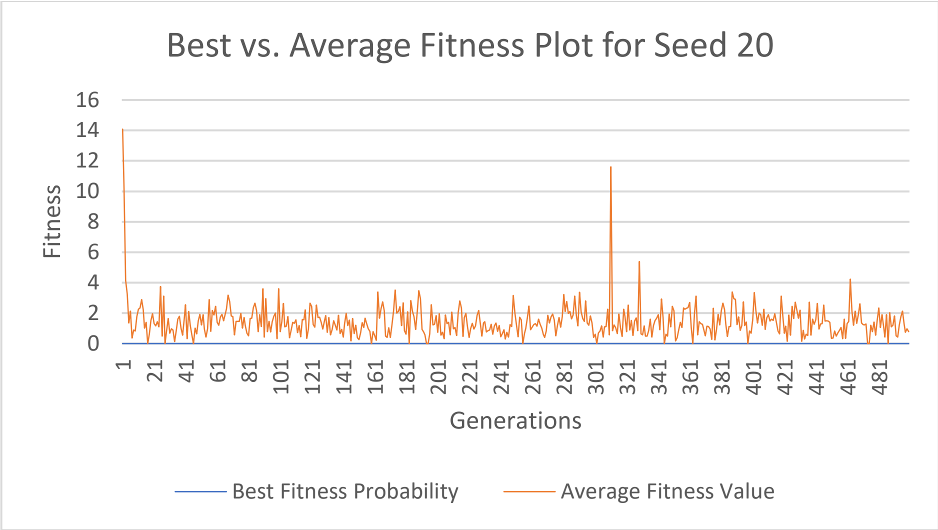
(b)

Figure E. 4 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for Second VE for 500 generations for Framebounds (Seed 5)

E.1.2.2 Results for Seed 20

This section states the results for frame bounds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.5. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)

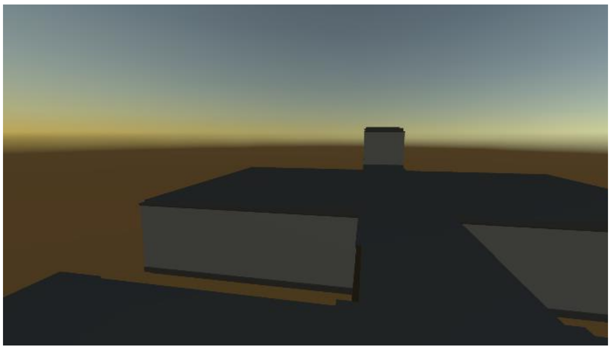


(b)

Figure E. 5 Visual Results (Figure a) and Best vs. Average Fitness plot (Figure b) for Second VE for Frame bounds (Seed 20)

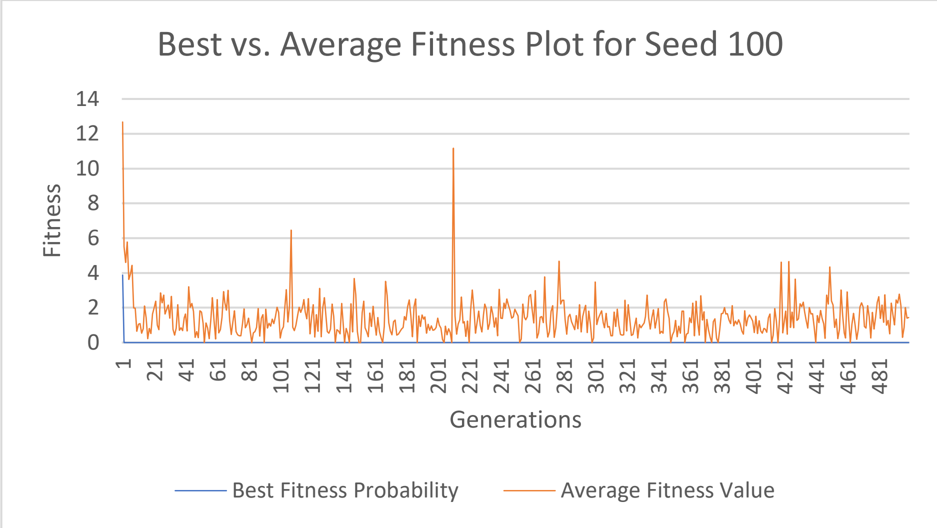
E.1.2.3 Results for Seed 100

This section states the results for frame bounds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.6. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.



(a)

(b)



(c)

Figure E. 6 Visual Results (a and b) for Framebounds for second VE. Two different optimum viewpoints according to fitness function given in Equation 5.1 and 5.2. Best vs. Average fitness plot (Figure c) for first 500 generations (Seed 100)

E.1.3 Third Virtual Environment (VE)

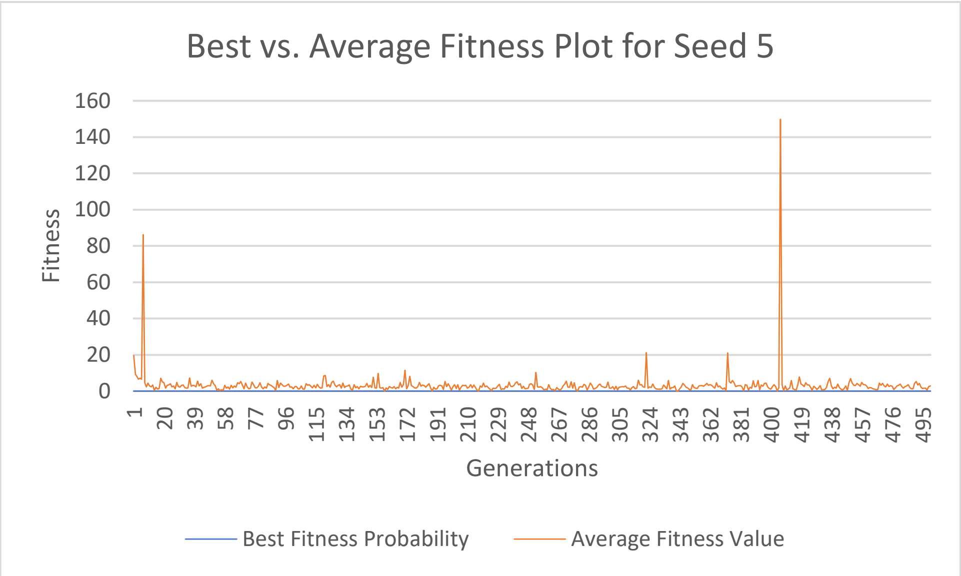
Following are results for Frame bounds for Virtual Environment (VE) three.

E.1.3.1 Results for Seed 5

This section states the results for frame bounds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.7. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

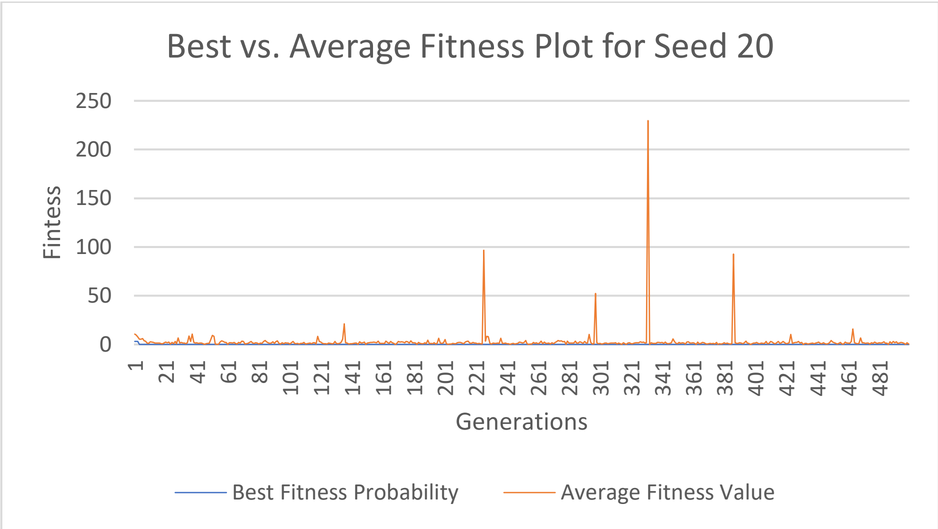
Figure E. 7 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for third VE for 500 generations for Frame bounds (Seed 5)

E.1.3.2 Results for Seed 20

This section states the results for frame bounds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.8. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



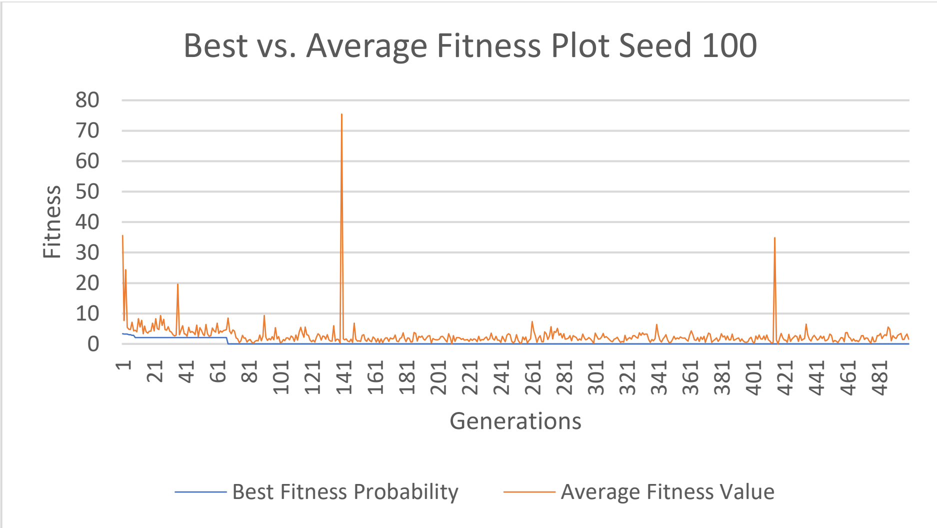
(c)

Figure E. 8 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for third VE for 500 generations for Frame bounds (Seed 20)

E.1.3.3 Results for Seed 100

This section states the results for frame bounds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.9. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

Figure E. 9 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds (Seed 100)

E. 2 Visual and Best vs. Average fitness plot Results for Frame Bounds + Occlusion

Results were generated for three different VEs. Visual results along with best vs. average plots are given below.

E.2.1 Results for First Virtual Environment (VE)

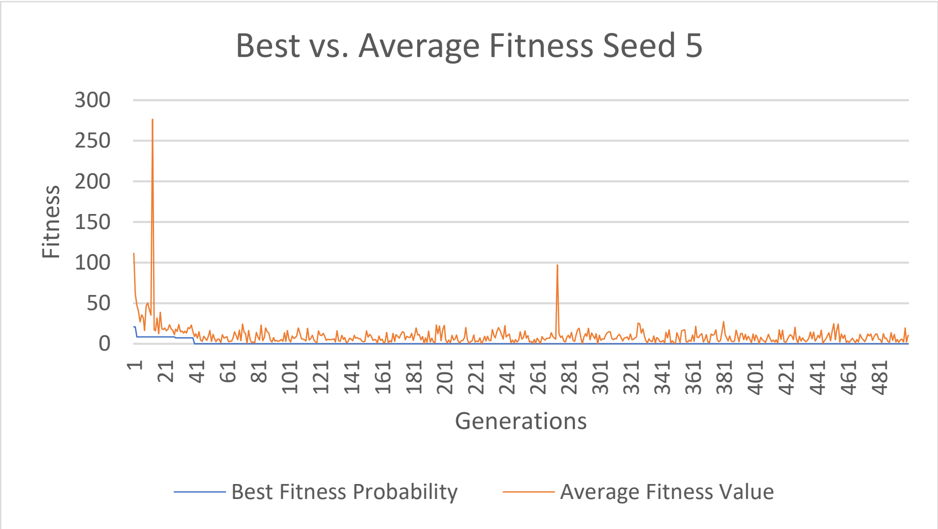
Following are results for Frame bounds + Occlusion for Virtual Environment (VE) 1.

E.2.2.1 Results for Seed 5

This section states the results for frame bounds + occlusion for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.10. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

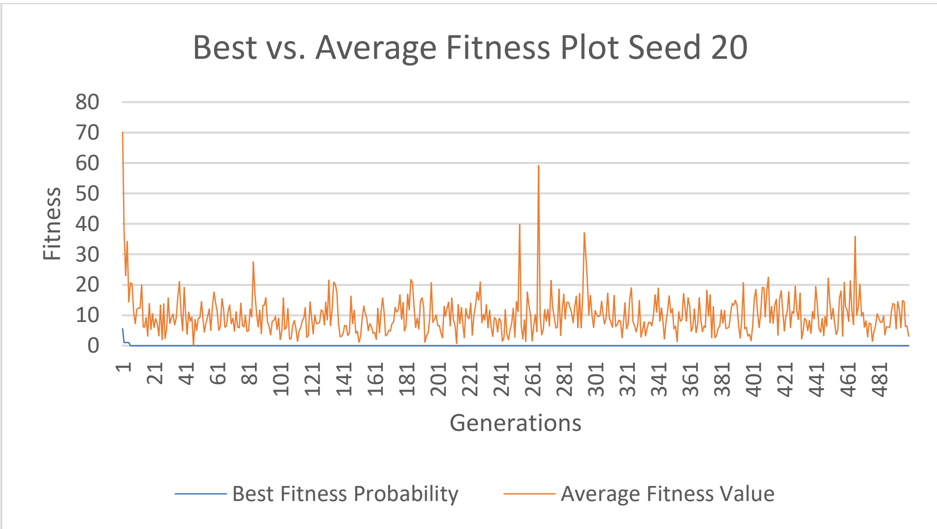
Figure E. 10 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for first VE for 500 generations for Frame bounds + Occlusion (Seed 5)

E.2.2.2 Results for Seed 20

This section states the results for frame bounds + occlusion for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.11. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

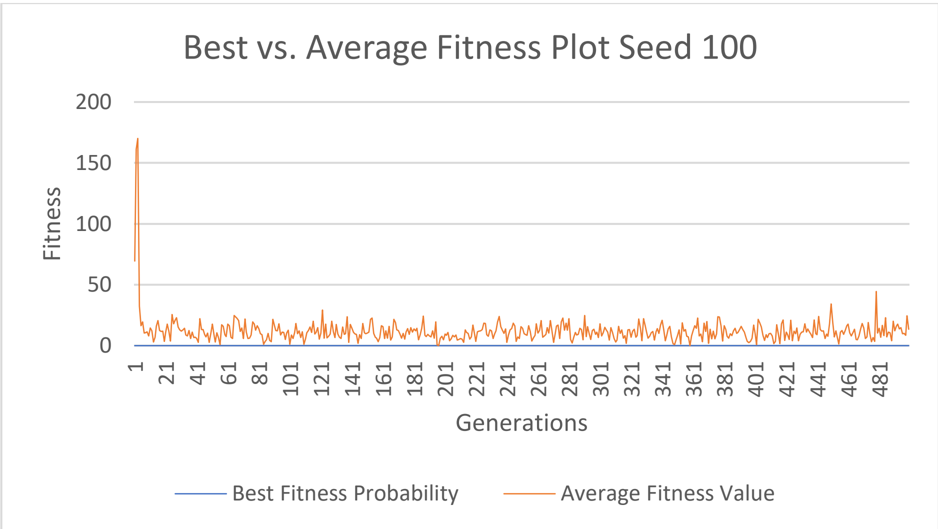
Figure E. 11 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for first VE for 500 generations for Frame bounds + Occlusion (Seed 20)

E.2.2.3 Results for Seed 100

This section states the results for frame bounds + occlusion for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.12. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

Figure E. 12Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for first VE for 500 generations for Frame bounds + Occlusion (Seed 100)

E.2.2 Results for Second Virtual Environment (VE)

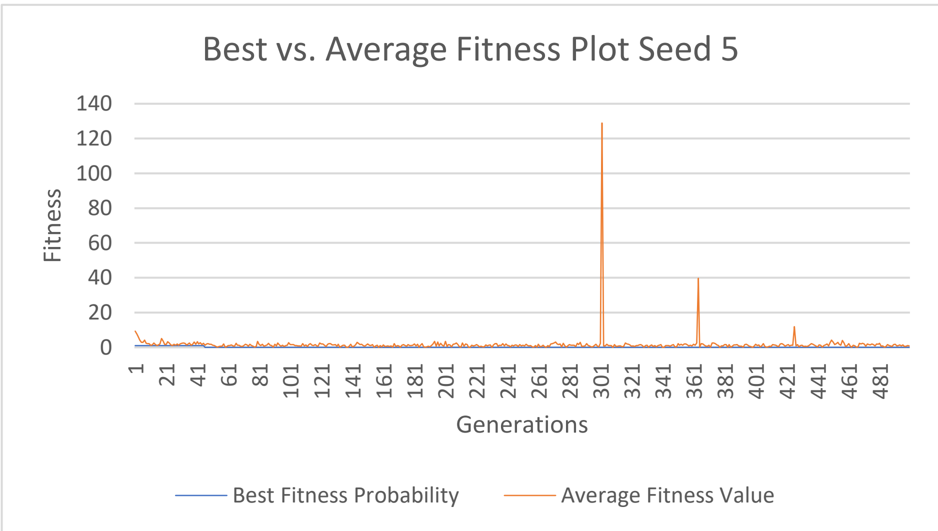
Following are results for Frame bounds + Occlusion for Virtual Environment (VE) 2.

E.2.2.1 Result for Seed 5

This section states the results for frame bounds + occlusion for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.13. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

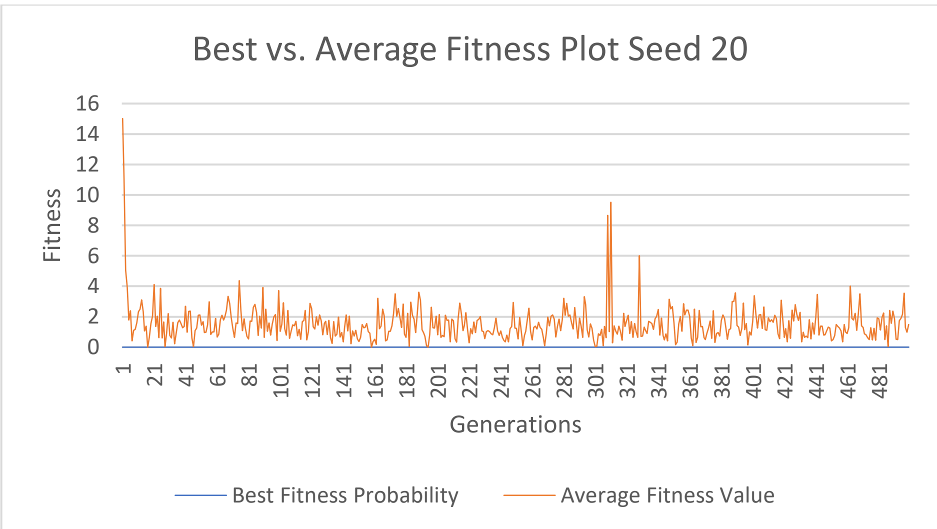
Figure E. 13 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for second VE for 500 generations for Frame bounds + Occlusion (Seed 5)

E.2.2.2 Result for Seed 20

This section states the results for frame bounds + occlusion for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.14. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

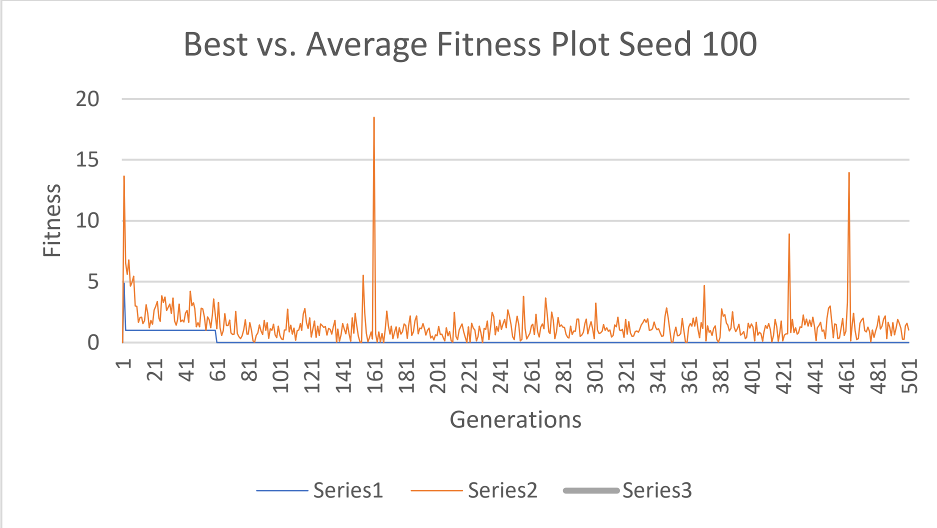
Figure E. 14 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for second VE for 500 generations for Frame bounds + Occlusion (Seed 20)

E.2.2.3 Result for Seed 100

This section states the results for frame bounds + occlusion for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.15. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

Figure E. 15 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for second VE for 500 generations for Frame bounds + Occlusion (Seed 100)

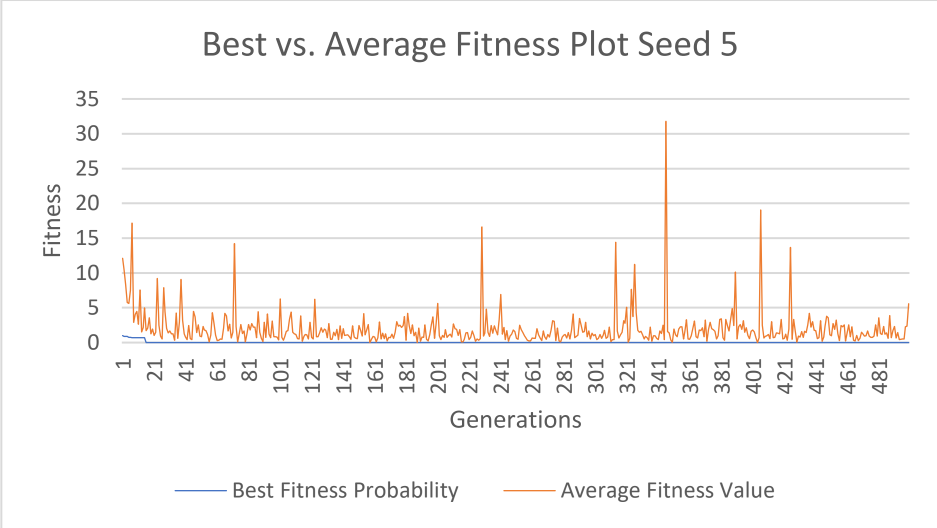
E.2.3 Results for Third Virtual Environment (VE)

Following are results for Frame bounds + Occlusion for Virtual Environment (VE) 2.

E.2.3.1 Results for Seed 5

This section states the results for frame bounds + occlusion for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.16. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



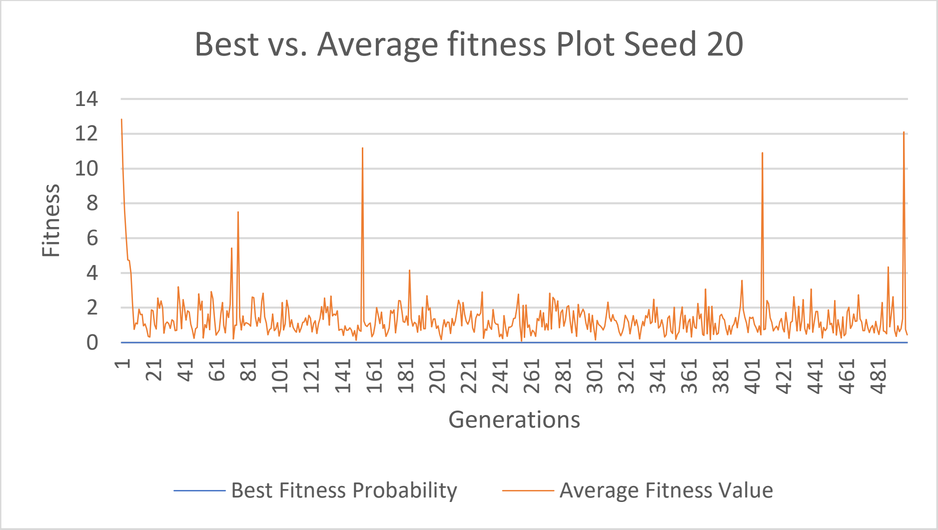
(b)

Figure E. 16 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion (Seed 5)

E.2.3.2 Results for Seed 20

This section states the results for frame bounds + occlusion for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.17. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

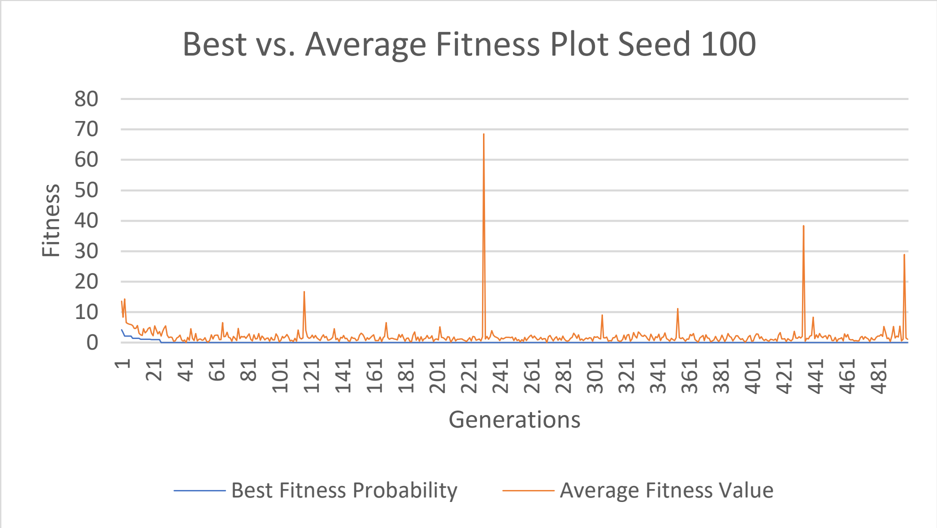
Figure E. 17 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion (Seed 20)

E.2.3.3 Results for Seed 100

This section states the results for frame bounds + occlusion for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.18. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



(c)

Figure E. 18 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion (Seed 100)

E.3 Visual and Best vs. Average fitness plot Results for Shotsize (Full)

Following are results for Frame bounds + Occlusion+ Shotsize for Virtual Environment (VE) 2.

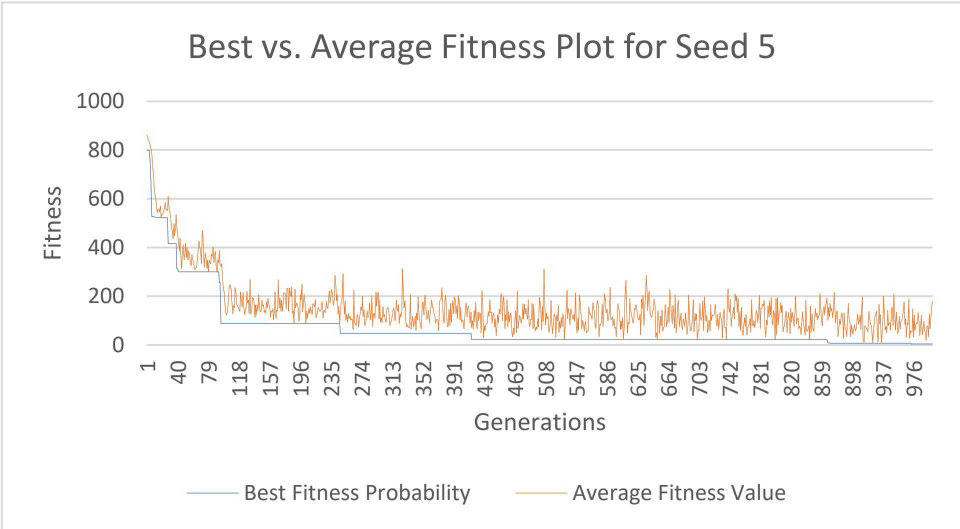
E.3.1 Results for First Virtual Environment (VE)

E.3.1.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.19. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



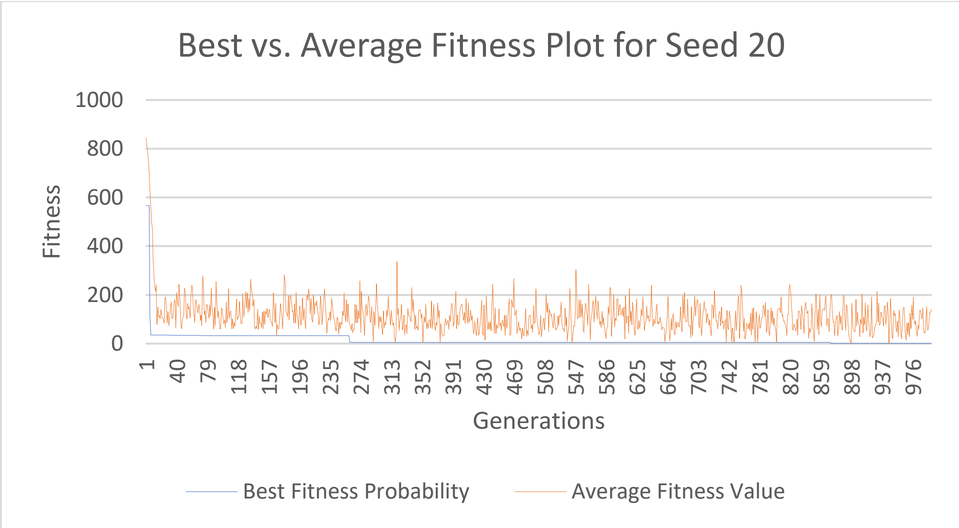
(c)

Figure E. 19 Visual Results (Figure a, and Figure b) and Best vs. Average fitness plot (Figure c) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 5)

E.3.1.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.20. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



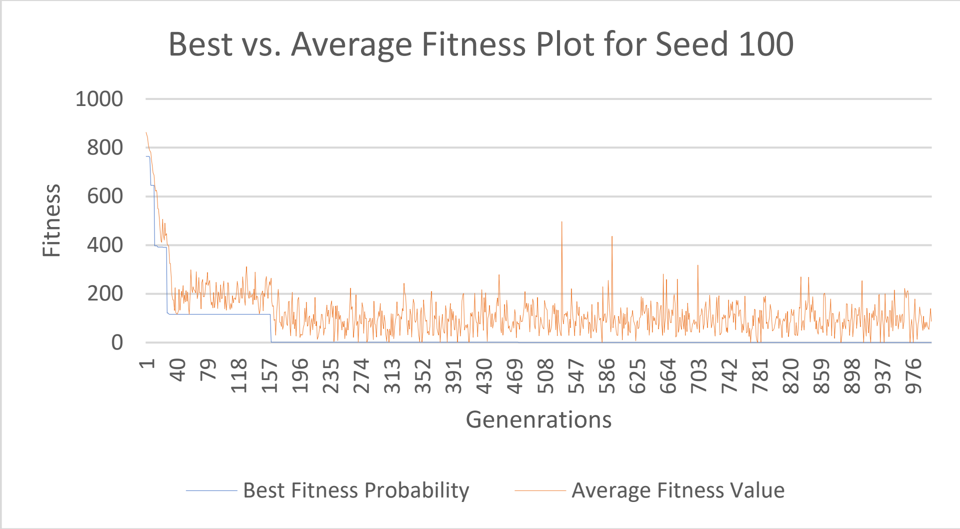
(b)

Figure E. 20 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 20)

E.3.1.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.21. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

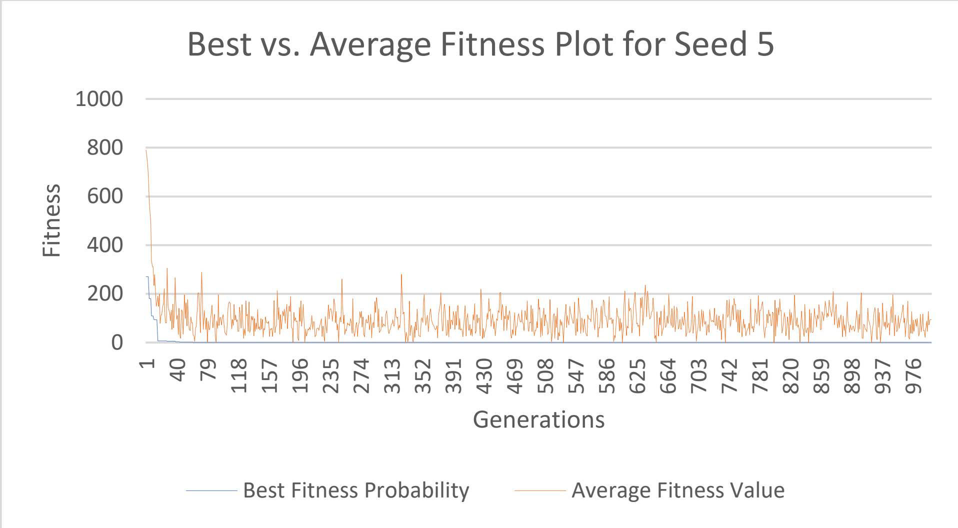
Figure E. 21 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 100)

E.3.2 Results for Second Virtual Environment (VE)

E.3.2.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.19. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)

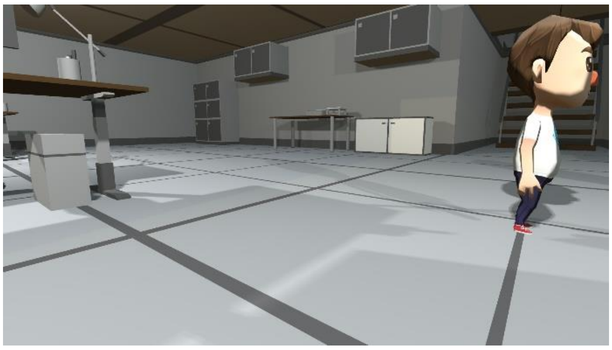


(b)

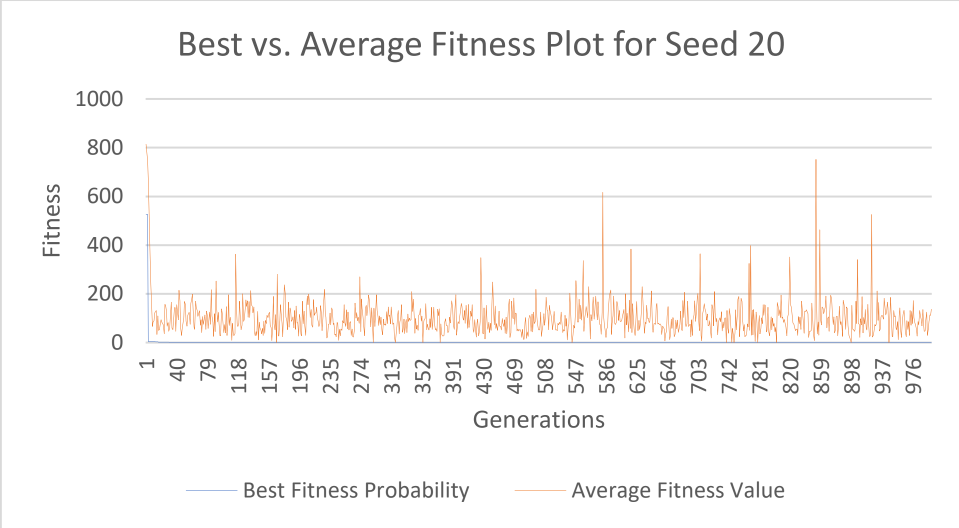
Figure E. 22 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 5)

E.3.2.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.23. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



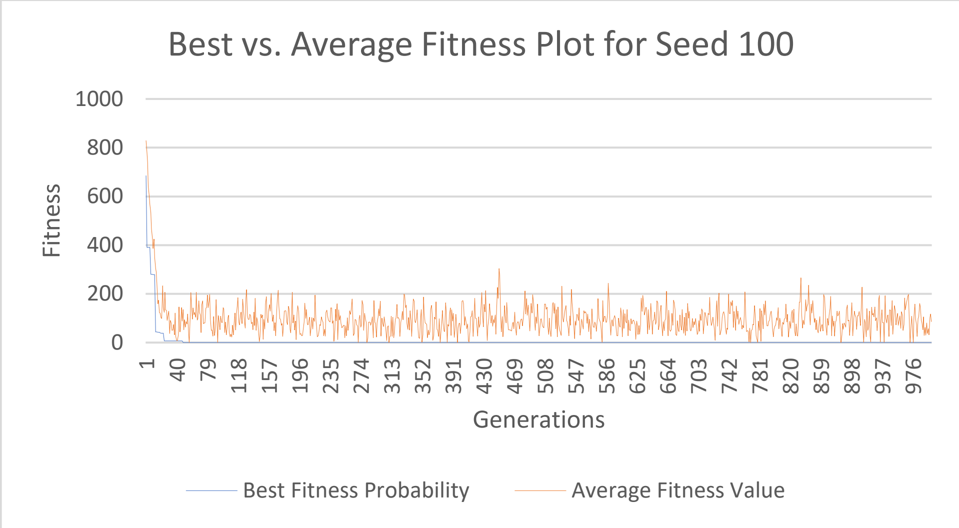
(b)

Figure E. 23 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 20)

E.3.2.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.24. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

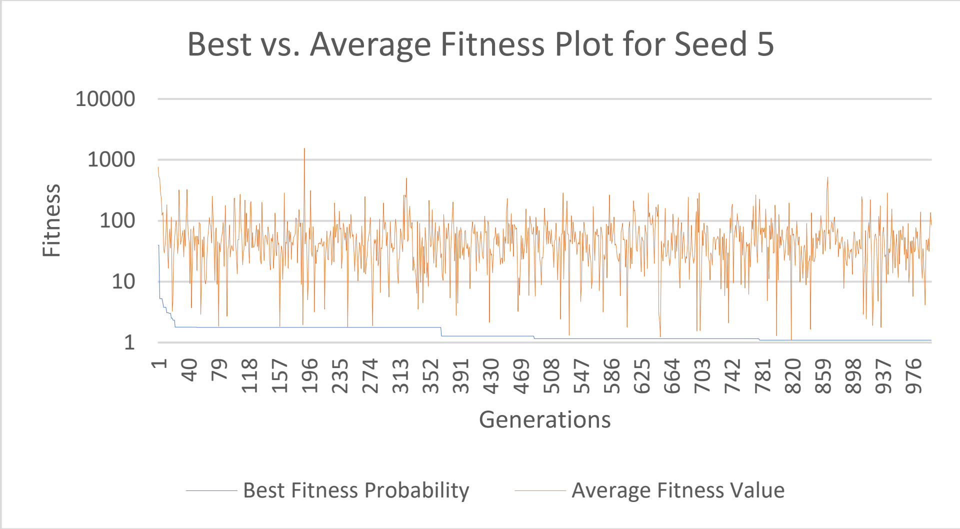
Figure E. 24 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 100)

E.3.3 Results for Third Virtual Environment (VE)

E.3.3.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.25. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



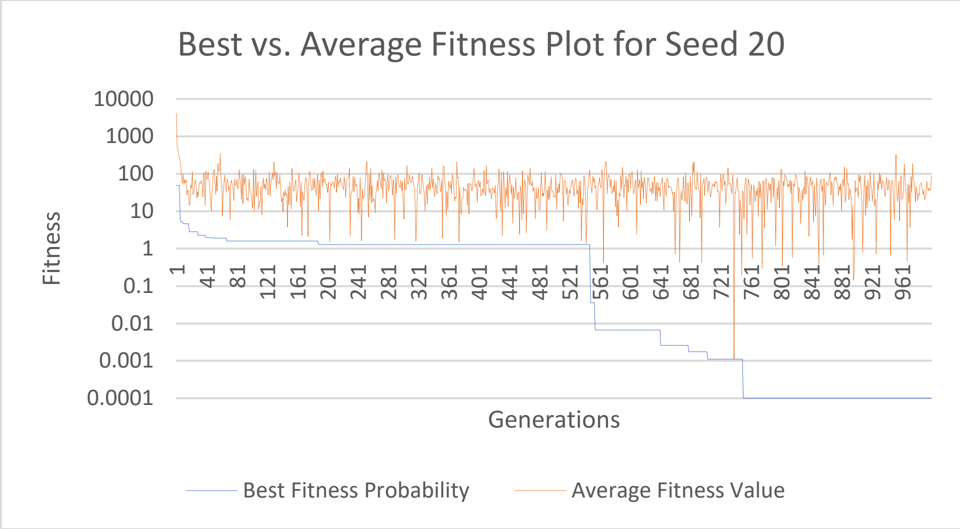
(b)

Figure E. 25 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 5)

E.3.3.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.26. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



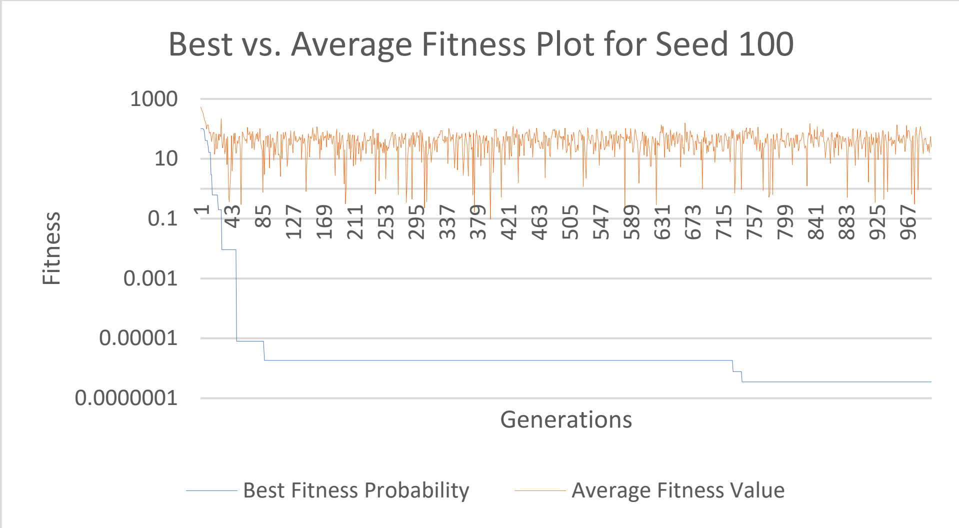
(b)

Figure E. 26 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 20)

E.3.3.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.27. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

Figure E. 27 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Full) (Seed 100)

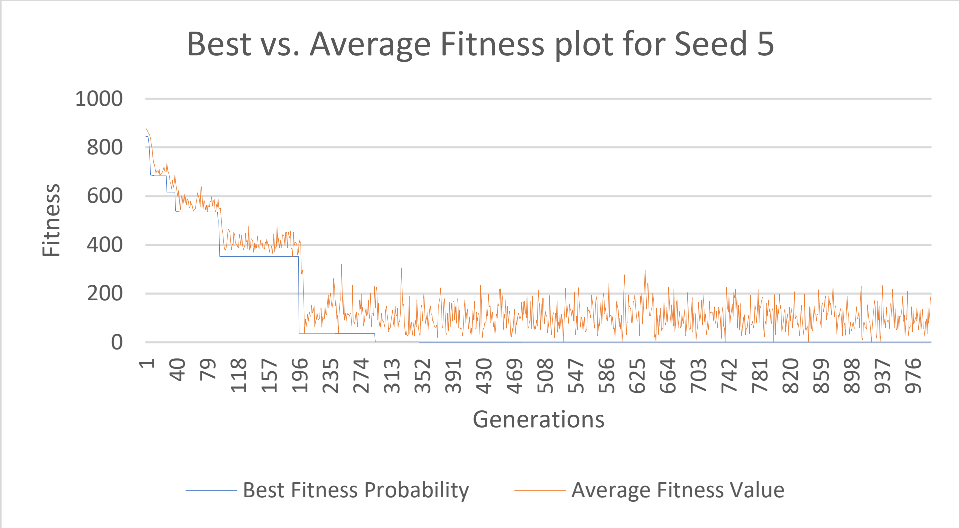
E.4 Visual and Best vs. Average fitness plot Results for Shotsize (Medium)

E.4.1 Results for First Virtual Environment (VE)

E.4.1.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.28. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



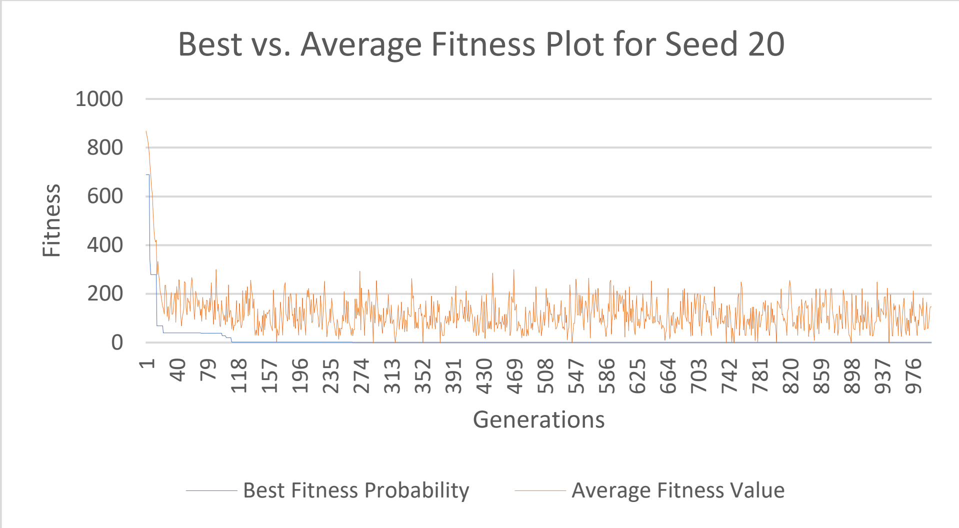
(c)

Figure E. 28 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 5)

E.4.1.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.29. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



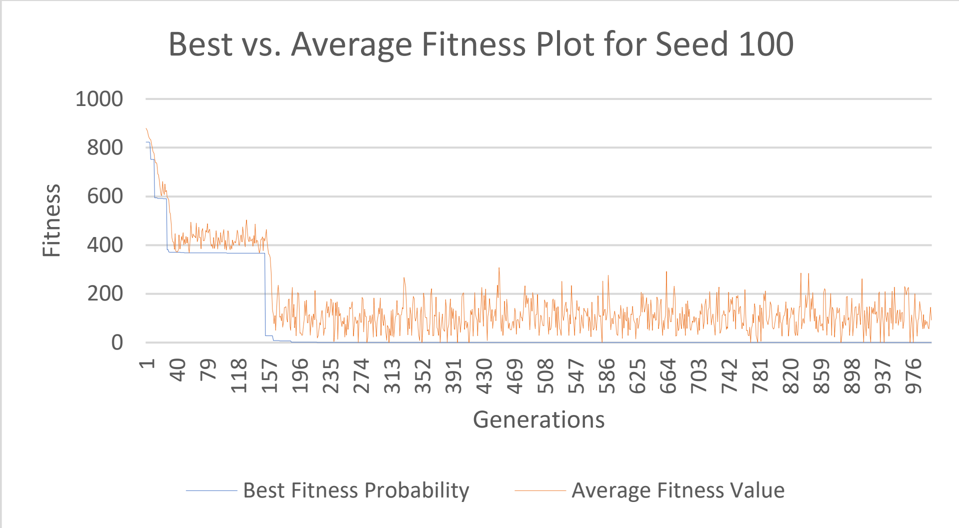
(b)

Figure E. 29 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 20)

E.4.1.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.30. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



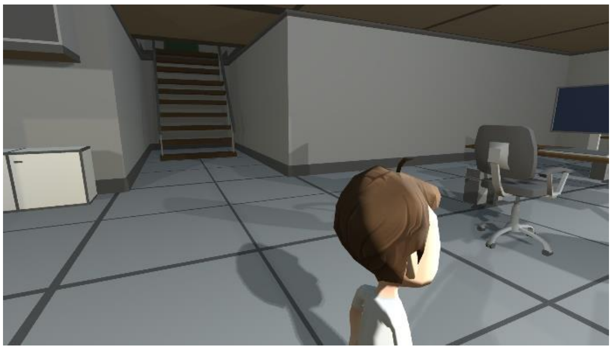
(b)

Figure E. 30 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 100)

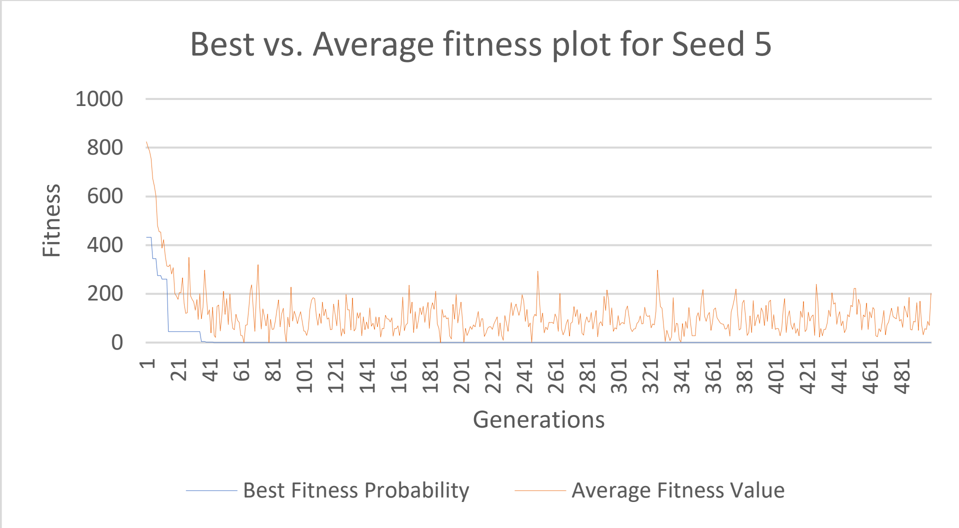
E.4.2 Results for Second Virtual Environment (VE)

E.4.2.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.31. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



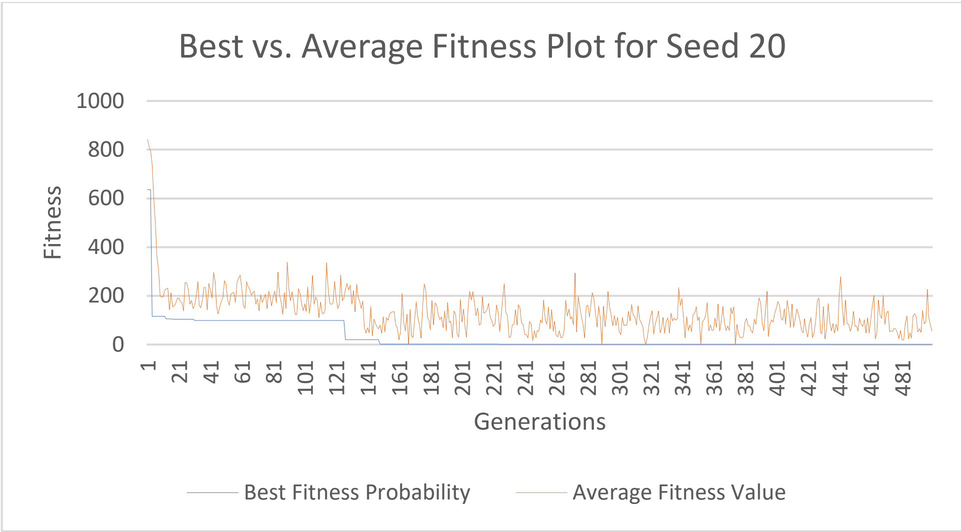
(b)

Figure E. 31 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 5)

E.4.2.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.32. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



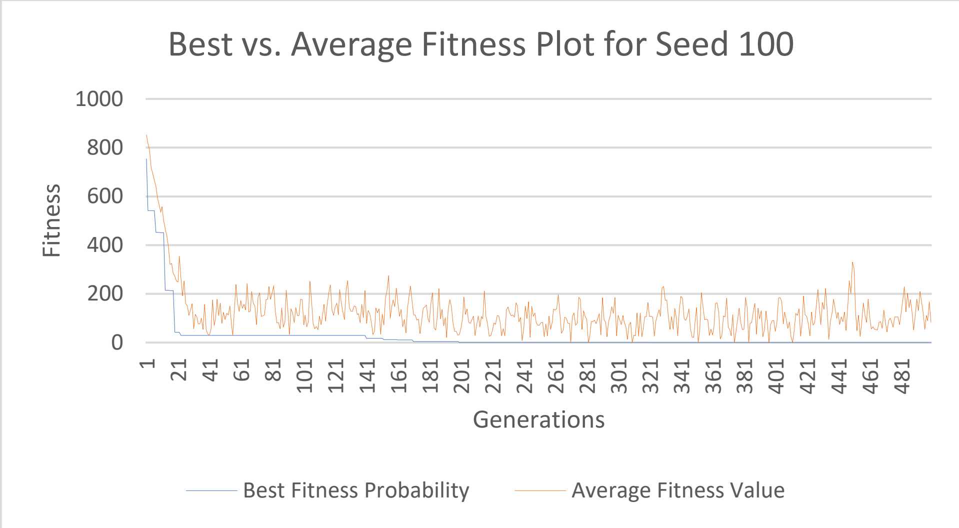
(b)

Figure E. 32 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 20)

E.4.2.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.33. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

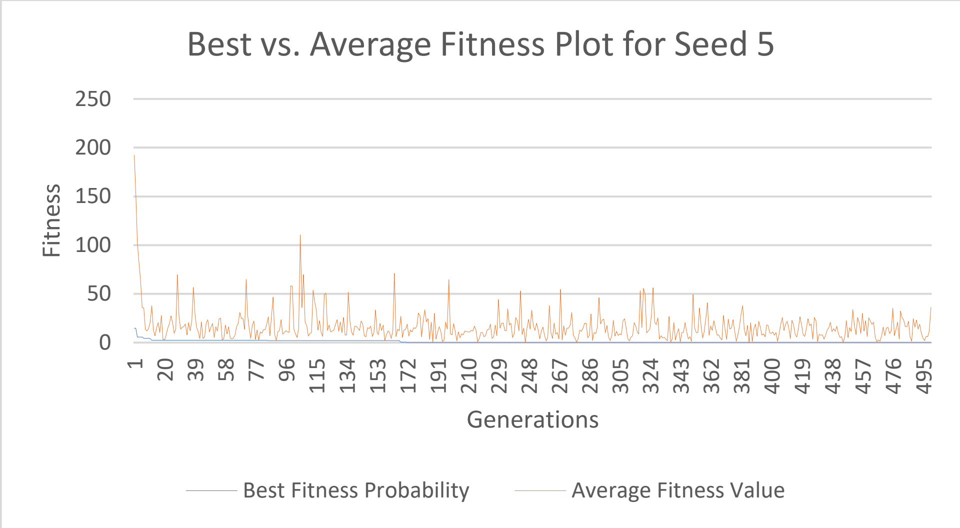
Figure E. 33 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 100)

E.4.3 Results for Third Virtual Environment (VE)

E.4.3.1 Results for Seed 5

This section states the results for Shotsize for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.34. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



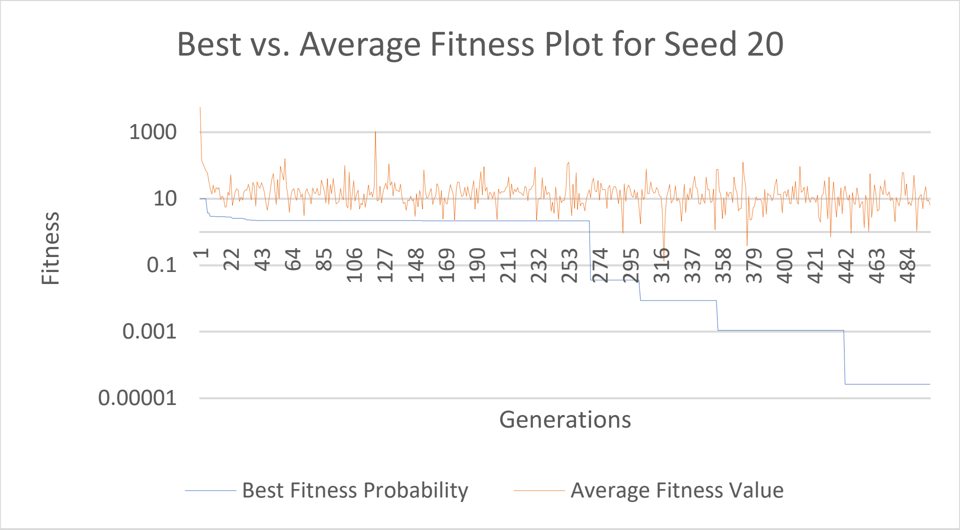
(b)

Figure E. 34 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 5)

E.4.3.2 Results for Seed 20

This section states the results for Shotsize for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.35. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



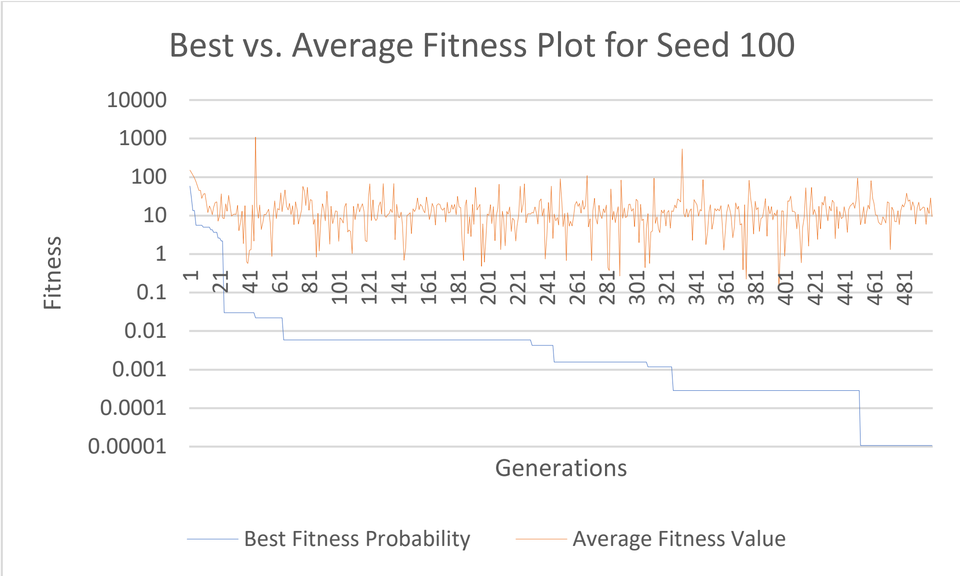
(b)

Figure E. 35 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 20)

E.4.3.3 Results for Seed 100

This section states the results for Shotsize for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.36. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

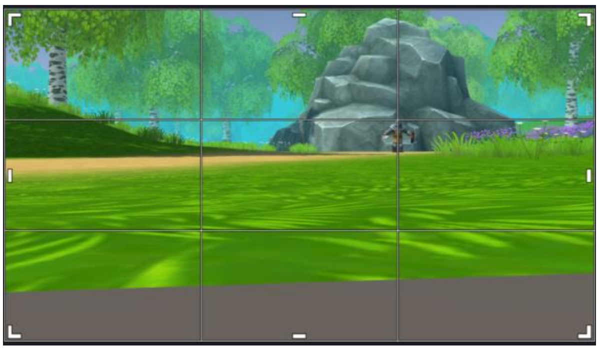
Figure E. 36 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion + Shotsize (Medium) (Seed 100)

E.5 Visual and Best vs. Average fitness plot Results for The Rule of Thirds

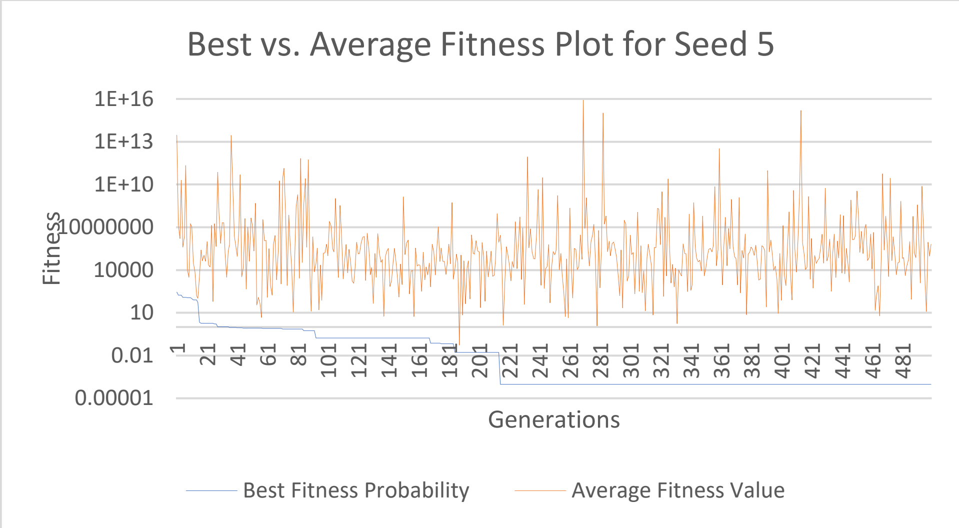
E.5.1 Results for First Virtual Environment (VE)

E.5.1.1 Results for Seed 5

This section states the results for the rule of thirds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.37. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



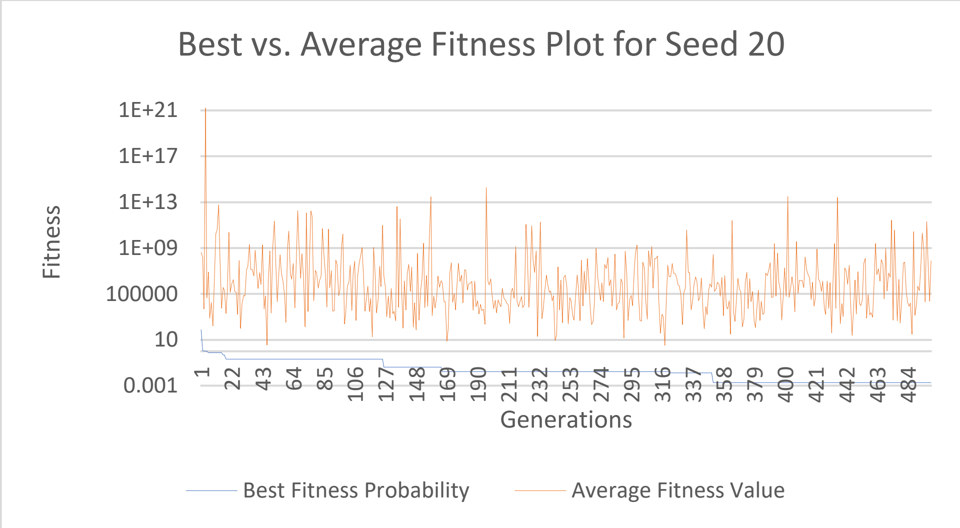
(b)

Figure E. 37 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 5)

E.5.1.2 Results for Seed 20

This section states the results for the rule of thirds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.38. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



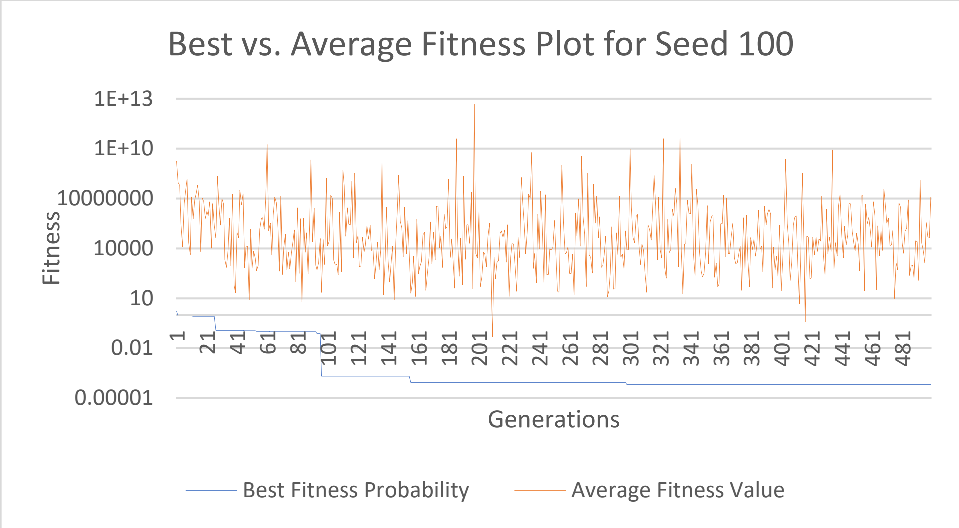
(b)

Figure E. 38 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 20)

E.5.1.3 Results for Seed 100

This section states the results for the rule of thirds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.39. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

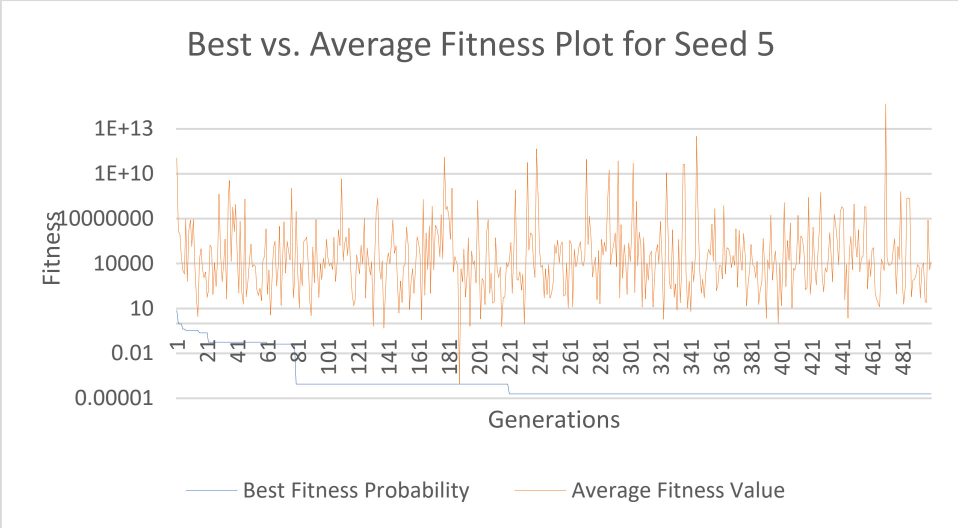
Figure E. 39 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for first VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 100)

E.5.2 Results for Second Virtual Environment (VE)

E.5.2.1 Results for Seed 5

This section states the results for the rule of thirds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.40. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)

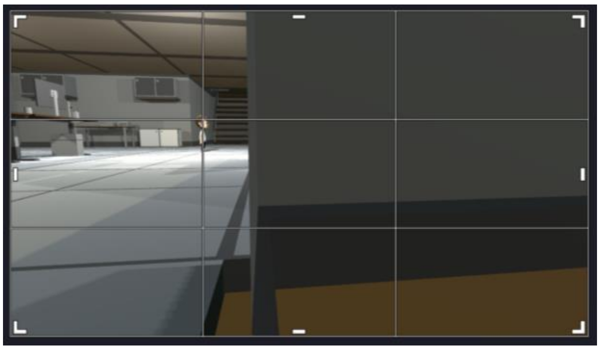


(b)

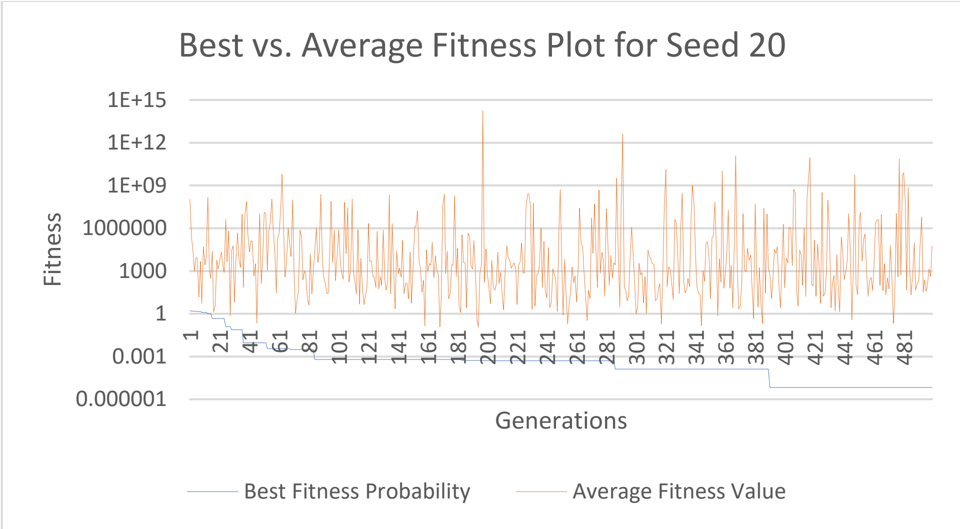
Figure E. 40 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 5)

E.5.2.2 Results for Seed 20

This section states the results for the rule of thirds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.41. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



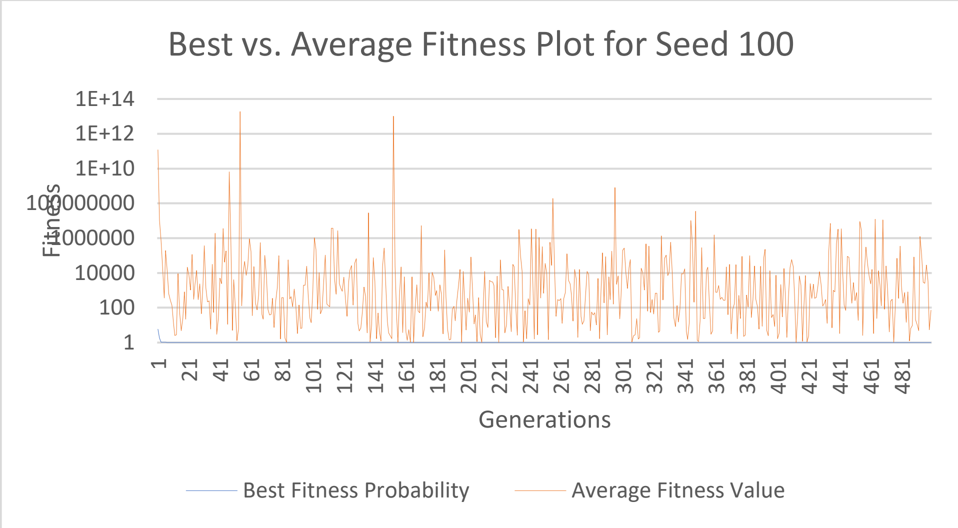
(b)

Figure E. 41 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 20)

E.5.2.3 Results for Seed 100

This section states the results for the rule of thirds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.42. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



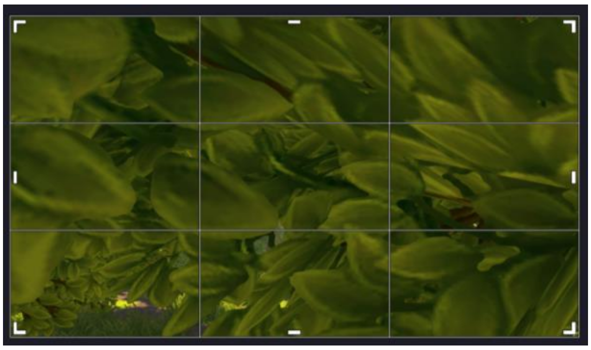
(b)

Figure E. 42 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for second VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 100)

E.5.3 Results for Third Virtual Environment (VE)

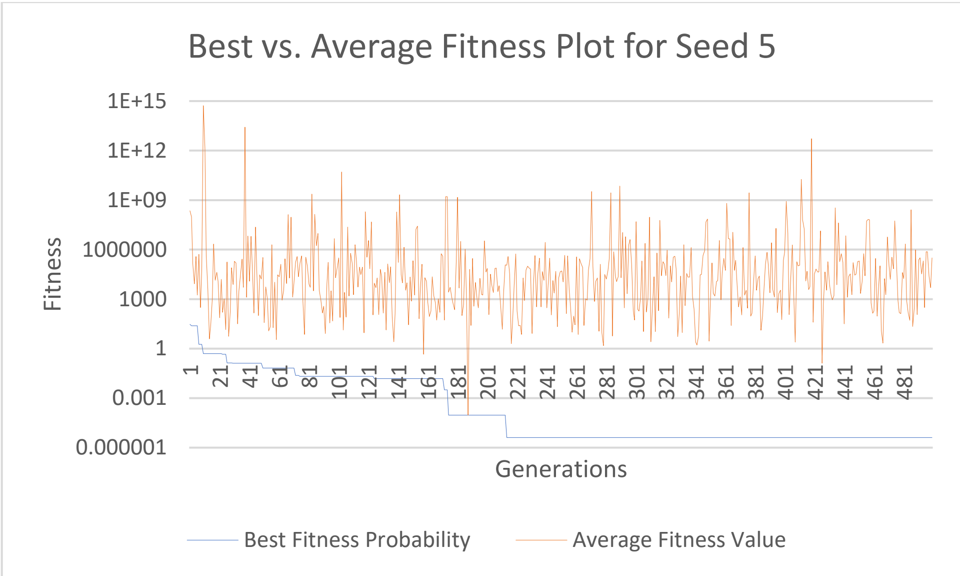
E.5.3.1 Results for Seed 5

This section states the results for the rule of thirds for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.43. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.



(a)

(b)

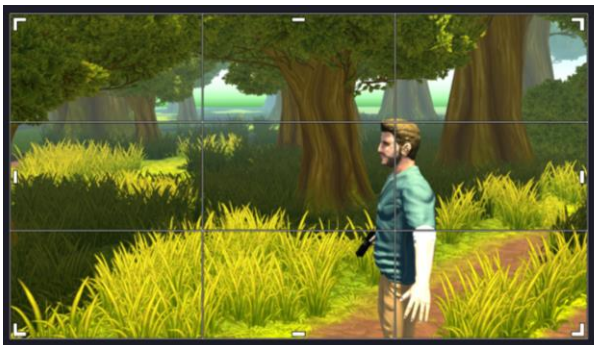


(c)

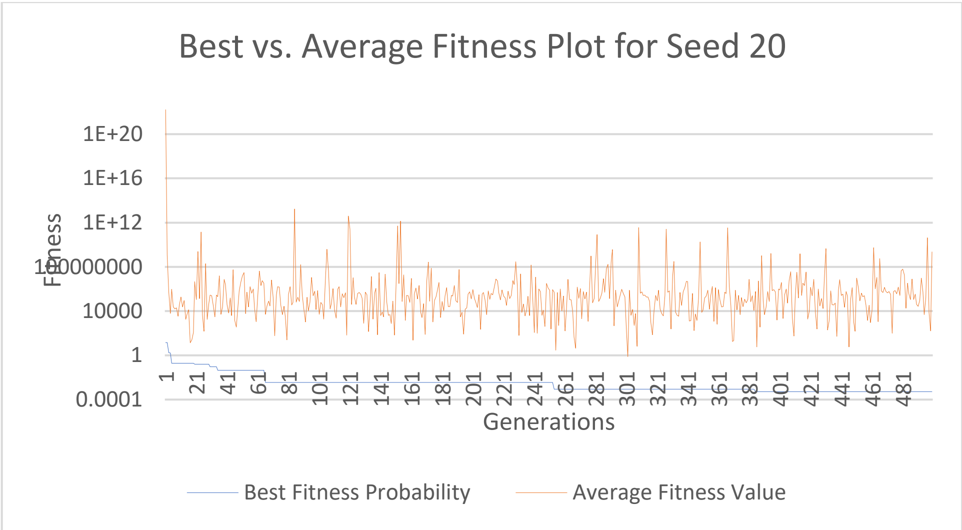
Figure E. 43 Visual Results (Figure a and Figure b) and Best vs. Average fitness plot (Figure c) for third VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 5)

E.5.3.2 Results for Seed 20

This section states the results for the rule of thirds for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.43. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.



(a)



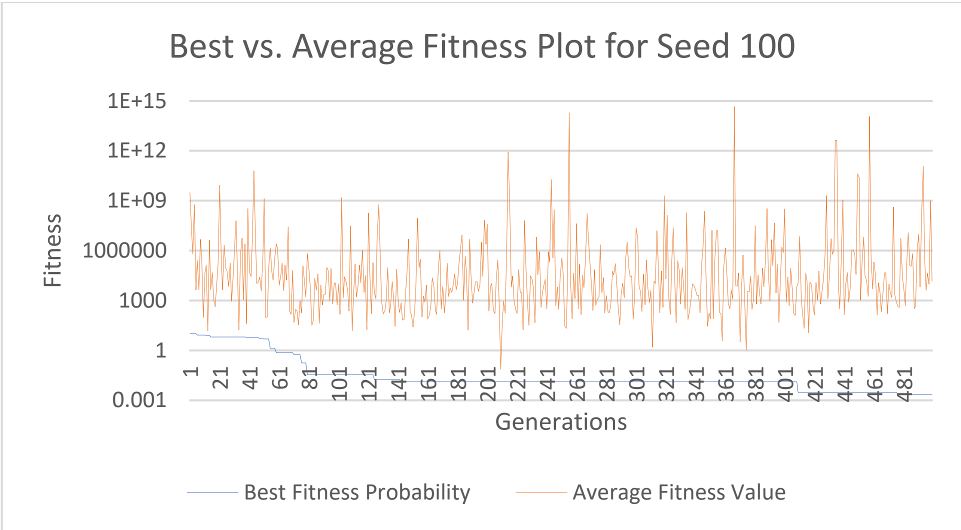
(b)

Figure E. 44 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 20)

E.5.3.3 Results for Seed 100

This section states the results for the rule of thirds for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.45. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

Figure E. 45 Visual Results (Figure a) and Best vs. Average fitness plot (Figure b) for third VE for 500 generations for Frame bounds + Occlusion + The Rule of Thirds (Seed 100)

E.6 Visual and Best vs. Average fitness plot Results for All Parameters Combined (Full Shotsize)

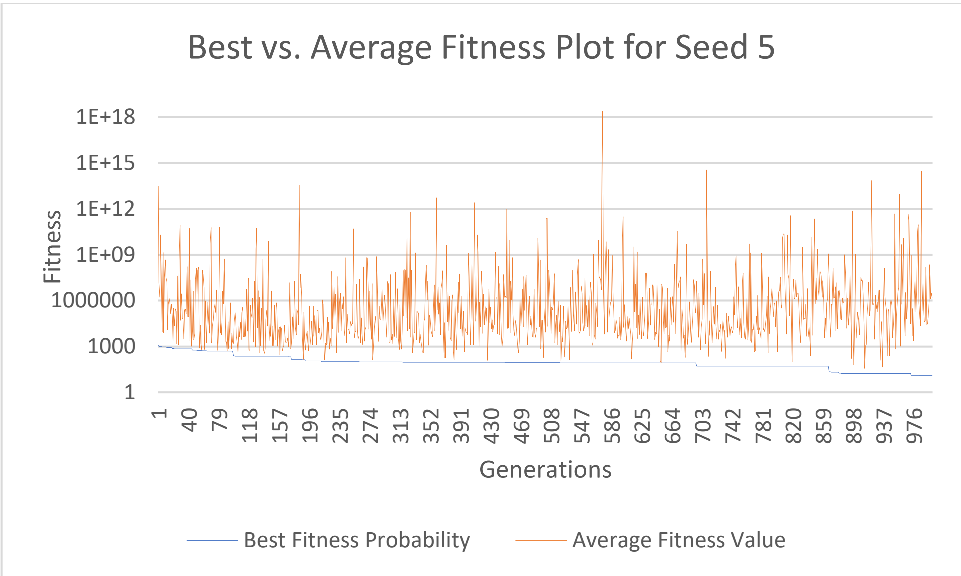
E.6.1 Results for First Virtual Environment (VE)

E.6.1.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.46. In this figure, part a and part b consist of visual results for frame bounds. Part c consist of graphical results of Best vs. Average Fitness plot.

(a)

(b)



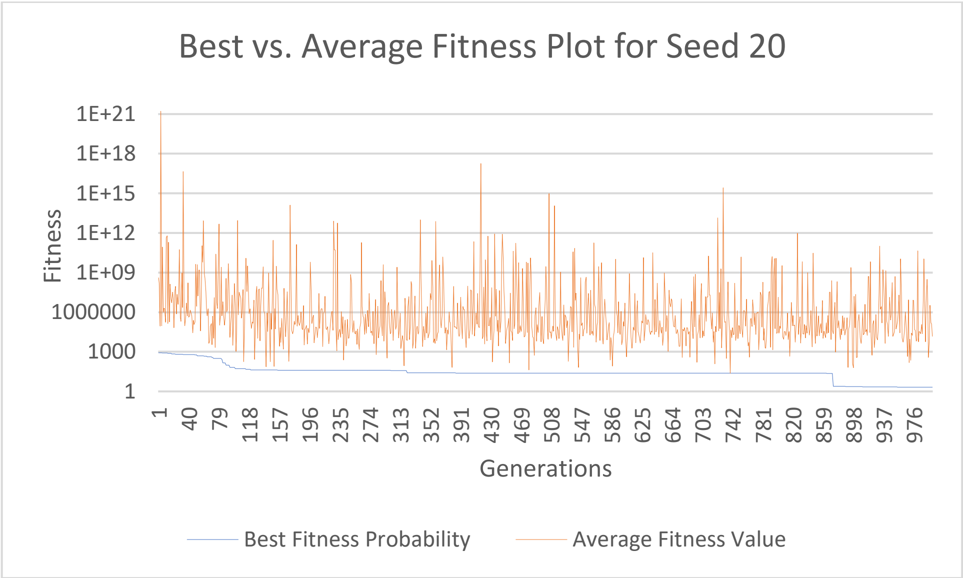
(c)

Figure E. 46 Visual Results (Figure a) after 1000 Generations, Visual Results (Figure b) after 10,000 Generations and Best vs. Average fitness plot (Figure c) for first VE for 1000 generations for All parameters combined (Full Shot) (Seed 5)

E.6.1.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.47. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



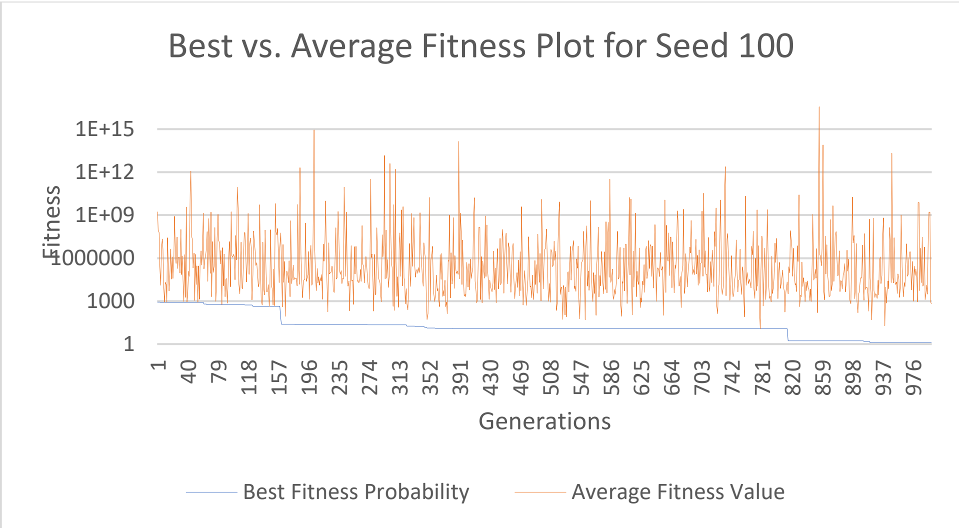
(b)

Figure E. 47Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for All parameters combined (Full Shot) (Seed 20)

E.6.1.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.48. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

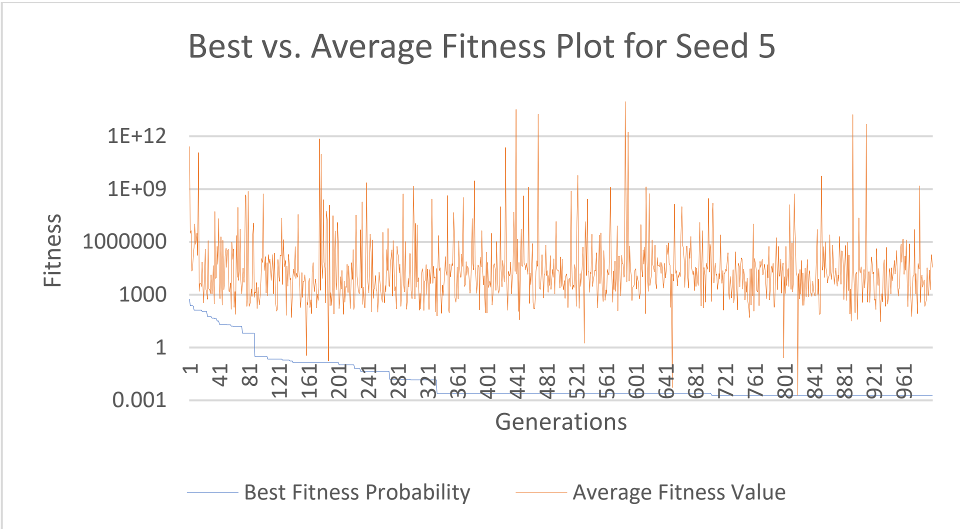
Figure E. 48 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for All parameters combined (Full Shot) (Seed 100)

E.6.2 Results for Second Virtual Environment (VE)

E.6.2.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.49. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



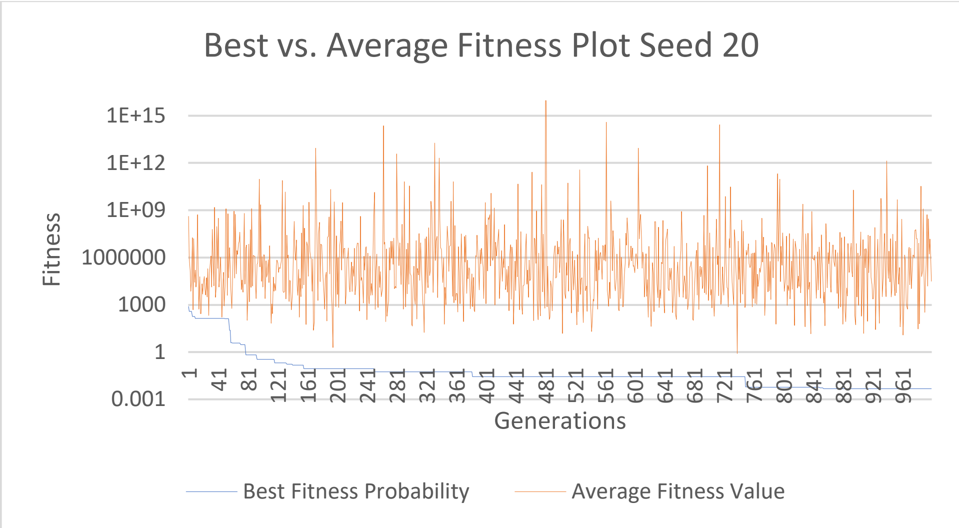
(b)

Figure E. 49 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Full Shot) (Seed 5)

E.6.2.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.50. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



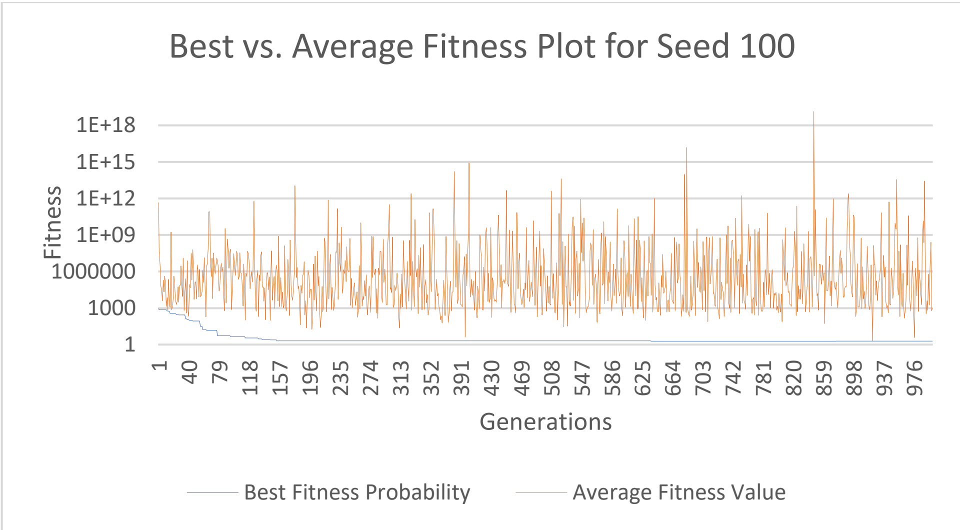
(b)

Figure E. 50 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Full Shot) (Seed 20)

E.6.2.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.51. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

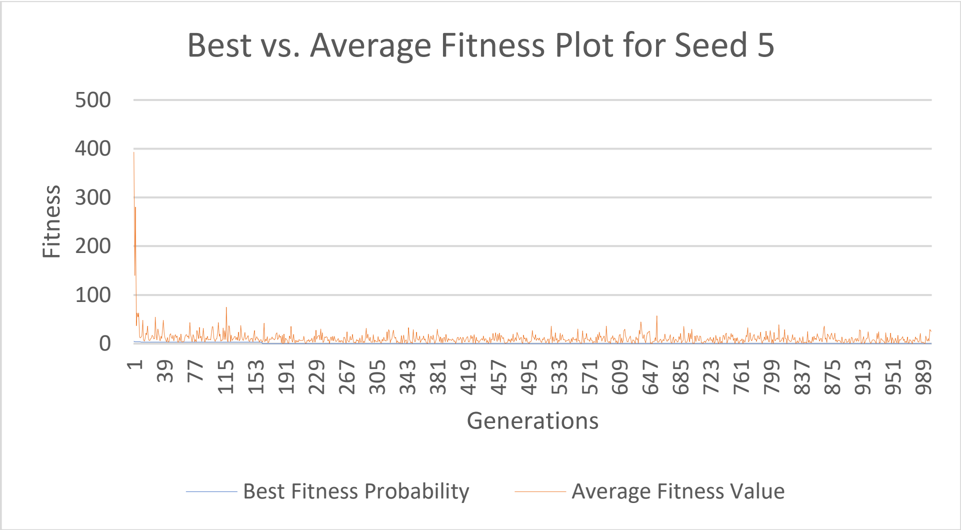
Figure E. 51 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Full Shot) (Seed 100)

E.6.3 Results for Third Virtual Environment (VE)

E.6.3.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.52. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



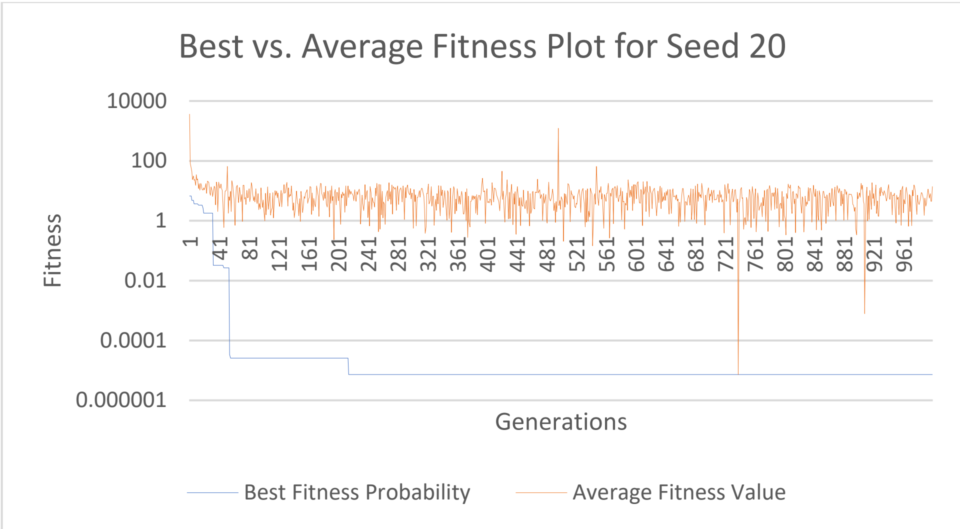
(b)

Figure E. 52 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Full Shot) (Seed 5)

E.6.3.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.53. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



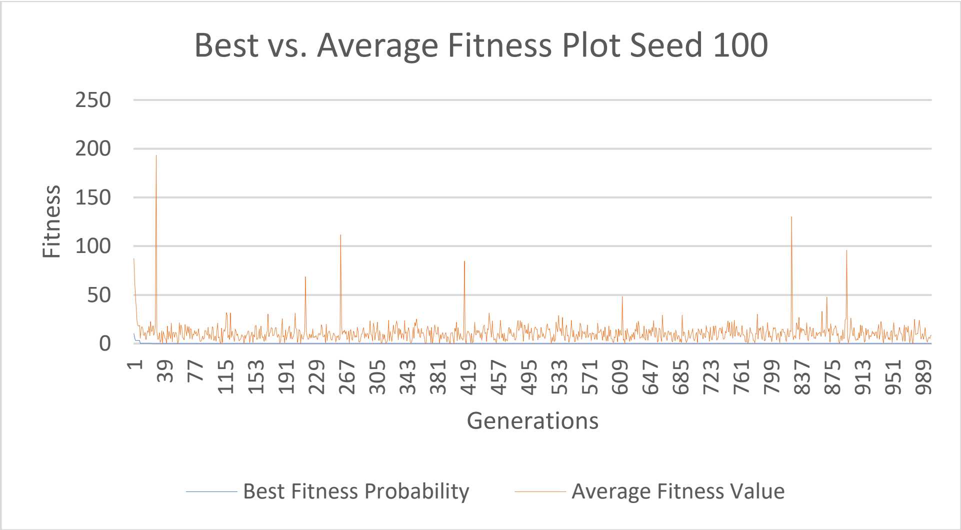
(b)

Figure E. 53 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Full Shot) (Seed 20)

E.6.3.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.54. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

Figure E. 54 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Full Shot) (Seed 100)

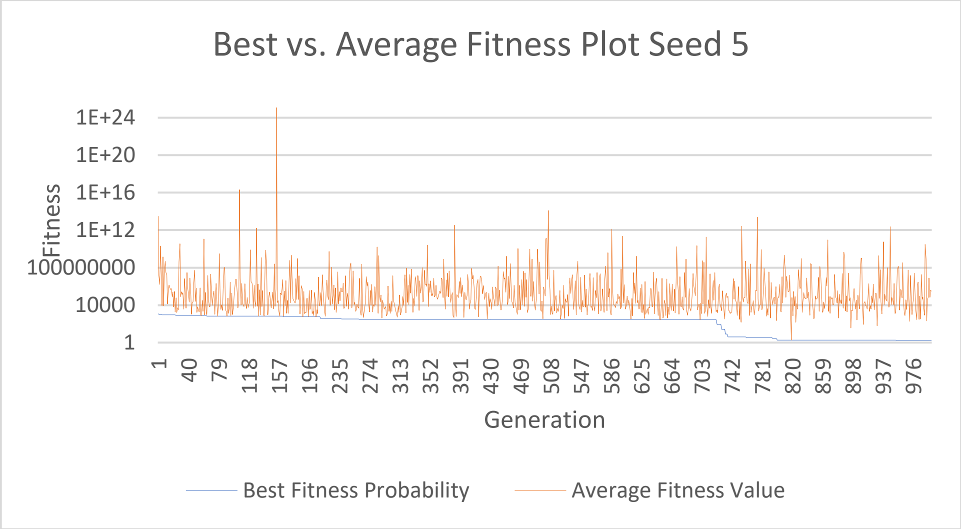
E.7 Visual and Best vs. Average fitness plot Results for All Parameters Combined (Medium Shotsize)

E.7.1 Results for First Virtual Environment (VE)

E.7.1.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.55. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



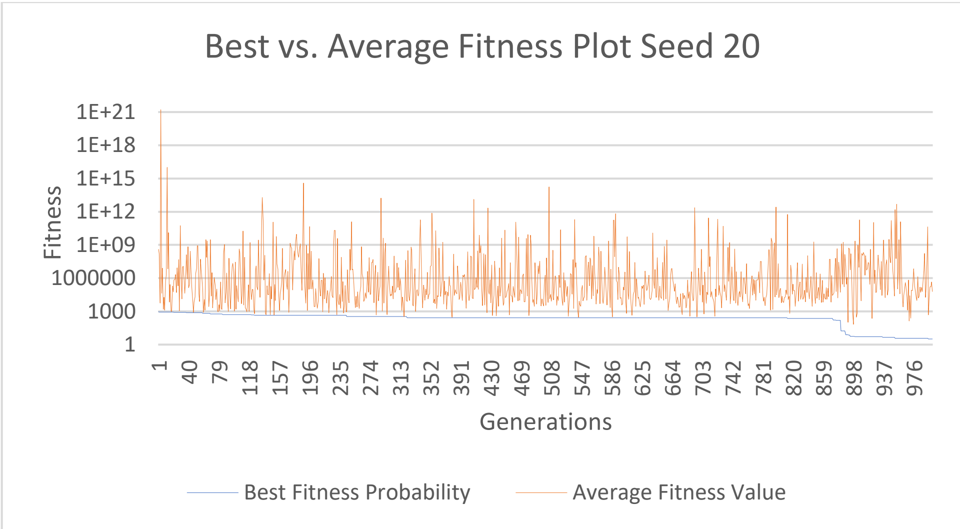
(b)

Figure E. 55 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for All parameters combined (Medium Shot) (Seed 5)

E.7.1.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.56. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



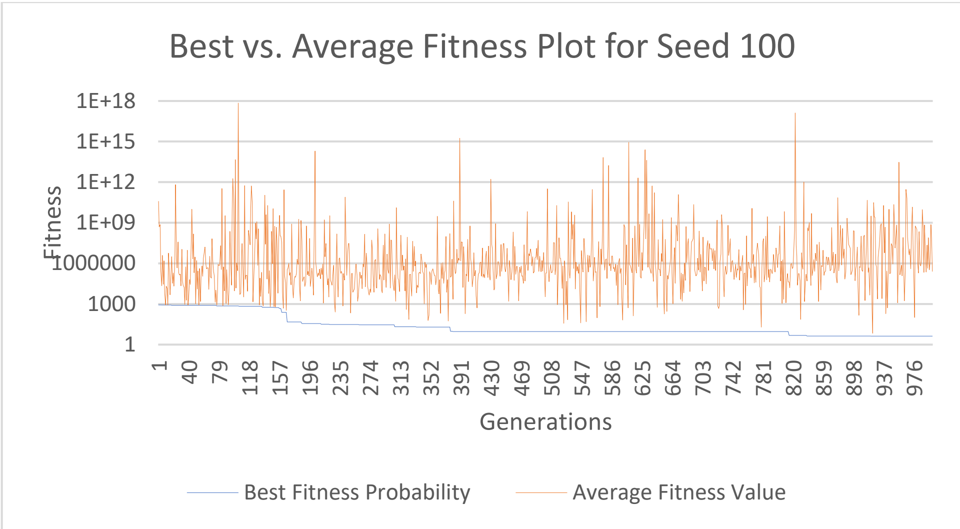
(b)

Figure E. 56 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for All parameters combined (Medium Shot) (Seed 20)

E.7.1.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.57. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

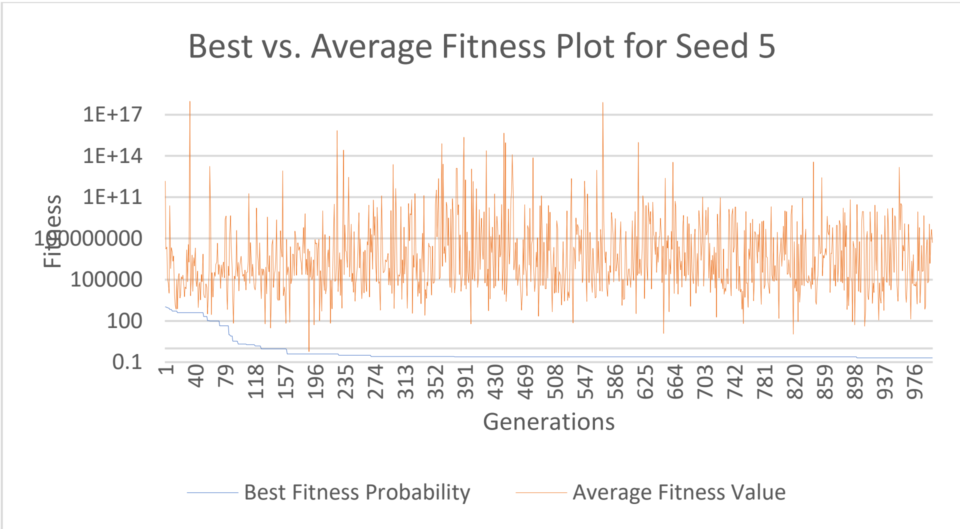
Figure E. 57 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for first VE for 1000 generations for All parameters combined (Medium Shot) (Seed 100)

E.7.2 Results for Second Virtual Environment (VE)

E.7.2.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.58. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



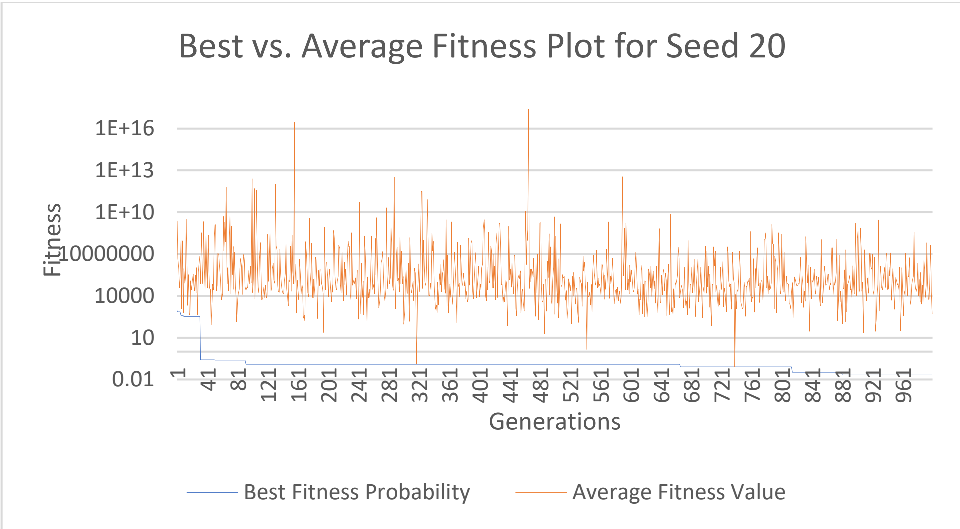
(b)

Figure E. 58 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Medium Shot) (Seed 5)

E.7.2.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.59. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



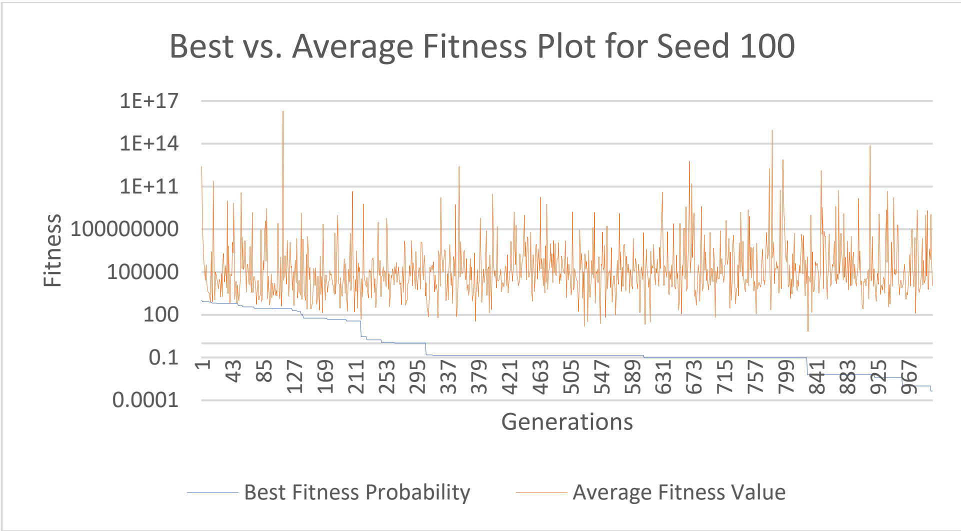
(b)

Figure E. 59 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Medium Shot) (Seed 20)

E.7.2.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.60. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

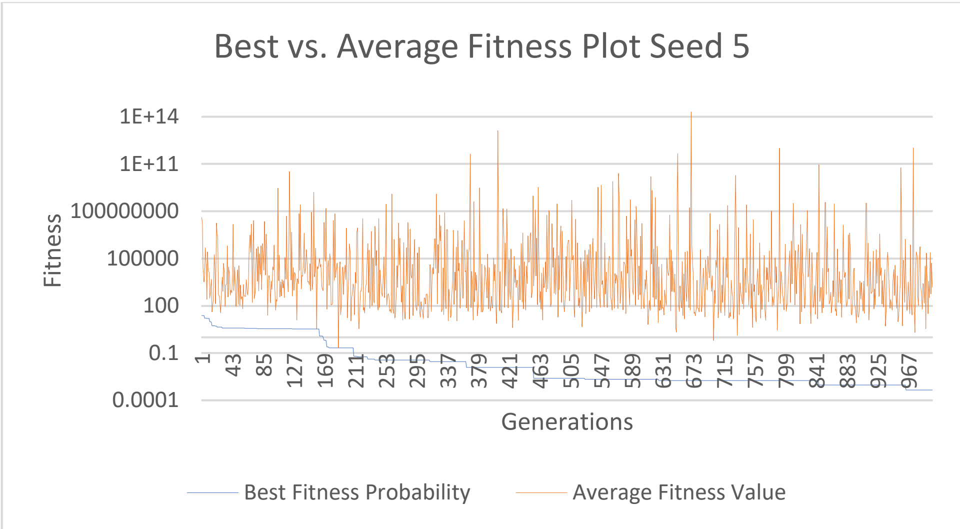
Figure E. 60 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for second VE for 1000 generations for All parameters combined (Medium Shot) (Seed 100)

E.7.3 Results for Third Virtual Environment (VE)

E.7.3.1 Results for Seed 5

This section states the results for all parameters combined for Seed 5. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.61. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



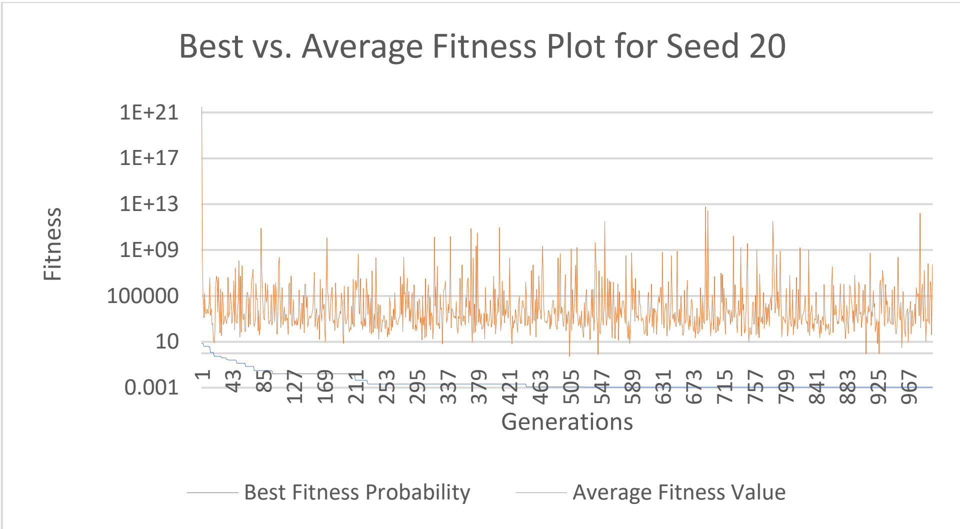
(b)

Figure E. 61 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Medium Shot) (Seed 5)

E.7.3.2 Results for Seed 20

This section states the results for all parameters combined for Seed 20. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.62. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



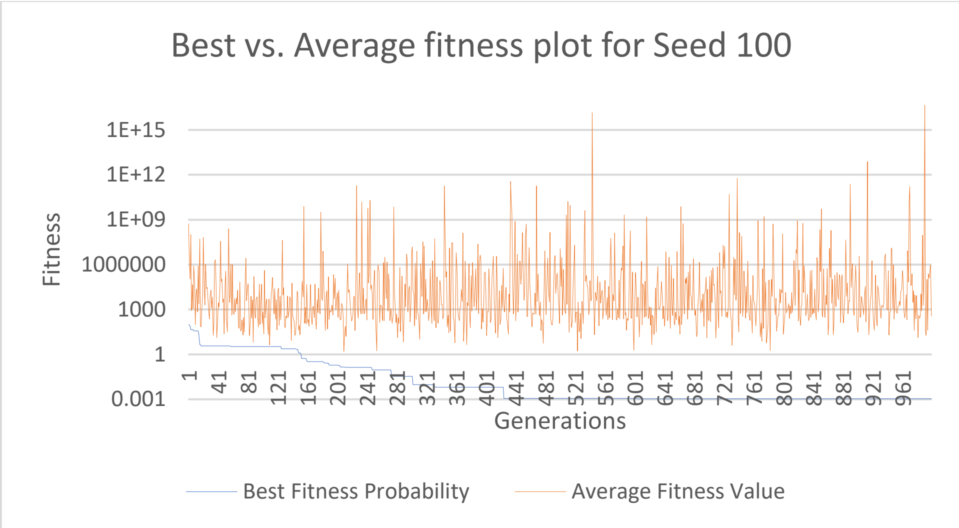
(b)

Figure E. 62 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Medium Shot) (Seed 20)

E.7.3.3 Results for Seed 100

This section states the results for all parameters combined for Seed 100. These results were obtained using GA. Both visual and graphical results are given are given in Figure E.63. In this figure, part a consist of visual results for frame bounds. Part b consist of graphical results of Best vs. Average Fitness plot.

(a)



(b)

Figure E. 63 Visual Results (Figure a) after 1000 Generations and Best vs. Average fitness plot (Figure b) for third VE for 1000 generations for All parameters combined (Medium Shot) (Seed 100)