# An Investigation into Web-based Panoramic Video Virtual Reality with Reference to the Virtual Zoo

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# ABSTRACT

Panoramic image Virtual Reality (VR) is a 360 degree image which has been interpreted as a kind of VR that allows users to navigate, view, hear and have remote access to a virtual environment. Panoramic Video VR builds on this, where filming is done in the real world to create a highly dynamic and immersive environment. This is proving to be a very attractive technology and has introduced many possible applications but still present a number of challenges, considered in this research.

An initial literature survey identified limitations in panoramic video to date: these were the technology (e.g. filming and stitching) and the design of effective navigation methods. In particular, there is a tendency for users to become disoriented during way-finding. In addition, an effective interface design to embed contextual information is required.

The research identified the need to have a controllable test environment in order to evaluate the production of the video and the optimal way of presenting and navigating within the scene. Computer Graphics (CG) simulation scenes were developed to establish a method of capturing, editing and stitching the video under controlled conditions. In addition, a novel navigation method, named the "image channel" was proposed and integrated within this environment. This replaced hotspots: the traditional navigational jumps between locations. Initial user testing indicated that the production was appropriate and did significantly improve user perception of position and orientation over jump-based navigation. The interface design combined with the environment view alone was sufficient for users to understand their location without the need to augment the view with an on screen map.

After obtaining optimal methods in building and improving the technology, the research looked for a natural, complex, and dynamic real environment for testing. The web-based virtual zoo (World Association of Zoos and Aquariums) was selected as an ideal production: It had the purpose to allow people to get close to animals in their natural habitat and created particular interest to develop a system for knowledge delivery, raising protection concerns, and entertaining visitors: all key roles of a zoo.

The design method established from CG was then used to develop a film rig and production unit for filming a real animal habitat: the Formosan rock monkey in Taiwan. A web-based panoramic video of this was built and tested though user experience testing and expert interviews. The results of this were essentially identical to the testing done in the prototype environment, and validated the production. Also was successfully attracting users to the site repeatedly.

The research has contributed to new knowledge in improvement to the production process, improvement to presentation and navigating within panoramic videos through the proposed Image Channel method, and has demonstrated that web-based virtual zoo can be improved to help address considerable pressure on animal extinction and animal habitat degradation that affect humans by using this technology. Further studies were addressed. The research was sponsored by Taiwan's Government and Twycross Zoo UK was a collaborator.

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# Chapter One: Introduction

## 1.1 Introduction

Panoramic video composed of video/s filmed in natural environments is categorized as panorama virtual reality (VR) and interpreted as a kind of VR technology to create virtual environments, in many respects (Xiao, 2000; Dorta, 2004; Tzavidas and Katsaggelos, 2005). The panorama technologies provide users with the ability to experience an environment and let them pick the direction of view in a scene (Naimark, 1991; Chen, 1995). In addition, panoramic video contains all the required information so that the whole of the 360 degrees field-of-view (FOV) in any direction is covered (IVPL[1], 2004; Tzavidas and Katsaggelos, 2005). The visual efficiency is apparently, as Jochmann (1967) revealed, "The amount of work done doubles under the Lord's eye, not His hand". According to Bougainville (1772), a famous voyager in 18$^{th}$ century, "Nothing is more precious than the view of a landscape that is open on every side". This formed the potential value of panorama technologies in seeing the natural environment. Gilloch (2002) interprets the presence performance of the panorama VR technologies thus, "The interesting thing about the panorama is to see the true city – a city inside a building. What stands in the windowless building is the truth". The art of the panorama in showing 360 degrees of view initially started from painting in 1787. It was Robert Barker who demonstrated the first panorama art by displaying to audiences, a painting of Edinburgh placed in a large circular building. This led people to have the experience of being in city without really being there. This demonstration presented nature as an illusion, and was to form the core idea of current panoramic video VR, which adopts video/s for presenting a natural and dynamic environment created on websites. The web-based panoramic video VR delivered nature's beauty with additional information to far distant audiences, and has the great potential advantage to meet the purposes of the applications if the technologies and productions have been well designed.

In past years, there has been an ongoing discussion about the status of the image in art

[1] IVPL (2004), The Image and Video Processing Laboratory is headed by Professor Aggelos K. Katsaggelos, the Ameritech Chair of Information Technology and Director of the Morotola Center for Telecommunication Research, source: http://ivpl.eecs.northwestern.edu/

history, philosophy, and cultural studies, which has gained in topicality and brisance through the advent of media art (Amout, 1997). However, studies of the technologies have identified noteworthy design problems, including resolution being impaired after creating the panoramic video (Zimmerman and Kuban, 1992; Xiong and Turkowski, 1997; Downs, 2000) compared to the original video/s, panning the video/s control (McNeill et al, 2002; Cramer, 2004). Also, the disorientation that takes place when navigating the scenes needs to be improved (McNeill et al, 2002; Haik, 2002; Mourouzis et al, 2004; Cramer, 2004; Bartneck, 2007). In addition, enhancing the experience and keeping information in the context of the environment of the web interface/interactive design which contains recommended elements (Kimber, 1998; Kimber et al, 2001; Haik et al, 2002; Ijsselsteijn and Riva, 2003; Pea et al, 2004; Kerremans, 2007) need to be investigated.

The research considers the above in relation to a suitable test environment; one that will be challenging and benefit from the ability of these virtual environments to allow access to information that is otherwise difficult to convey. According to Favreau et al (2004), surveys indicate that animals and their habitats documented as video sequences have been revealed to be a good resource and provide significant information. A potential and emerging integrated application, a virtual zoo, created using the web-based panoramic video integration, will be investigated to meet the requirements of the vital roles of zoos, i.e. education, conservation, and entertainment (WAZA[2], 2009). Moreover, the large investment costs of constructing natural habitats in zoos to allow visitors to experience and view the animals in close to their own habitat, emphasizes the potential inquiry in adopting the integrated application of web-based panoramic video.

## 1.2 Motivation

Web-based panoramic video VR, which is an integrated application of panoramic video on the web, is facing several major concerns regarding the technologies themselves and the productions to which they are applied. The panoramic video has defects such as the resolution decreasing after building, and the panning control needs to be properly

[2] WAZA: World Association of Zoos and Aquariums

designed. These technological issues appeared in pervasive studies and have made it necessary, indeed essential, to develop a new method to create optimal panoramic video. In addition, the traditional navigation style in scenes encounters, namely Hotspot jumping style, causes disorientation in position and way-finding perception, and that it needs to be improved has raised many notices recommending embedded elements in the web-based interface. Furthermore, the identification of the requirement of any integrated application should be investigated before putting the technologies into any application, not just to make a web-based panoramic video of a place. This can be traced back to when the author was practically undertaking a panorama project of Leeds Castle in 2000. The project received great praise from users, but did not successfully answer the question: why is it so important to demonstrate Leeds Castle in this way? The practical question happens to every production (Beriso, 2007) and raises the necessity to investigate the requirements of the proposed integrated application, virtual zoo, when developing the application. The interest in the specific area for adopting the integrated application of web-based panoramic video as the production can be very apparently seen in zoos' work in trying to immerse the visitors in the sights and sounds of habitats, and bring visitors up close to the animals. An example of this is Gorilla Kingdom built in London Zoo in 2007[3]. Moreover, the presentation of animals by web-based panoramic video has not only potentially met the three musts[4] of WAZA (educational value, focus on natural behaviours, and not demean or trivialize the animal in any way) but also keeps visitors safe and secure, and communicates animal and habitat messages. Overall, current zoos' websites present animal and habitat information using basic texts and images, e.g. London Zoo[5] (Figure 1.1), Twycross Zoo[6] and Taipei Zoo[7]. From this has emerged the opportunity to upgrade the sophistication level by adopting the technologies of building the virtual zoo for web users to see and experience animals in their natural habitat on the retrieved environment. This also motivates the research in undertaking the mission to develop the integrated application

[3] Gorilla Kingdom opened in 2007 and is a pioneering £5.3million exhibit bringing Central Africa to the heart of ZSL London Zoo. The purpose is to immerse visitors in the sights and sounds of the rainforest and brings visitors up close to Western lowland gorillas. The Kingdom took 18 months to construct it. Source: http://www.zsl.org/zsl-london-zoo/exhibits/gorilla-kingdom/

[4] The three musts of presenting the animals of zoo is available in the source: http://www.waza.org/ethics/index.php?main=ethics&view=ethics

[5] London Zoo official website: http://www.zsl.org/

[6] Twycross Zoo official website: http://www.twycrosszoo.com/

[7] Taipei Zoo official website: http://www.zoo.gov.tw/

of web-based panoramic video.


Figure 1.1: The information, texts and images of the squirrel monkey and its habitat on a zoo's website (London Zoo[8], 2008)

At the present time, the built panoramic video has not completely achieved the optimal technologies performance. The use of defective panoramic video in the application will influence the determination of the created productions performance level. The created panoramic video needs to be approved in video/s composition with properly panning control and orientation recognition performance in advance, and the built production requires an understanding of the requirement as criteria to determine the integrated application. These motivations form the aims and objectives of the proposed research, starting with an investigation of technologies, then application creation and evaluation.

### 1.3 Aims of the research

The motivations form the aims of the proposed research in dealing with the technologies and the production of the integrated application.

**Aim one**: To investigate innovative methods to create panoramic video with regard to optimal resolution in editing and stitching, and acceptable panning control.

[8] London Zoo's website, source: http://www.zsl.org/

**Aim two**: To investigate creative techniques to improve the disorientation issue when navigating in scene of panoramic video, with practicable interface design of a web-based integrated application.

**Aim three**: To develop and examine an emerging and potential web-based integrated application, virtual zoo, of panoramic video to the production requirement.

### 1.4 Objectives of the research

In reaching the aims of the research, the objectives are proposed as following:

1. To undertake a literature review of the technologies which focus on panorama evolvement, and address the issues of the current technologies of panoramic video

2. To investigate a design model for developing the integration of web interface

3. To investigate and test innovative methods for creating panoramic video with optimal resolution and panning control by having videos obtained in 3D CG world method

4. To investigate and test creative technology of in-scene navigation by using videos obtained in 3D CG world idea

5. To determine the necessity of recommended embedded elements, which enhance information and spatial recognition by videos obtained in 3D CG world idea

6. To review the relevant literatures on the application domain, that is the zoo, with particular focusing on emergence and requirement of the proposed production

7. To identify the practical requirement of the proposed production through zoo visits

8. To create the proposed integrated application, virtual zoo, using video/s obtained in the selected animal's habitat (natural environment) through the tested design method for creating and improving the panoramic video with web-based interface design developed in the 3D CG world idea

9. To determine the created virtual zoo in the requirement performance through end user testing and expert interview evaluation, and also determine the design method with web-based interface design in the created panoramic video through the same participants of the user testing (Qualitative and Quantitative methods)

10. To identify more potential employments of the created technologies both in zoos and other fields

**1.5 Outline of the thesis**

The organization of the thesis is built with the motivations and the objectives of the research. The formulation is to ascertain the infrastructure, which is the web-based panoramic video created by the author, of optimal performance after investigating the technologies, and then creating and evaluating the proposed integrated application, the virtual zoo, after having studied the requirements of the proposed creation of the application domain, that of zoos. The structure of the thesis is divided into eight chapters: introduction, panorama Virtual Reality (VR) overview, methodology, testing of the proposed solution - in 3D CG, Virtual Zoo as an idea integrated application - review of zoological data resource, Virtual Zoo as an idea integrated application - review of zoological data resource, production of the integrated application, Virtual Zoo, production evaluation, and conclusions and recommendations. The content of each chapter is outlined as follows:

Chapter One: indicates the research problems and motivations, the aims and objectives of the research, and the overall structure of the thesis.

Chapter Two: is the relevant literature review of panorama VR technologies, which consists of the evolvement, the characteristics, and the applications. The vital portion of this chapter is to highlight the existing issues of panoramic video, including elements recommended by former researchers to enlarge information acquirement and enhance spatial perception in web-based integrated applications.

Chapter Three: covers the methodology, overall research framework, and the adopted methods. In addition, the qualitative method and statistical analysis methods will be outlined.

Chapter Four: is concerned with proposing and testing the design method that deals with the addressed problems of panoramic video, included finding a cost and time effective idea by adopting video/s obtained in 3D CG world. In addition, the web-based interface of integrating panoramic video will be analyzed and generated with recommended embedded elements. Hypotheses will be produced related to the addressed issues as criteria for testing in four selected experiments.

Chapter Five: is the proposed integrated application domain study, which comprises the roles of contemporary zoos, what the visitors learned from the zoo and the motivation of visitors to visit a zoo, virtual museum concept to virtual zoo, online zoological information provided by zoos, and Multimedia and VR technologies used by zoos. The main study of this chapter is aimed at obtaining knowledge of the methods of information provision, and understanding the requirements of the proposed integrated application, the virtual zoo, in exhibiting the animal and its habitat.

Chapter Six: consists of visiting real zoos and creates the proposed integrated application, the virtual zoo. The main investigation of this chapter is to present a practical point of view (from zoos) of the requirement of the proposed virtual zoo creation by visiting zoos, and to create the virtual zoo by adopting the tested design method and essential embedded elements of the web interface in Chapter Four.

Chapter Seven: gives an appraisal of the created virtual zoo, including the performance level determination of the requirements of the creation, using the generated hypothesis as criteria and the addressed issues of panoramic video mentioned by Chapter Two. The requirement and interface design determinations will be evaluated through user testing by recruiting end users and undertaking expert interview with varied specialists who work in the zoo. In addition, the user testing also involved testing the performance of the panoramic video composition method and spatial recognition using the video/s obtained in natural environment filming.

Chapter Eight: discusses overall process of the study, starting with addressing problems, then the methods proposed as solutions, and the last determination to acquire the results of each aim of the research. Evidence will be attached to aid understanding of how the aims were processed and achieved by logically constructing the study. The necessity and essentiality of adopted methods in processing the research to achieve the aims of the research are presented. The research findings and contributions to knowledge, followed by recommendations for future studies are covered.

# Chapter Two: Panorama Virtual Reality (VR) Overview

## 2.1 Introduction

People have always been curious about nature (Benosman and Kang, 2001). There have been many attempts to recreate the experience of being in a particular place by having a panoramic view (Kimber et al, 2001). The Panoramic Video as dynamic Panorama VR has been interpreted as a kind of Virtual Reality technology to create virtual environments, which provides users with the ability to look around and pick the direction of view in a dynamic scene, fulfil the interest and curiosity. This chapter presents a wide range of studies of relevant literature relating to the technology development, in order to gather knowledge of Panoramic Video and identify any existing problems of Panoramic Video creation.

The technology review in this chapter is divided into ten sections: 1) Virtual Reality and panorama VR, 2) Advantage of Panorama VR compared to CG VR, 3) Panorama VR evolution, 4) Advantage of dynamic over static images , 5) Basic operation of Panorama VR, 6) Characteristics of the Panoramic Video, 7) Application of web-based Panorama VR, 8) Web-based integrated applications, 9) Current issues in Panoramic Video, and 10) Multimedia integration and web-based Panoramic Video.

## 2.2 Virtual Reality and Panorama VR

Virtual Reality can be defined as telepresence, or the projection of a human mind to a remote site (Larijani, 1994). Burdea and Coiffet (1994) mentioned Virtual Reality as a high-end users' interface that involves immersion, interaction and imagination. Further, more definitions of VR were:

"Virtual Reality is electronic simulations of environments experienced via head mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations." (Coates, 1992)

“Virtual Reality is an alternate world filled with computer-generated images that respond to human movements. These simulated environments are usually visited with the aid of an expensive data suit which features stereophonic video goggles and fiber-optic data gloves.” (Greenbaum, 1992)

“The definition of virtual reality is based on concepts of “presence” and “telepresence”, which refer to the sense of being in an environment, generated by actual or mediated means, respectively.” (Steuer, 1993)

“As a working definition, we may say that virtual reality is a three-dimensional, computer-generated simulated environment that is rendered in real time according to the behaviour of the user.” (Loeffler and Anderson, 1994)

“The word ‘reality’ in the phrase “Virtual Reality” does not have its usual meaning. Virtual Realism would be a better phrase, or possibly even pseudo realism, since what researchers seem to be striving for is the ability to interact more realistically with a computer-generated world.” (Crowe, 1995)

“Virtual Reality (VR) is a technology which allows a user to interact with a computer-simulated environment, be it a real or imagined one.” (Wikipedia[9], 2008)

Panorama VR can be said to be associated to VR, as the definitions of VR can be summarized as an informative scene, which allows a user to look around and navigate using interactive design, and uses computer-generated, three dimensional graphics or digital image composition, to present an experience of “being there”.

Panorama VR can commonly be defined as an image that contains all the required information, so that the whole of the 360 degrees field-of-view (FOV) in any direction is covered (IVPL, 2004; Tzavidas and Katsaggelos, 2005). Panorama VR had been interpreted as the kind of Virtual Reality technologies used to create virtual environment from retrieved real scene (Xiao, 2000, Dorta, 2004; Tzavidas and Katsaggelos, 2005).

[9] Wikipedia, Virtual Reality, source: http://en.wikipedia.org/wiki/Virtual_reality

Panorama VR provides the users with the ability to look around an environment similar to Virtual Reality, and lets the users pick the direction of view in a scene (Naimark, 1991). Xiao conducted research to investigate Panorama VR and illustrates the potential of using it to develop web-based library instructions for users to experience. Xiao suggested that Panorama VR could be a useful medium that allows users to navigate, view, and hear, and allow remote access to the virtual environment. Xiao and Othman et al (2002) have both indicated that Panorama-based virtual realty is an extension of computer graphics (CG) and virtual reality, and Panorama VR can be defined as "telepresence", or the "projection of a human mind to a remote site". Othman et al (2002) took this one step further and states that Panorama VR can be classified as a kind of Virtual Reality, which provided scenes using CG technologies. Furthermore, Panorama VR has been used on the web for people to experience presence, or a feeling of "being there" in virtual environments for commercial purposes, such as the VRHull[10] (2007) website.

### 2.3 Advantage of Panorama VR compared to CG VR

Traditionally, virtual reality systems used 3D computer graphics to shape and render virtual environments (VE) in real-time. The achievement of the creation normally demanded exhaustive modelling, and high cost, special purpose rendering hardware. The real-time constraints limited the rendering quality and scene complexity (Chen, 1995). The advantage of Panorama VR that is produced in the virtual environment by image capturing is apparently in saving time and cost with high visual realism. Panorama VR was chosen because it easily produces an informative environment using quality images, and has no requirement for expensive hardware or software (Xiao, 2000; Nischelwitzer, 2001). It is easier for the user to navigate within, can provide better user control, and can be viewed on standard monitors and needs less computer power and bandwidth size than a real 3D visualization (Chen, 1995; Othman et al, 2002). Othman et al also revealed Panorama VR is an effective communication tool which focuses on visualization information and benefits the representation on the websites e.g. museum exhibitions. In addition, the Panorama VR avoids the tedious 3D modelling stage, and

[10] VRHull is a website which used hundreds of 360 degree panoramas to provide online user to have Virtual Reality tour of the City of Hull, East Yorkshire. Source: http://www.vrhull.co.uk/

rendering from images is usually faster than rendering complex geometric models (Fleisman et al, 1999; Dorta, 2004).

### 2.4 Panorama VR evolution

The history of Panorama VR can be tracked back to Scotland over 200 years ago. In 1787, Robert Barker demonstrated a panoramic painting of Edinburgh to audiences, placed in a large circular building. The exhibition allowed people to share the experience of being in the city without really being there. The public response was unremarkable, but the art world began to take notice of the potential of this technique for visualization. This demonstration presented nature in an illusion but formed the core idea of current panorama VR in delivering a reproduced informative environment (Oettermann, 1997; Wright, 2000; Dorta, 2001; Grau, 2003). The demonstration indicated that Panorama VR was seen as a new art form, but how amazingly new can be illustrated by the history of the word "panorama" itself. Panorama is in common use today, and it is difficult to find a synonym. Barker's exhibition displayed almost exactly the history of Edinburgh in the seventeenth century, and was, as the National Maritime Museum revealed, a "Panorama showing the time and space development" (Allies and Morrison, 2005; National Maritime Museum, 2007).

Oettermann (1997) reveals that the term "panorama" is derived from ancient Greek and relates to an elevated geological formation or the view from a look-out point. The etymological Dictionary interprets "panorama" as originating from two Greek roots: pan (all) and horama (view), and it is comparable to other modern words such as "telephone" and "automobile". Panorama is an artificial, technical expression; in other words, it is created for a specific form of landscape artwork, which represents a 360-degree view. Panoramic drawing is an amazing art from, and panorama painting represented the first true visual mass medium. As voyager Louis Antoine de Bougainville (1772) said, "nothing is more precious than the view of a landscape that is open on every side".

A wide-angle lens is not always wide enough for viewing all surroundings (Singer, B. and Singer, D., 2006). Panorama VR created by digital images, a highly effective way of showing spacious scenes, creates a dramatic display. Wikipedia, the free encyclopaedia on the web, (Nov., 2007 revised) concluded the history of Panorama VR stating, “Panorama is any wide view of a physical space. It has also come to refer to a wide-angle representation of such a view – whether in painting, drawing, to digital photography, or digital video/videos”. Furthermore, Kimber et al (2001) interprets and defines the current Panoramic Video development of Panorama VR as, “Users can interactively replay the video with the ability to view any interesting object or choose a particular direction”. Panorama VR is moving forward to acquire more reality in this case.

Panoramic Video is one way to provide the experiences of “being there”, in a retrieved nature scene. It is a development originating from painting, through to stitched digital images, augmenting a greater reality. Figure 2.1 shows the evolution of Panorama VR. There are many studies in the field of enhancing the reality of Panorama VR by Panoramic Video provision, to give better immersion benefits to Virtual Reality (see 2.2 and 2.3). As the immersive video effect of Panoramic Video, Panorama VR is often introduced by modern camera manufacturers, which create digital videos in the new format (Majumder et al, 1999; Wikipedia, 2008).

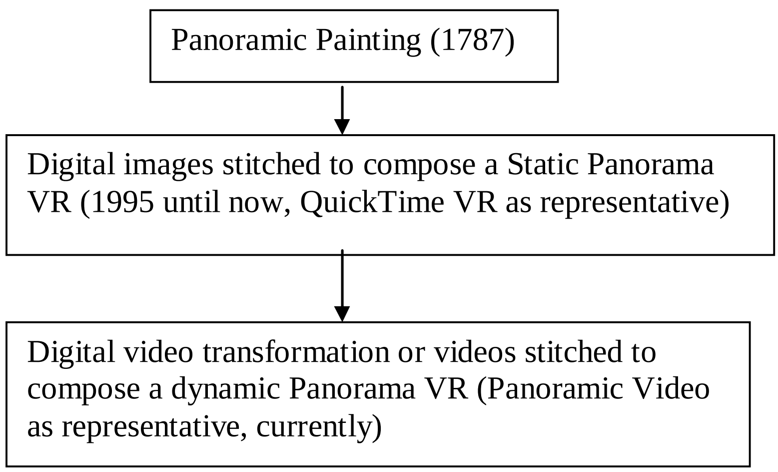


Figure 2.1: The Panorama VR evolution

2.4.1 Classification of Panorama VR by image display

It is useful to classify Panorama VR by looking at the type of image display. This thesis classifies Panorama VR in image display into Static Panorama VR (photo-based Panorama VR) and Dynamic Panorama VR (thereafter called Panoramic Video). It subdivides Panoramic Video by video capture system, into single camera systems and multi camera systems (see Fig. 2.2). This way to classify Panoramic Video has been introduced by Fritz in 2004. Fritz suggested using four ways to capture Panoramic Video. The video capture systems should be narrowed down to two categories, which are single camera systems and multi-cameras systems.

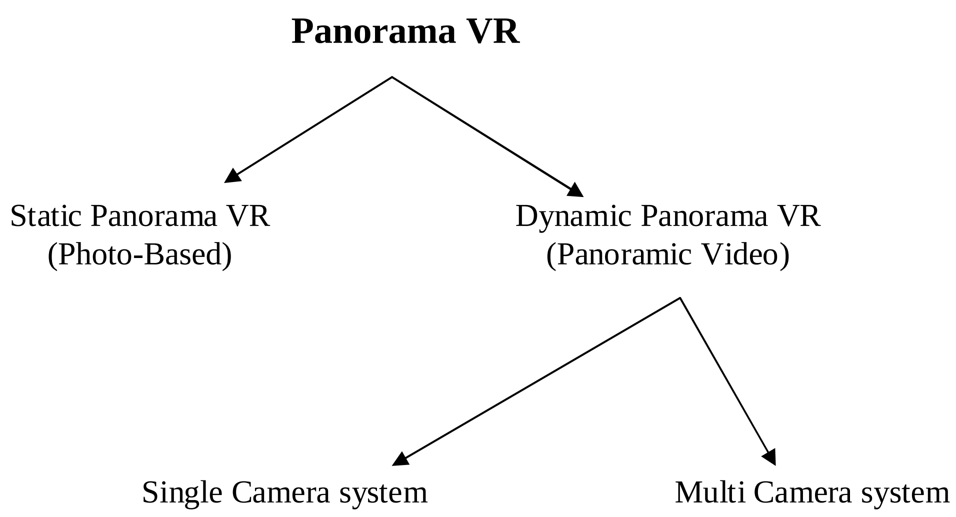


Figure 2.2: Panorama VR types

Panorama VR can be classified as Static Panorama VR (Image-Based) and Dynamic Panorama VR (Video-Based), according to image display format. Needless to say, the images displayed in Static Panorama VR are still. Panoramic view of Static Panorama VR is stitched photos, QuickTime VR being representative of this. In addition, the display can present a stereo visual effect when properly designed, which exploits human sensitivity to differences between the parallax views of the world afforded by having two eyes slightly offset. This occurs as a result viewing corresponding points in a scene containing objects at different depths, producing two retinal images (McAllister, 1993; Davis and Hodges, 1995; Martens et al., 1996; Peleg and BEN-Ezra, 1999; Nagata, 2002; Cohen et al., 2007) or by colour stereo anaglyph (JPL[11], 2006). Figure 2.3 shows an example of stereo static Panorama VR, Figure 2.4 gives an instance of a stereo single camera system of Panoramic Video, and Figure 2.5 is the stereo multi-camera system of panoramic video for reference.

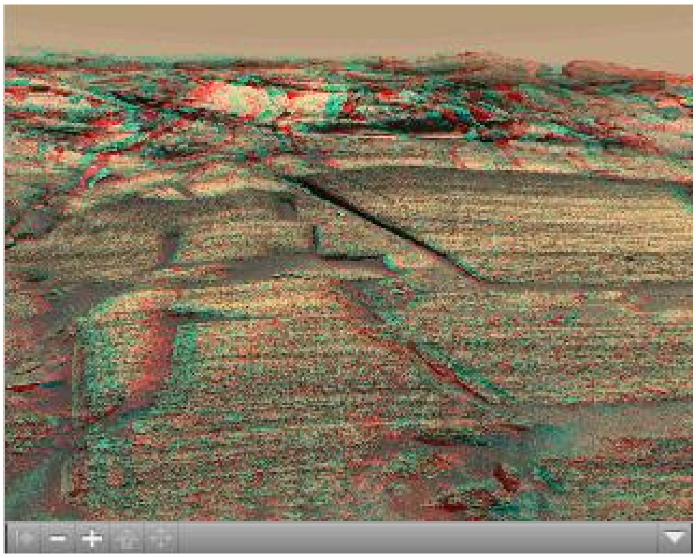

Figure 2.3: The stereo static Panorama VR (QuickTime VR format) of Burns Cliff on Mars by colour stereo anaglyph, offering a 3D quality when see properly through red/blue glasses (JPL, 2006)

[11] JPL (Jet Propulsion Laboratory) is a federally funded research and development centre located in the San Gabriel Valley area of Los Angeles County and is managed by the nearby California Institute of Technology for the National Aeronautics and Space Administration (NASA) projects. Source: http://photojournal.jpl.nasa.gov/catalog/PIA08578

Figure 2.4: Single camera system video capturing equipment to generate stereo effect using a convex mirror and a concave lens (Yi and Ahuja, 2006)

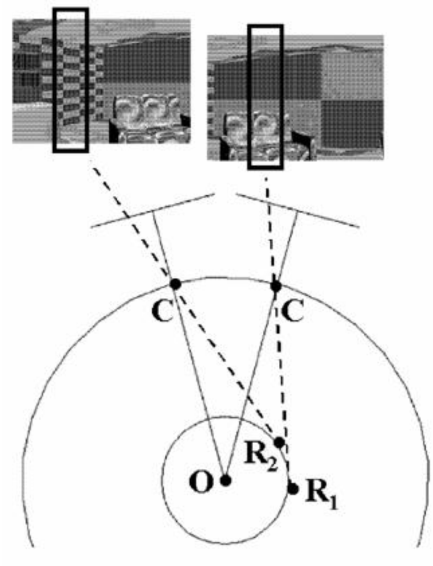


Figure 2.5: Eyes' offset concept applied to multi camera system to obtain stereo visual effect (Tzavidas and Katsaggelos, 2005)

2.4.2 Static Panorama VR

With static Panorama VR, the user is presented with a single still image of every direction of view. Still Panorama VR is typically created by taking a set of images of a scene using a rotating camera, and by projecting these images onto a common surface

(Szeliski, 1996; Gumustekin and Hall, 1996; Szeliski and Shum, 1997; Huang and Hung, 1998). A good example to introduce static panorama VR is "QuickTime VR". This is originally created by Chen (1995). It is the typical example of a photo-based Panorama VR tool; there are also many other tools to create static Panorama VR (BeHere, 2005; IPIX, 2007). QuickTime VR is a popular photo-based Panorama VR. It is created by a series of still images being stitched together, e.g. a 360-degree panorama of Twycross zoo (Figure 2.6). The images are taken from the users' point of view and form the panoramic view. The QuickTime VR allows the user interactivity by clicking on it, to move the view point.

This photo-based Virtual Environment is low cost and effective, and is similar to computer graphics models. All the scenes are created using real pictures taken by users themselves, whether the scenes are complex or not (Liu et al, 2003; Singer, B. and Singer D., 2006). Distinct from the computer graphics based techniques, photo-based Panorama VR is more concerned with image synthesis (Chen, 1995). A stitched method of capturing surrounding images in advance was used to establish the photo-realistic virtual environment, and then to create a fresh panoramic view for the viewers.

Figure 2.6: Example of QuickTime VR: A monkey closure (Twycross Zoo[12], 2007)

Photo-based Panorama VR can be made using appropriate hardware and composing software. Figure 2.7 gives the camera and photo stitching tool for creating photo-based Panorama VR.

[12] Twycross Zoo (2007) website: http://www.twycrosszoo.com/home.htm

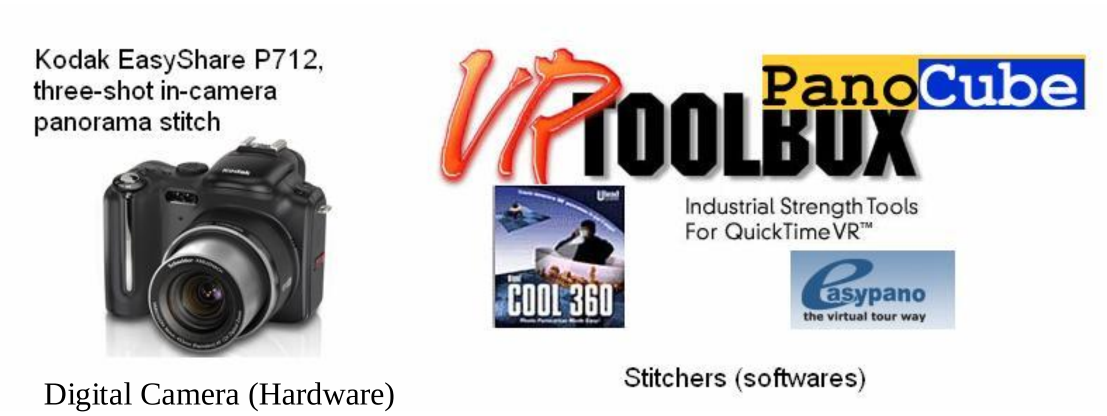


Figure 2.7: Images capture system and composition Software to make photo-based Panorama VR

The equipment for photographing a panorama is not complex, using a normal digital camera and a tripod with levels. The first step in making any static Panorama VR is to take the pictures. Lawler (1998) and Peiker (2004) provide the general steps to take photos for static Panorama VR:

1. Level the tripod perfectly horizontal.
2. Locate the camera at the tallest area of the tripod and select a suitable focal length lens.
3. Compose the shots.
4. Avoid using auto-exposure between shots.
5. Pan the camera from left to right or right to left to take photos, and make sure to leave an overlap space in every shot.

The next step is to stitch the photos together. There are many ways to do this. One of the common processes to stitch photos to form a panorama is typically based on the Ulead® COOL 360™ operation:

1. Start: Create a project and import images to the project.
2. Stitching: depending on the functions provided by software, mostly have rotate, rearrange the sequence of the image, colour balance functions between frames. And transformed images to correct lens distortion.
3. Save the file in QuickTime VR format.

A stitched Panorama VR example created using the above method, shown in Figure 2.8 for reference.

Figure 2.8: Panoramic campus tour of De Montfort University made on 21st May, 2007

The overall process of making static Panorama VR is shown in Figure 2.9, and an image-based Panorama VR example created by the method is shown in Figures 2.6 and 2.8.

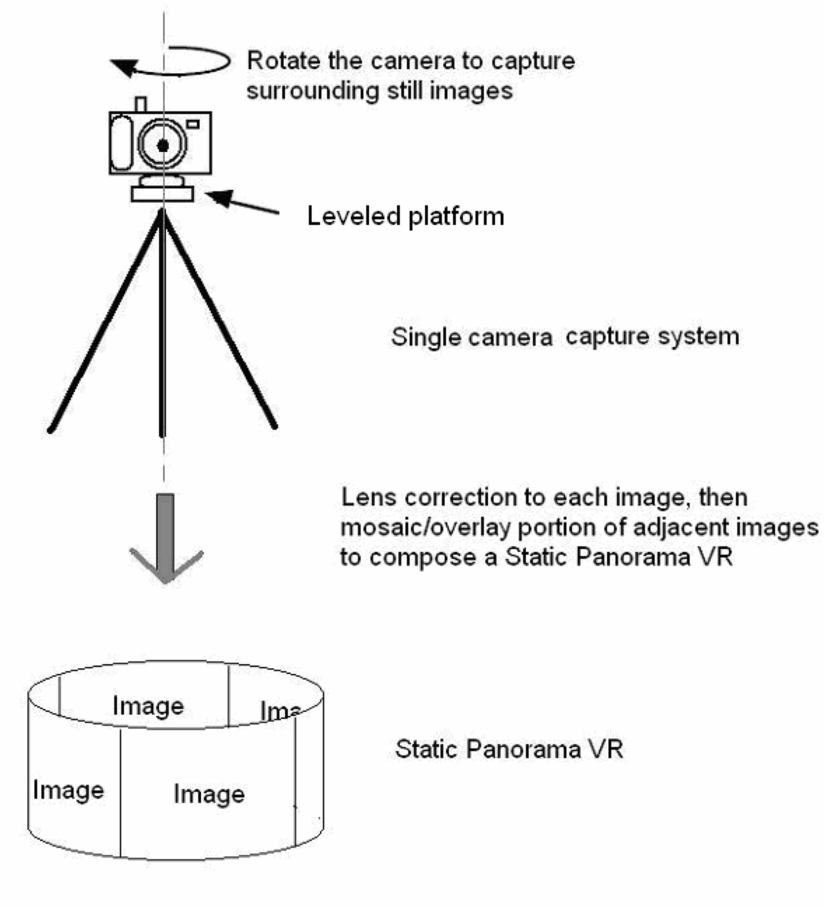


Figure 2.9: Overall process of making static Panorama VR

2.4.3 Video/s Panorama VR

This type of Panorama VR is called Panoramic Video because the view is formed by digital video footage whether using a single camera system (Nayar, 1997, Naar and Baker, 1997; Onoe et al, 1998) or multi cameras system to obtain the video/s (Nalwa, 1996; Fritz, 2004). The Panoramic Video is able to provide the user with a video sequence, instead of a single still image, in every direction.

2.4.3.1 Single Camera system

The hardware of a single camera system to capture video to create Panoramic Video can be approached either by fisheye lens (see Figure 2.10), Panoramic Annular Lens (PAL) (see Figure 2.11), or by pointing the lens into a curved or parabolic non-planar mirror (see Figure 2.12). The advantage of the single camera with fisheye lens is that it is simple and portable, and users can attach it directly to an existing digital video camera.

Figure 2.10: A digital fisheye camera and a self-portrait in a mirror[13]

[13] Image retrieved (2007), Source: http://appregate.org/DIT/PEEPFISH/ . The website claimed (2006) the major reasons that fisheye imaging has become of much greater importance are the ability to "see everything" using a single camera.

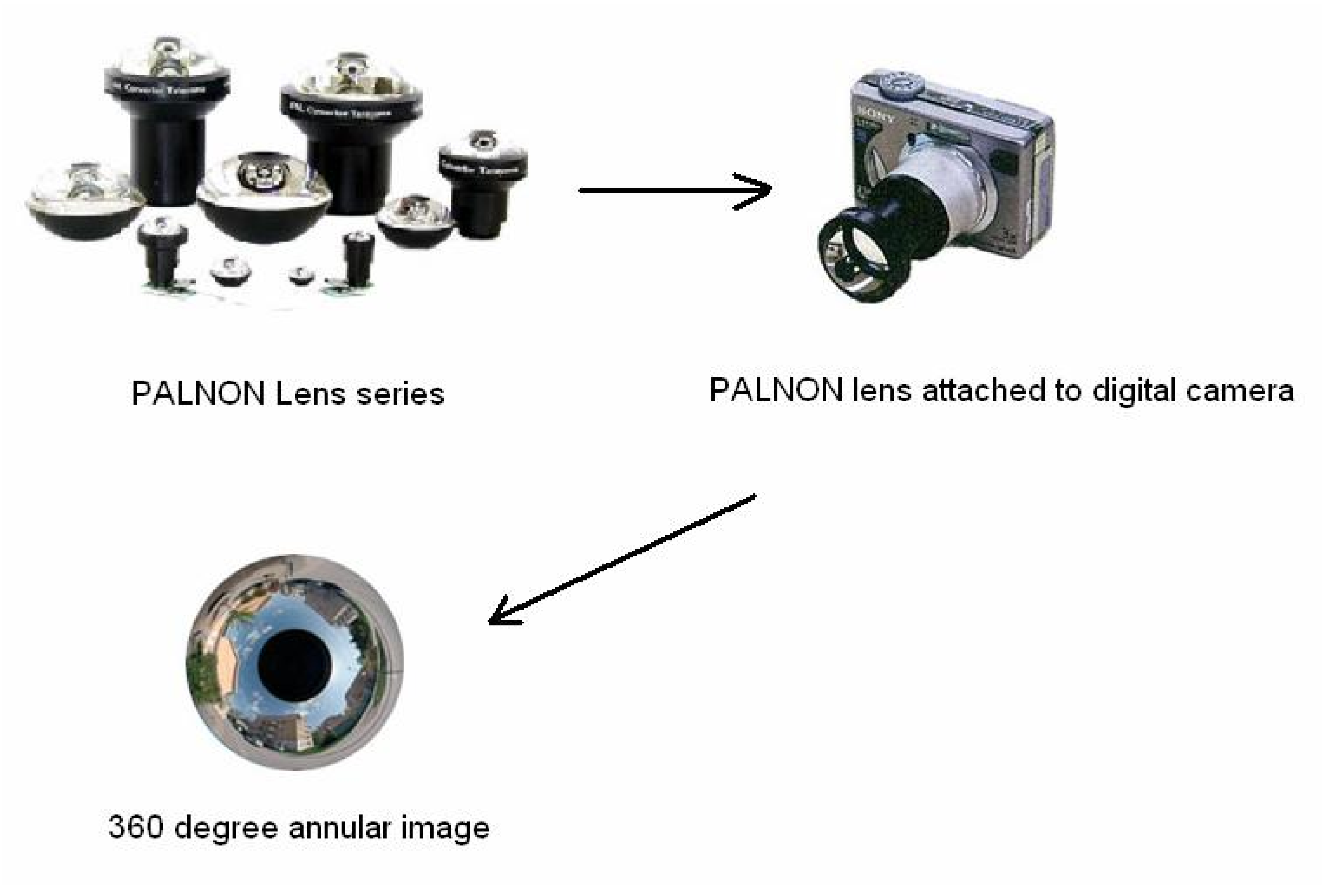


Figure 2.11: The figure shows the PAL products, PALNON series, of JBC Group mounted on the digital camera and the annular image display (JBC[14], 2007)


Figure 2.12: A single camera pointed at a curved mirror to retrieve omni-directional image (Yachida Lab of Osaka University [15], 2007)

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[14] JBC Group (2007) is a Japan company who helps foreign companies to the market studies and high-tech equipment. PAL is one of the services. Source: http://www.jbc-group.com/

[15] Yachida Lab (2007) aims at the research of 360 degree techniques and their application. Source: http://www3.sys.es.osaka-u.ac.jp/index.htm

Sony Electronics (Fritz, 2004 and Pajdla et al, 2004) illustrate (see Figure 2.13) the process of making Panoramic Video using Sony's Panoramic RPU-C251 Camera (PAL) Module on their promotional brochure. This provides the design and the flowchart to construct Panoramic Video through a single camera system.

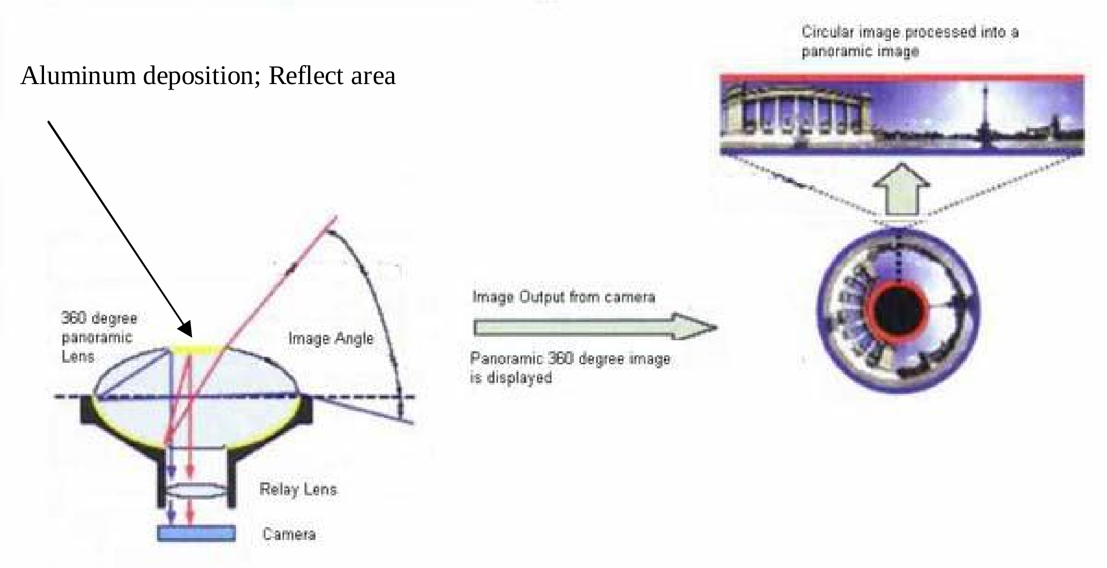


Figure 2.13: The diagram shows the process of Sony's Panoramic RPU-C251 Camera Module to create Panoramic Video (EMedia Magazine[16], 2004)

Yamazawa et al (1998) and Yokoya et al (2002) employed a single camera that points to a curved mirror, catadioptric omni-directional video camera HyperOmni Vision (see Figure 2.14), to retrieve omni-directional video and transform it to compose Panoramic Video. The HyperOmni Vision was developed by Yamazawa et al in 1995. Yokoya uses it to visualize information media with a focus on activities including environment observation.

[16] The diagram retrieved from the sidebar "Panoramic Video Camera Systems", EMedia Magazine August 2004

Figure 2.14: The Appearance of HyperOmni Vision (Yamazawa et al, 1998 and Yokoya et al, 2002)

There are many single digital video cameras, for example "FlyAbout" (Kimber et al, 2001), employed to create Panoramic Video. A practical design comparison of the single camera systems is shown in Table 2.1.

| **Single Camera Systems** | | | | | |
|---|---|---|---|---|---|
| System | FlyCam | EyeSee360 | Be Here | Ipix | Remote Reality |
| Design | Single camera with a custom lens | Single camera with a custom lens | Single camera with a custom lens | Single camera with a fisheye lens | Single camera looking off a parabolic mirror |
| Field of View | Panoramic | Panoramic | Panoramic | Hemispherical | Hemispherical |

Table 2.1: The single camera systems comparison (TX Immersive Ltd., 2008)

The image process to employ single digital video camera to construct a Panoramic Video is extracted normally by using geometric transformation (see Figure 2.15) from a part of omni-directional image to a planar perspective image (Onoe et al, 1998), after capturing the images. Yokoya illustrates (see Figure 2.16 (a)) the reconstructed image and computes the transformation to rectangle spaced grid points (see Figure 2.16 (b)). The correspondences from destination to source images are sparsely determined for an evenly spaced grid pointed to a rectangular destination image, and then applying image-warping techniques completed the destination image. The techniques sheared source image portions to corresponding rectangular grids in the destination image (Wolberg, 1990). Figure 2.17 shows the result of panoramic imaging using the method above. The result image is a perspective and reconstruction image. The grids are generated for users to disregard the geometric distortion of the computed image.

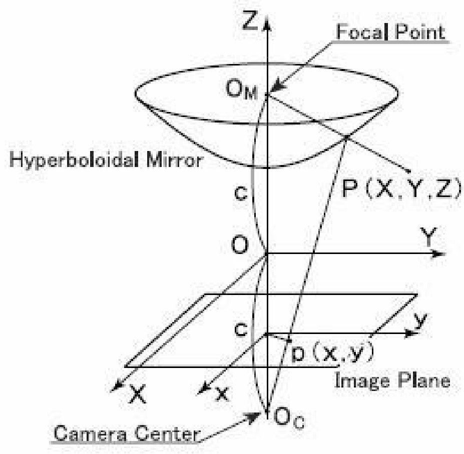


Figure 2.15: A complex geometrical configuration (Onoe et al, 1998)

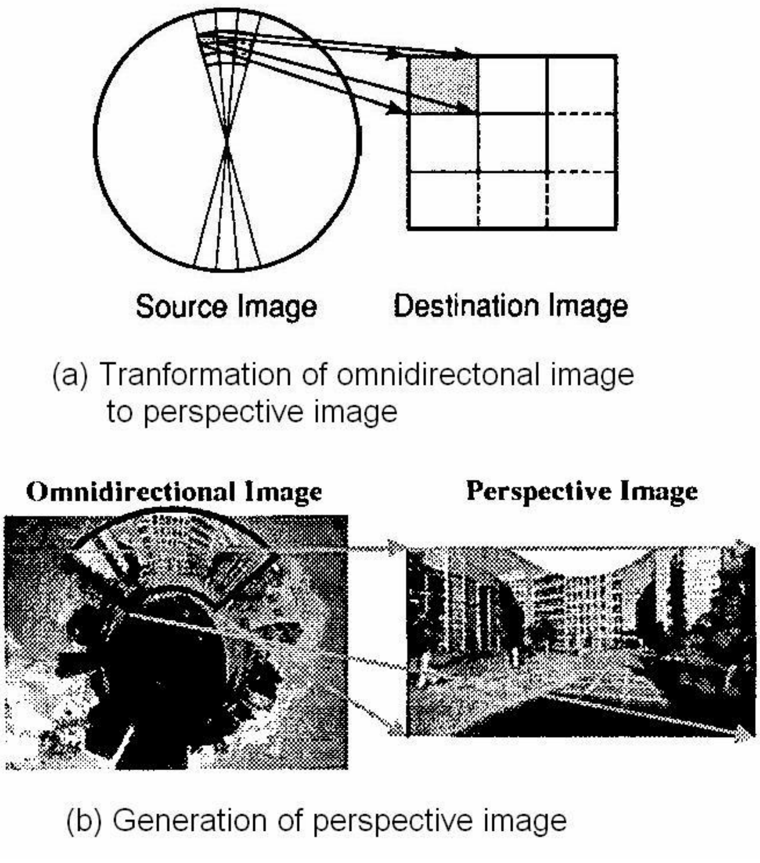


Figure 2.16: Transformation of omni-directional image to perspective image (Yokoya et al, 2002)

Figure 2.17: Computing and constructing panoramic image from perspective image (Wolberg, 1990)

The process of Panoramic Video created by single camera system is shown in Figure 2.18. Special care needs to be taken in the construction of Panoramic Video by single camera system, as it requires developers to have certain mathematical abilities to calculate the curve and reflection line of the mirror used (Nayar and Baker, 1997).

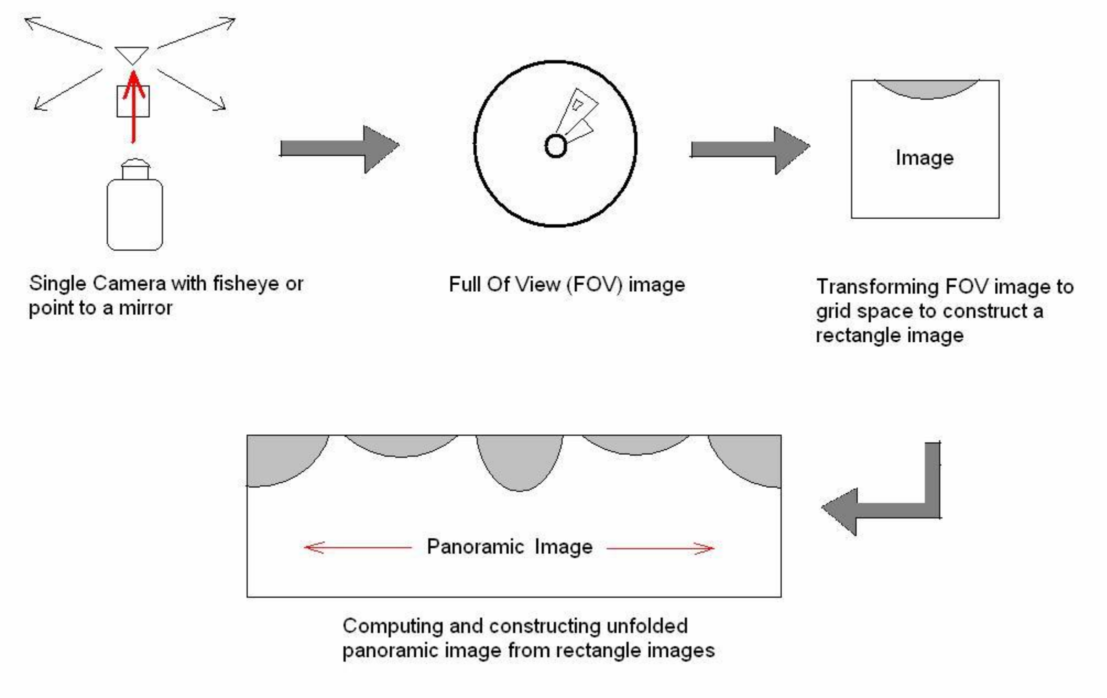


Figure 2.18: Overall process of Panoramic Video creation from a single camera system

2.4.3.2 Multi Camera system

An alternative solution to compose Panoramic Video utilizes multiple cameras in fixed relative positions, and created each frame in the sequence by appropriately stitching the resulting images (Rizzo et al, 2004, and Macedonio et al, 2007). A common design comparison of multi camera systems is shown in Table 2.2.

| **Multi Camera Systems** | | | |
|---|---|---|---|
| System | IMC Telemmersion | FullView | iMove |
| Design | Eleven cameras in a compact ball or globe | Five or nine cameras looking off flat mirrors | Six cameras looking out directly from the faces of a large cube |
| Field of View | Spherical & Omnidirectional | Panoramic | Spherical |

Table 2.2: The multi camera systems comparison (TX Immersive Ltd., 2008)

Multi-Cameras Panoramic Video acquired videos through several adjacent digital video cameras depend on the numbers of digital video cameras (Tzavidas and Katsaggelos, 2005). The digital video cameras can be aligned in a circle, and point out in different directions (see Figure 2.19), or point into a planar or curved mirror (see Figure 2.20). Figure 2.21 displays a design concept of the equipment to acquire videos.

Figure 2.19: FlyCam (FX Palo Alto Laboratory[17]): equipment to create Panoramic Video by stitching together images from multiple video cameras

[17] FlyCam (FX Palo Alto Laboratory). Website: http://www.fxpal.com/?p=home

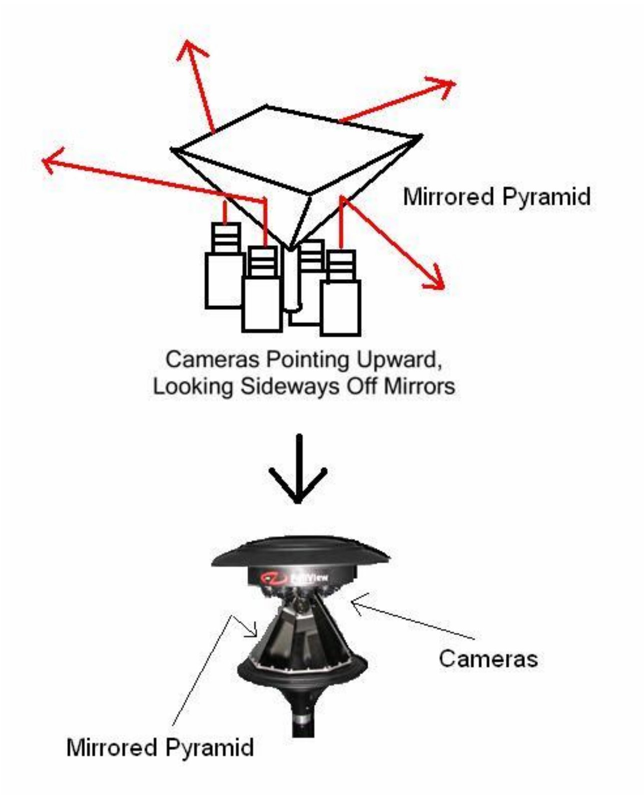


Figure 2.20: A type of multi cameras that points into a mirror to form Panoramic Video (FullView[18], 2007)

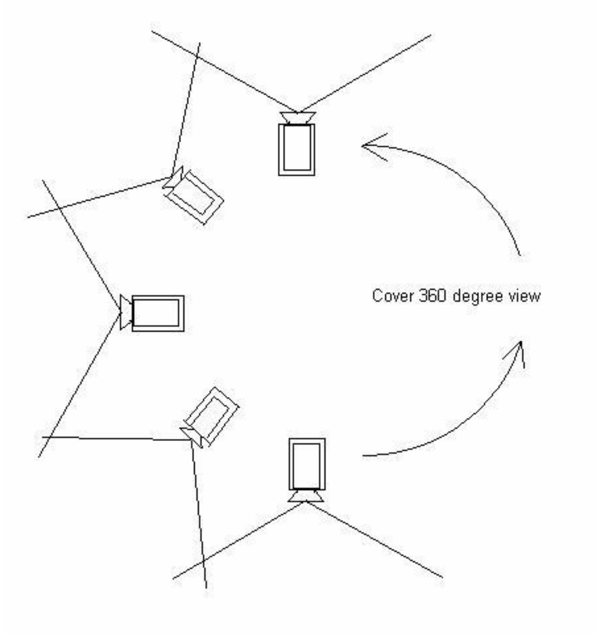


Figure 2.21: The general cameras set-up of multi camera system to form a panoramic view

[18] FullView (Fullview, Inc., 2007). Source: http://www.fullview.com/

A good example of multi camera system is given by Foote and Kimber (2000 and 2001) who use a multi camera system to capture and create Panoramic Video. They correct the lens distortion and map images from adjacent cameras onto a common image plane by bilinear warping of quadrilateral regions of images (see Figure 2.22), and merged the images to compose a panoramic image (see Figure 2.23) after capturing. The warping and merging process provided a general process of creating Panoramic Video after capturing videos by multi cameras system.

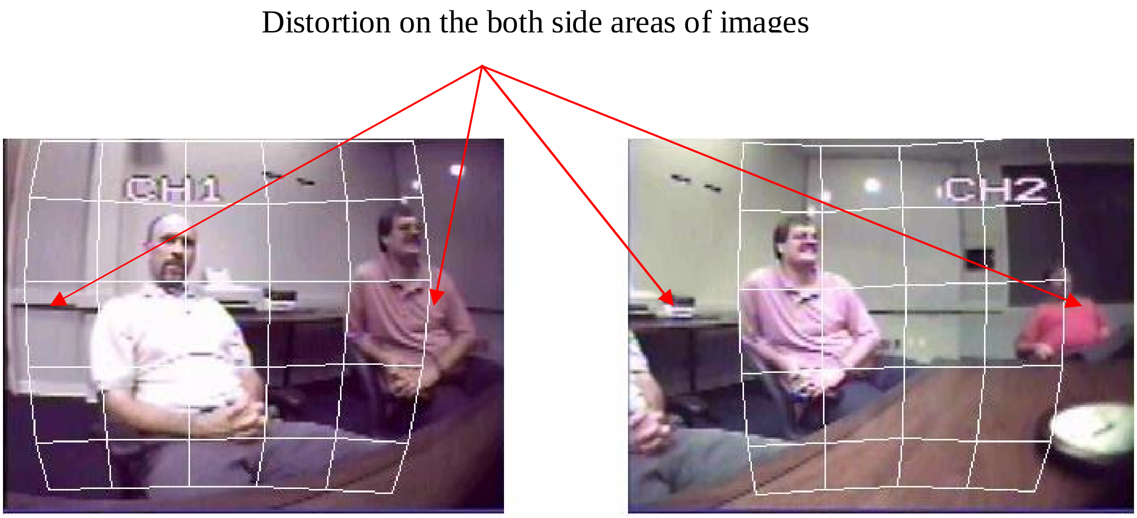


Figure 2.22: The red arrows show the distorted portion of images, and the white mesh displays the bilinear warping method (Foote and Kimber, 2000 and 2001)

Figure 2.23: A frame of 360 degree Panoramic Video created by Foote and Kimber (2001)

The composition of Panoramic Video by multi camera system is summarised in Figure 2.24.

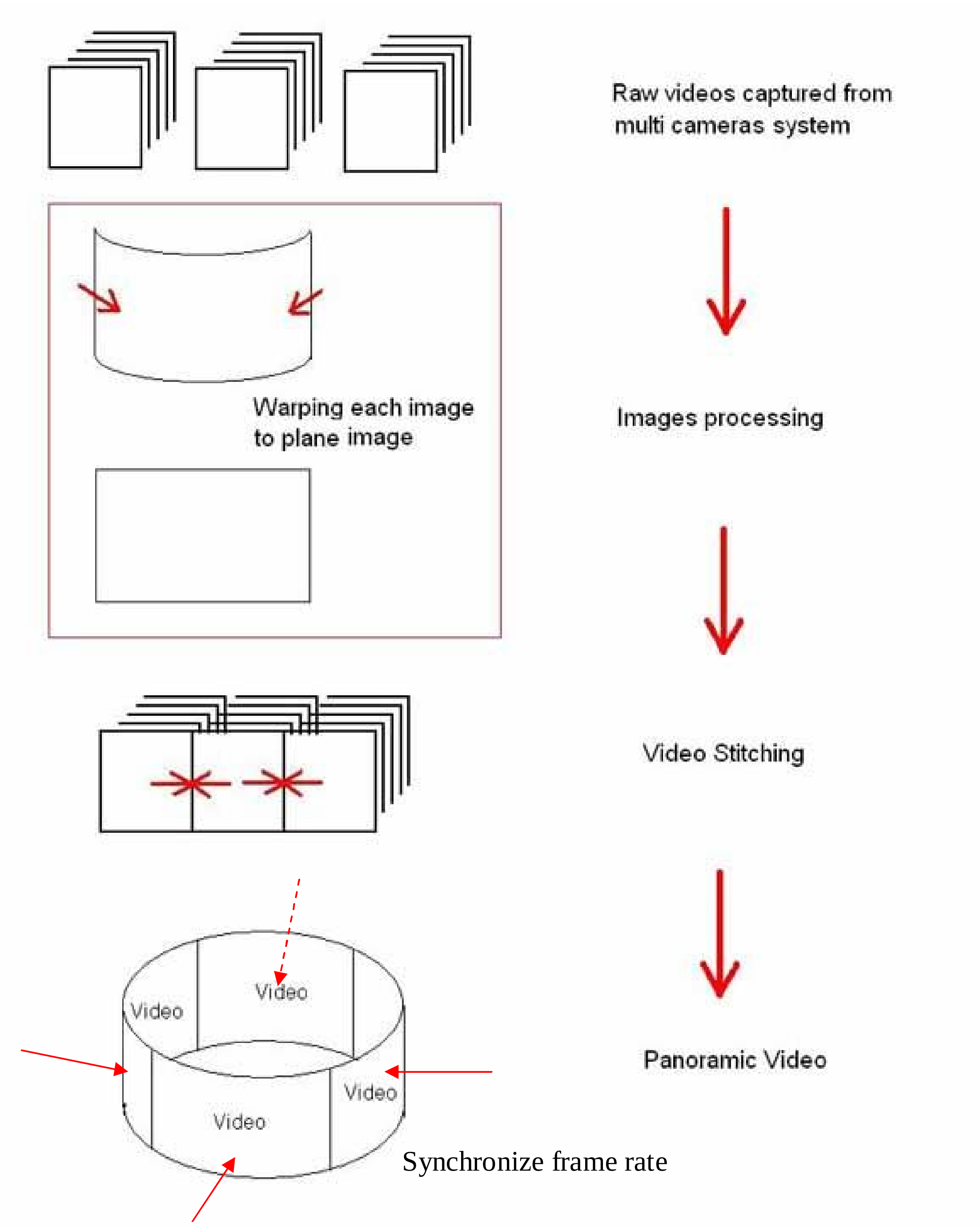


Figure 2.24: The basic process to compose Panoramic Video by multi camera system

## 2.5 Advantages of dynamic over static images

It is possible for users to take a virtual visit within static Panorama VR format, to the

Tower of London[19], the Great Wall of China[20], Glacier National Park[21], the Mount St. Helens volcano[22], Durham Cathedral[23], or a habitat of animals like Bicknell's Thrush[24] on the Web. On the NASA[25] (2003) (National Aeronautics and Space Administration) website, users can even virtually experience the surface of Mars. The author has composed a static panoramic view of Mars, which was considered the pioneering view of the Mars surface level. The static Panorama VR has been on the market for over 15 years (Chen, 1995), QuickTime VR for example, but all of the experiences of the static Panorama VR are based on still photos and are not nearly life-like enough, as birds do not fly through and cars do not pass by. The static Panorama VR may have good display quality (Xiao, 2000, and Othman, 2002) but the environment in natural human daily life is dynamic.

The reason photos-based Virtual Environment is called a non-immersive VR technique is not only that the images are displayed on a desktop, but also are static. It is difficult to imagine the world that people live in is motionless. The birds fly through, and cars drive toward or away from the user created live experience perception when users navigating inside (Aumont, 1997). Gibson (1986) indicates "Virtual Reality integrated perceptualizations, not purely visualizations, for learners to create, observe, and understand relationship within the environment". From Gibson's point of view, knowledge begins with perception, and perception is perceived from observing the environment (Mace, 2005). Therefore, the virtual environment created by images composition should present a more life-like, natural environment, and a dynamic natural surrounding.

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[19] Tower Bridge and the Tower of London, Source: http://www.britishtours.com/360/towerbridge.html

[20] The great wall of China is of the 7 wonders of the world, Source: http://www.panoramas.dk/7-wonders/great-wall.html

[21] Glacier National Park is located in Kalispell, Montana U.S.A. and is a hiker's paradise for adventurous visitors to seek wilderness, Source: http://www.panoramas.dk/7-wonders/great-wall.html

[22] A static 360 panorama view of Mount St, Helens volcano taken in 2003, Source: http://www.fullscreen360.com/mt-st-helens-summit-2003.htm

[23] A exterior 360 panorama view of north flank of Durham Cathedral, Source: http://www.learn.columbia.edu/ha/html/medieval_durham_n_flank.htm

[24] Bicknell's Thrush is a new bird species of North America in 2004. Researchers and conservationists provided static 360 panorama views of the habitat of the bird to users as starting point to know more about the species, Source: http://www.ns.ec.gc.ca/wildlife/bicknells_thrush/e/index.html

[25] NASA launched the Mars Exploration Rovers toward Mars in 2003 to liquid water tracks, Source: http://marsrover.nasa.gov/home/index.html

The Panorama VR on the web that people visited could provide users' with some sort of immersion when navigating it (Pintaric et al, 2000) if it is both vivid and lively. Fritz (2004) revealed "the moving pictures expand the possibility exponentially, as the production and delivery pieces fall into place, digital video will soon supersede still images as the next medium of choice for creating immersive VR-style experience". Panoramic Video as an upgraded version of static Panorama VR yields not a single shot, but a sequence of a 360-degree view of the environment, which allows users to experience a feeling of being there.

Pintaric et al (2000) indicates that Panoramic Video retains distant times and locations of video images and overcomes the passive and structured limitation of how video imagery is presented and perceived. Viewers of Panoramic Video are allowed to individually control their view direction as virtual participants immersed in the observed scenes. Panoramic Video as an upgrade version of photo-based Panorama VR, such as QuickTime VR, enhancing views' experience as virtual participants, and creates an interactive method for human perception in a virtual environment. Tzavidas and Katsaggelos (2005) took a step forward and said that, "The Virtual Reality system in this case to be able to provide the user with a video sequence, instead of a single still image, in every direction." Many users and content creators have been expecting passive linear experience to move to the interactive non-linear experience of visual perception and transformation on Panoramic Video (Fritz, 2004).

## 2.6 Basic operation of Panorama VR

The interactive design of the operation of Panorama VR is the most attractive feature to users. Users can look around the reproduced environment, even navigating in scenes, because of the interactive operations including panning, zooming in and out, and navigating the scene using the Hotspot navigation method. It is necessary to introduce these basic functionalities of Panorama VR provision to users for interacting and navigating, before application introduction. The Panorama VR is simulating digital camera panning, tilting and zooming, and accomplishes walking in scenes by jumping (Hotspot) to different panoramic view points for users to experience spatial sceneries on the computer (Chen, 1996; Bartneck, 2007).

### 2.6.1 Panning

Panorama VR that allows users to stand in a virtual place to look around and tilt up and down is the basic feature. The horizontal and vertical scope was decided by the panorama developing tool. Users drag with the mouse across to look left and right (Pan), and up and down (Tilt) across the vista to have a panoramic view (Apple Developer Connection, 2005). Figure 2.25 is a Panorama VR example on the web for geography and environment observation, retrieved from Don Bain's Virtual Guidebooks website to demonstrate the Pan and Tilt functions. Bain concluded that it is said to be "the next best thing to being there". The Pan and Tilt features of Panorama VR raised users' attention to the environment circumstance.

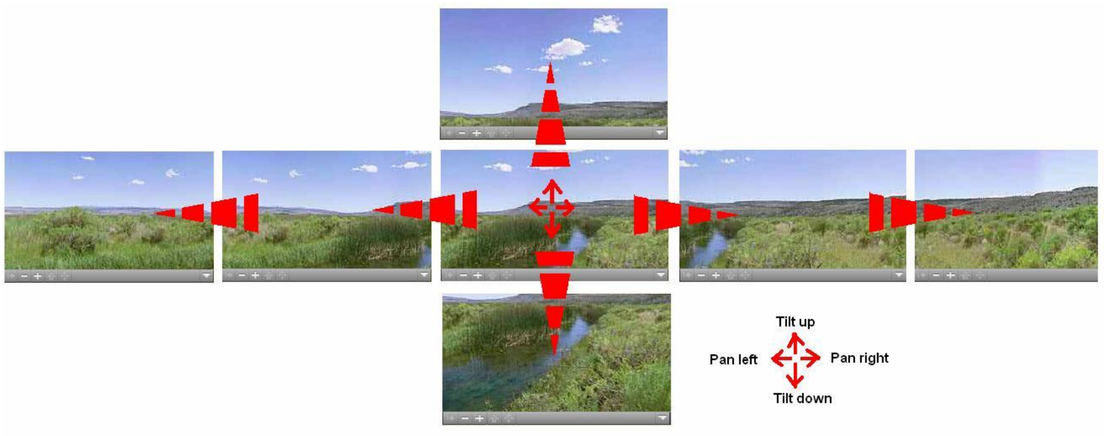



Figure 2.25: The Panorama VR shows the wetlands along the upper Malheur River of Eastern Oregon. The wetlands are one of the main links in the Pacific flyway of migratory birds (Don Bain's Virtual Guidebooks[26], 2007)

### 2.6.2 Zoom

The zoom in and out function of Panorama VR is similar to CG (computer graphic) VR for providing a close look at an object or target. Traditionally, users can zoom in and out by pressing the zoom in button and zoom out button on the controller bar, or

[26] Don Bain is Director of the Geography Computing Facility in University of California Berkeley (2007) : Website: http://virtualguidebooks.com/

pressing the Shift key to zoom in and pressing the Control key to zoom out, depending on the designing tools. Panoramic Imaging Ltd. (2007) has Panoramic Video samples on the web to demonstrate the zoom in and out functions (see Figure 2.26), for reference.

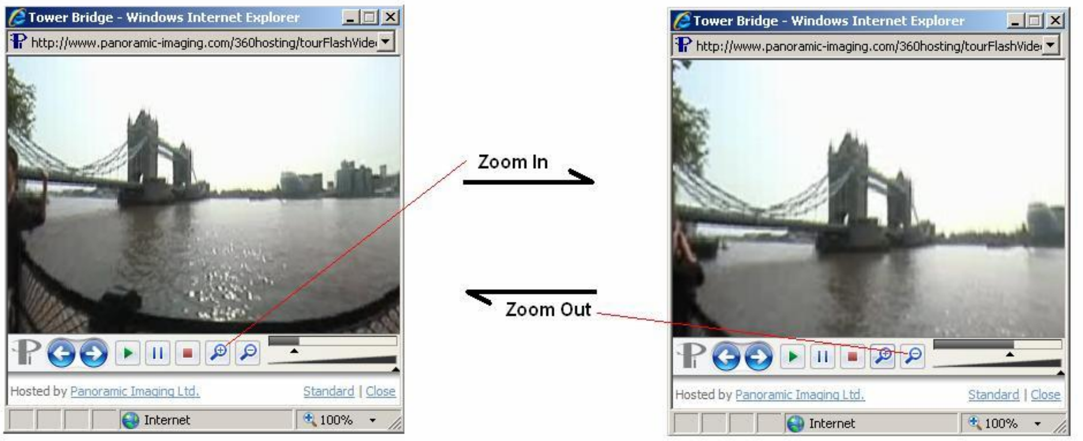


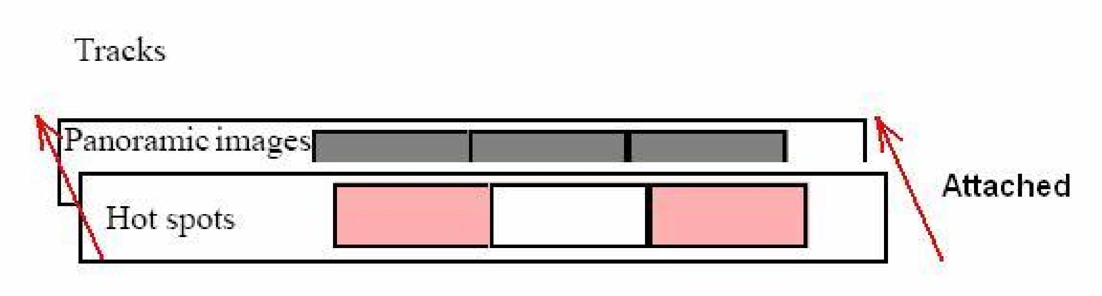

Figure 2.26: The zoom in and out effect of panoramic video on the London Bridge (Panoramic Imaging Ltd.[27], 2007)

### 2.6.3 Hotspots

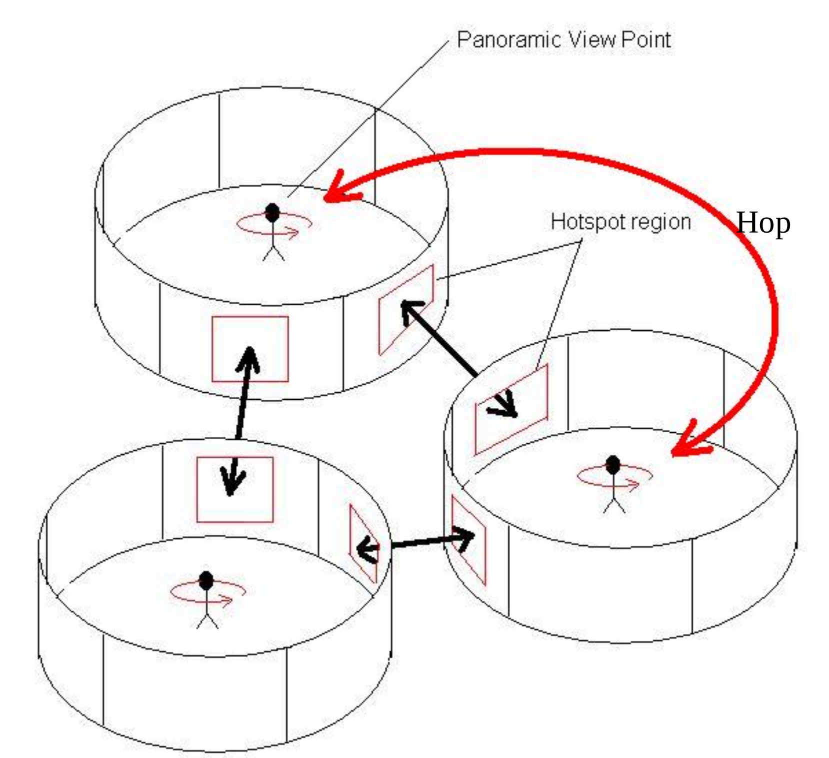
A key component in many virtual reality systems is the ability to perform a walkthrough of a virtual environment from different viewing positions and orientations. The Panorama VR uses Hotspot to hop from a panoramic viewpoint to another directly, to perform the walkthrough ability. "Hotspot" regions of a panoramic image are for interactions, such as navigation or activating actions. Chen (1995) illustrates (see Figure 2.27a) hotspot marking on panoramic images layout by merging the panoramic images track and the Hotspots track. Figure 2.27b shows the initial concept of hotspots in Panorama VR. The process of linking hotspots connects different viewpoints of scenes and produces navigation in a real environment virtually (Bartneck, 2007). Users, normally, find out the mouse cursor changes, an open arrow mouse icon for example, when it rolls over a Hotspot region to perceive the path to hop to another panoramic view point. A screenshot (see Figure 2.28) obtained from The University of Texas at

[27] Panoramic Imaging Ltd. is a company who serve 360 degree Panorama VR products to customers included hardware and website integration (2007), Source: http://www.panoramic-imaging.com/

Austin website[28] (2008) which introduces the Hotspot function of the Panorama VR to Educators, demonstrates this.




(a) The Hotspots track and panoramic images track constructed. The tracks are synchronised when panning and tilting (Chen, 1995)




(b) Users click Hotspot regions to hop to another Panoramic View Points to achieve walkthrough effect

Figure 2.27: The Hotspots constructed to interactive and navigation in Panorama VR scenes

[28] The College of Education of the University of Texas At Austin (2008), Source: http://www.edb.utexas.edu/education/

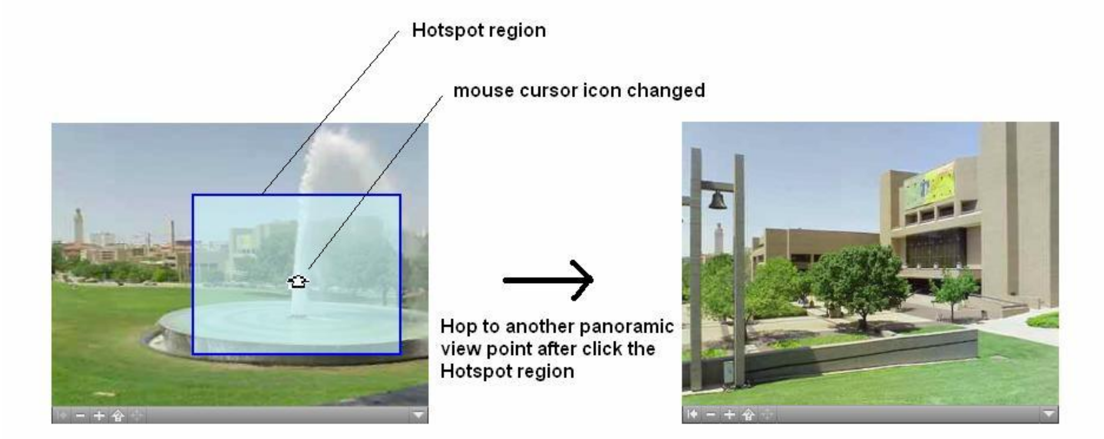



Figure 2.28: Clicking the Hotspot region to move to another panoramic viewpoint gives a tour of the University of Texas (2007)

## 2.7 Characteristics of the Panoramic Video

There are three vital features of the Panoramic Video in the process of delivering the retrieved natural environment. They are immersive, presence, and 3D effect when users are exploring.

### 2.7.1 A form of immersive video

Panoramic Video has been interpreted as a kind of immersive video in many researches (Pintaric et al., 2000; Hernandez et al., 2001; Rizzo et al., 2003; Tang et al., 2003; Miyahira and Folen, 2006; Mulligan, 2006; Xu et al, 2008). An immersive video is basically a video recording of a real world scene, where the view in every direction is recorded at the same time. During playback the viewer has control of the viewing direction, up, down and sideways. Generally, the only area that cannot be viewed is the view toward the camera support. The material is recorded as data which, when played back through a software player, allows the user control of the viewing direction. The play control is typically via a mouse or other sensing device and the playback view is a window on a computer display, projection screen or other presentation device such as Head Mounted Display (HMD) (TX Immersive Ltd., 2008).

Panoramic Video camera systems produce virtual environments in which the system users can capture, playback, and observe vivid, accurate 360-degree video scenes of the "real world" environment (Macedonio et al., 2007). Panoramic Video overcomes the passive and structured limitations of how video imagery is presented and perceived. The convergence of camera, processing, and display technologies make it possible to provide each user with individual control of their viewing direction. The viewers becoming virtual participants immersed in the observed scene is one of the great characteristics of the Panoramic Video (Pintaric, 2000; Macedonio et al, 2007).

### 2.7.2 Presence – as a feeling of "being there"

Morton Heilig described his experience of presence with Cinerama in New York, 1952:

"When the curtain swept up to reveal the now-legendary wide-screen roller coaster ride, I realized that the film's creators were no longer content to have me look at the roller coaster but were trying to put me physically on the ride. The audience no longer surrounded the work of art; the work of art surrounded the audience – just as reality surrounds us. The spectator was invited to plunge into another world. We no longer needed the device of identifying with a character on the other side of the 'window.' We could step through it and be a part of the action!" (Ijsselsteijn and Riva, 2003).

The Cinerama experience, as we already know, is often likened to transporting the audience to other lands; the experience of presence, or the sense of "being there", in an environment other than where one is physically located (Ijsselsteijn et al., 2001). When people make use of virtual environments, they normally experience presence, the subjective sense of being in the virtual place (Regenbrecht et al. 1998). Schubert et al. (1999) has further indication that presence is observable when people interact in, and with, a virtual world as if they are there. Panoramic Video providing the sense of presence, with users experiencing "being there" in the virtual environment, is an important feature of the performance (Kimber et al, 2001; Rizzo et al, 2004; Macedonio et al, 2007).

2.7.3 3D perception

The three-dimensions are commonly defined as length, width, and depth (or height), but any three mutually perpendicular directions can serve as the three dimensions (Wikipedia[29], 2009). Video is recognized as a sequence of images, which play orderly in presenting a dynamic scene. The objects in a video playing someone walking in, far to near, or reverse or turning around is creating the depth of 3D perception because of added time-axis (see Figure 2.29). The real world known as the 3D world is initially projected as a two-dimensional flat image after video camera shooting. The time passing of the sequence adds 3D perception, recovering the flat image back to the real world, e.g. dynamic objects in the scene moving from far to close, afterward. Goldluck (2006) illustrates (see Figure 2.30) the space-time concept of Panoramic Video. The philosophy had been used to create Panoramic Video in Agarwala et al. (2005) and Song's (2007) studies who investigated video frames' texturing to compose Panoramic Video (see Figure 2.31).

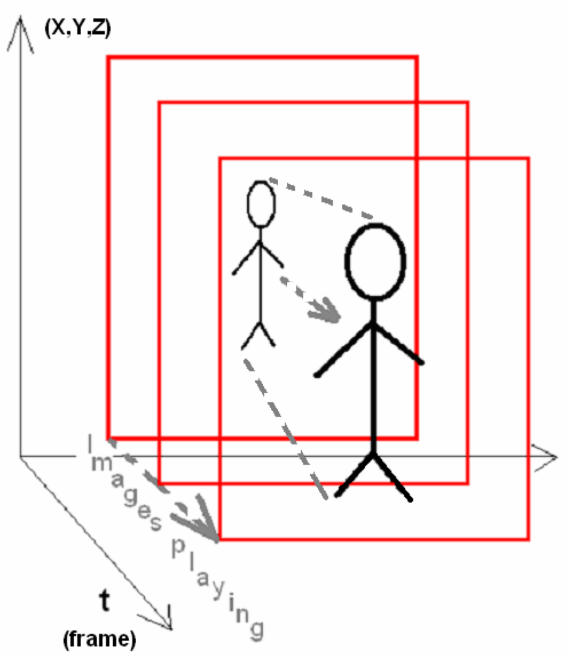



Figure 2.29: Dynamic object movement when video playing produces perspective parallax effect

[29] Wikipedia (2009), Three-dimensional space, Source: http://en.wikipedia.org/wiki/Three-dimensional_space

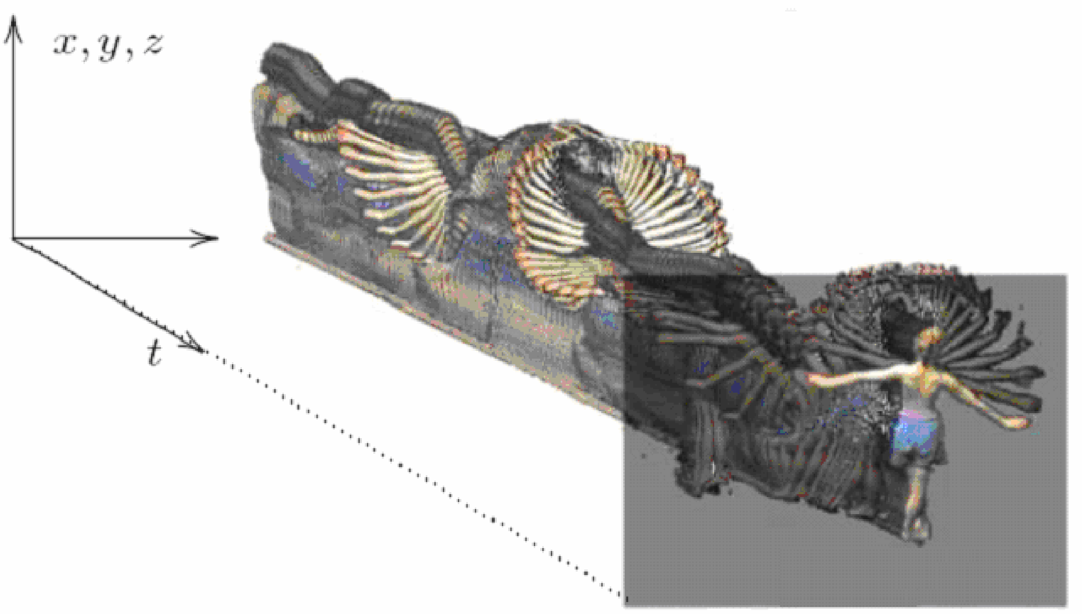



Figure 2.30: The space-time geometry of the video scene creating 3D effect (Goldluck, 2006)

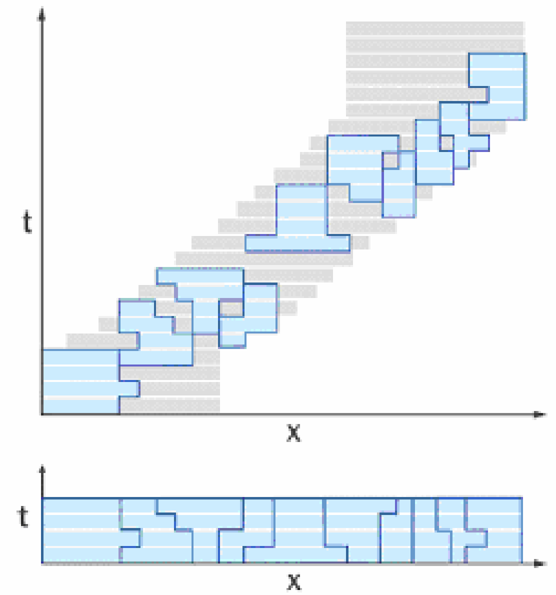



Figure 2.31: Each input video frame is shown as a grey rectangle in the top diagram. The frames were registered and the camera is panning to the right. The bottom diagram shows the output video volume. The two diagrams show how a Panoramic Video texture can be constructed (Agarwala et al, 2005)

## 2.8 Application of web-based Panorama VR

As Kimber et al (2001) pointed out: an obvious application of Panorama VR is for spatial databases. The use of Panorama VR has the advantage that the camera does not need to be accurately aimed (Boult et al 2000) and the user has a 360-degree surrounding view. According to the Internet rapid development and images pre-recorded technologies, the web-base integrated application of Panorama VR has broken through the wall of distance and time restraint. A multimedia website integrated with Panorama VR lead users to have close observation of, and collect information visually from, the scenes at a far distance.

### 2.8.1 Tourism

A better way to promote a town or region is to have immersive imagery (Weibel[30], 2007). By panning the panoramic images on the web such as cities, villages, coast, and rivers, Panorama VR allows users to have a pre-visit experience of a location, such as a virtual tour to the Covered Market in Oxford City (see Figure 2.32), or a place the people find hard to visit, for example a virtual tour of 10 Downing Street (see Figure 2.33).

Users can also virtually visit rooms, bathrooms, and hotel facilities to get the "feel" before making reservations. This is a benefit in that people can get a better idea of where they want to have a vacation before booking.

[30] Bob Weibel is a former technical editor for PUBLISH magazine and a past contributor to THE MACINTOSH BIBLE, Source: http://www.efuse.com/Build/panorama.html#shouldyou

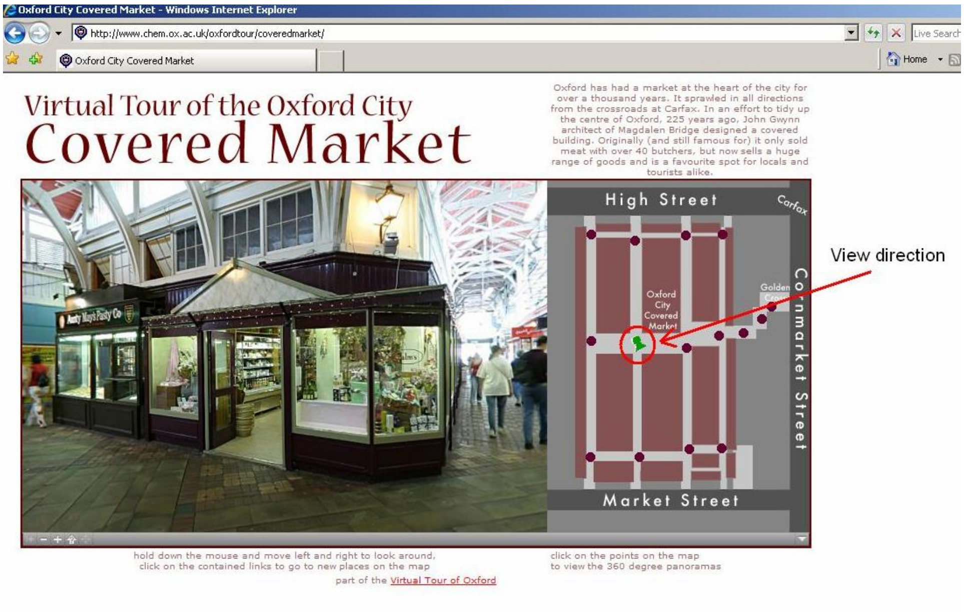



Figure 2.32: The website has a map with a camera icon allowing virtual users to have a conceptual position in the area (Oxford City[31], 2007)

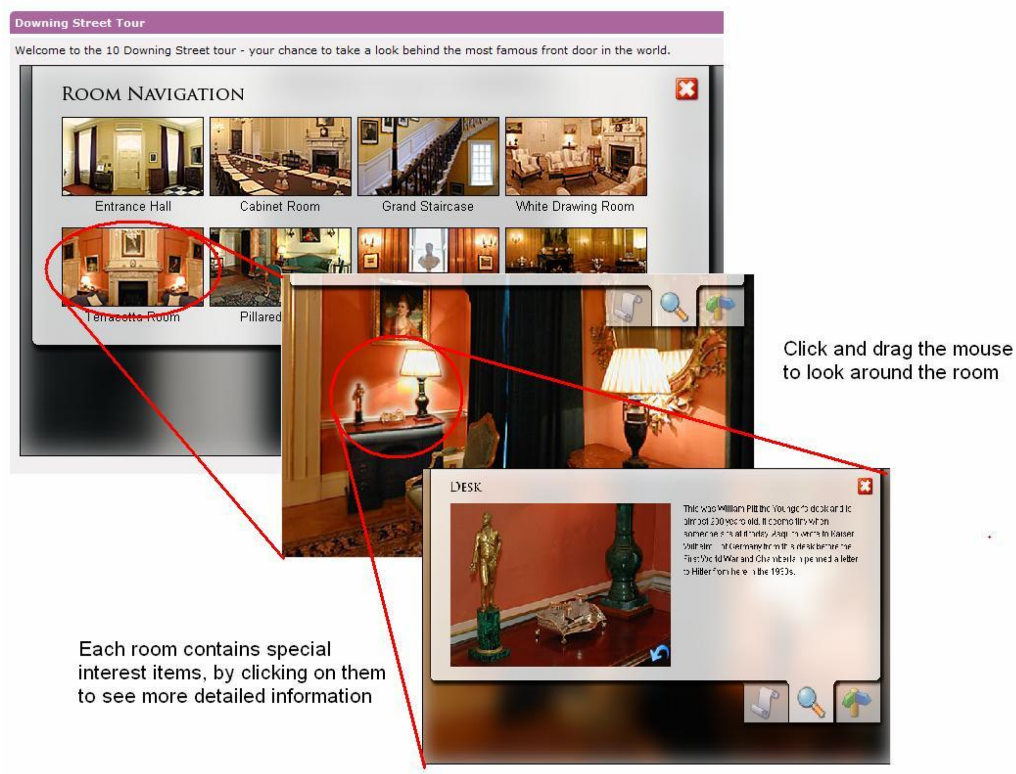



Figure 2.33: The website, Virtual tour of 10 Downing Street, provides users with a chance to take a look behind the one of most famous doors in the world (Number10[32], 2007)

[31] Covered Market of Oxford City, Source: http://www.chem.ox.ac.uk/oxfordtour/coveredmarket/
[32] Number10 (2007), Source: http://www.number10.gov.uk/output/Page41.asp

### 2.8.2 Architecture

Virtually looking around, and navigating between natural rooms are obviously a great advantage of Panorama VR. Virtual Museums are a good example of using Panorama VR technologies applied to Architecture. A virtual museum is a museum that takes advantage of using web pages to exhibit the environments and collections. Virtual Museums enable museums to be reached by audiences, new visitors or frequent visitors physically far away from their location (Wikipedia, 2007). Some studies have shown that the virtualization of museums can increase the interest of people who know about their collections already. The virtual visitors to museum websites have already outnumbered physical visitors, and many are engaged in dedicated information provision for education purposes (Futurelab[33], 2007). HR Giger Museum is an example, which opened in 1998 and had 280,000 visitors from all over the world in 2000, serving the many Giger fans that have not yet been able to make the trip to Gruyeres, Switzerland. The museum offers visitors a Panorama VR tour of the HR Giger Museum and its many exhibition rooms. Figure 2.34 illustrated one of the virtual navigation experiences on the HR Giger Museum website.

[33] Futurelab-innovation in education, Source: http://www.futurelab.org.uk

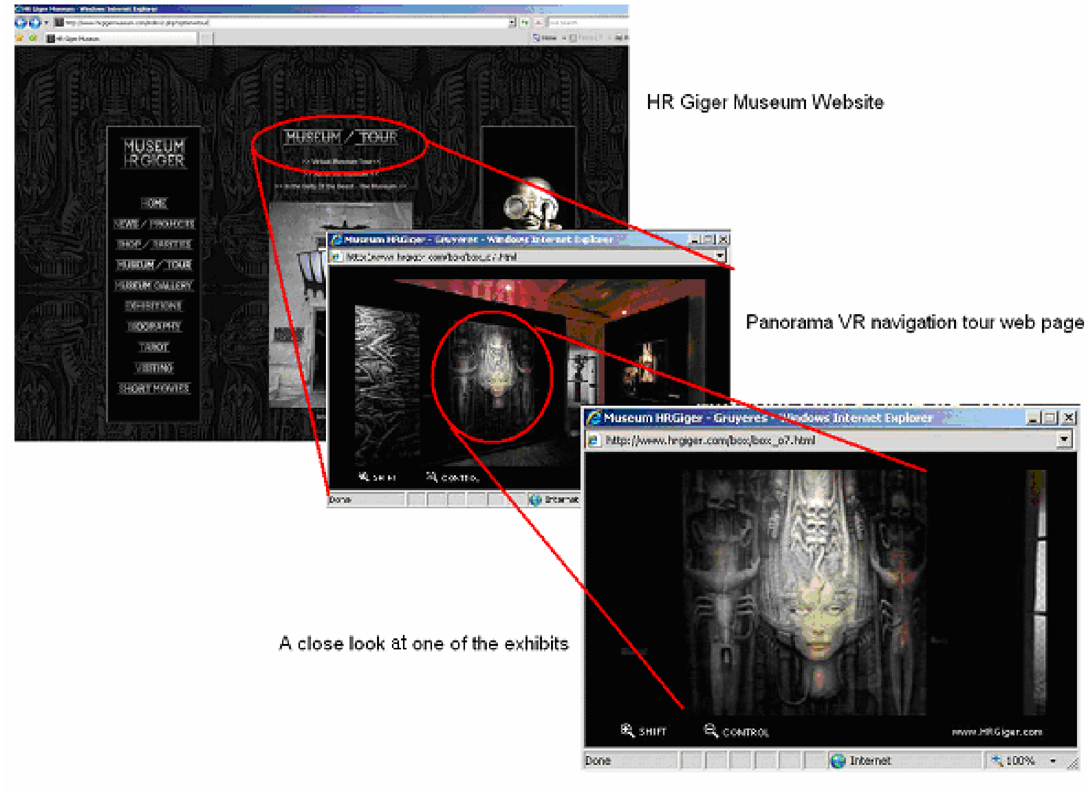



Figure 2.34: A close look to one of the exhibits in Room No 7, Key Painting from the 70s of online HR Giger Museum[34]

The Virtual Oxford University Museum of Natural History website[35] is another example of a Panorama VR application. The Museum exhibits Oxford University's extensive world-wide collections of zoology, entomology, geology, and mineralogy, including the local dinosaur finds. The building itself is one of the finest examples of the Victorian Gothic style of architecture, exhibiting a wealth of naturalist carving as well. By clicking on the positions in the map on the window, users can have a panoramic view of the exhibitions in the inner building, and zoom in/out to have a close look at the exhibits in a pop up window (see Figure 2.35).

[34] HR Giger Museum website (2007), Source: http://www.hrgigermuseum.com/index2.php?pg=1&option=tour
[35] Oxford University Museum of Natural History (2007), Source: http://www.chem.ox.ac.uk/oxfordtour/universitymuseum/#

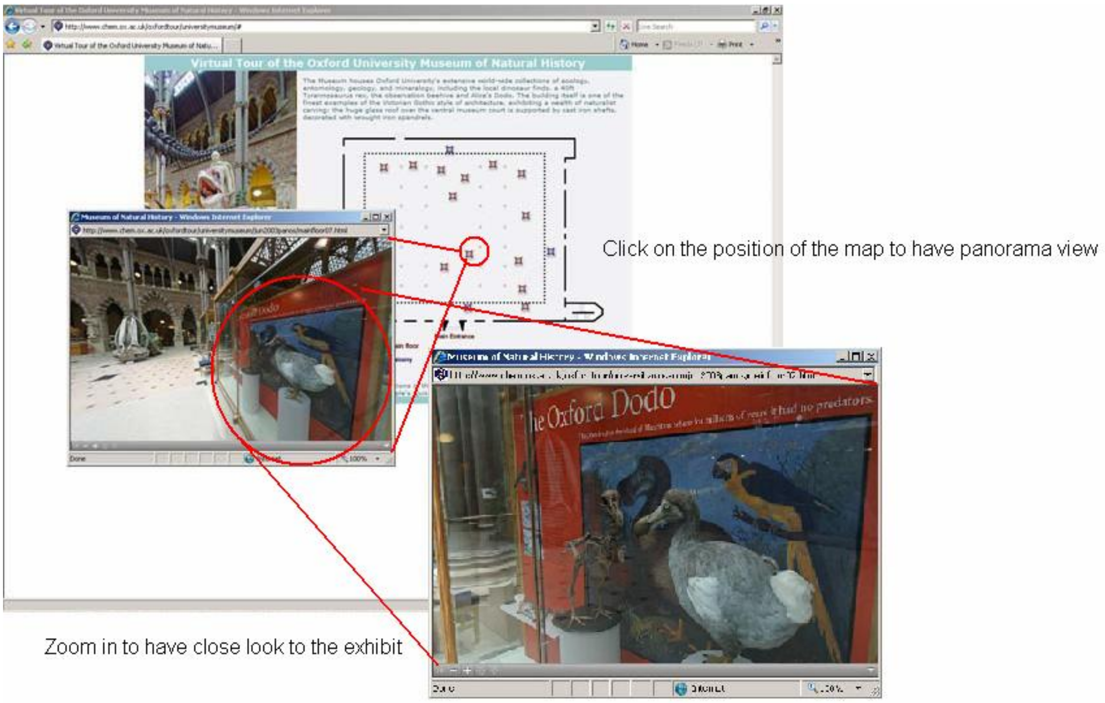



Figure 2.35: An approaching look to the exhibit of Virtual Oxford University Museum of Natural History website[36]

### 2.8.3 Heritage

The damage to natural heritage is continuing happen. It is possible to record the natural heritage before further damage occurs, in order to preserve the heritage in a digital format. Panorama VR captures the natural environment from the relevant site and recreates a virtual environment at the remote site where users are located. Users can have a 360-degree surround view of the recreated natural heritage. Panorama VR is live, low cost, and achievable (Tang et al, 2003). Tang et al developed a video-based tele-immersive system which captured videos from the site of interest, recreated an immersive environment and applied it to a natural heritage application. A grand event took place on June 19-21, 2004: more than 110 photographers in 32 countries around the world created Panorama VR of World Heritage Sites[37] for users all over the world to observe, and let them feel like they were in the natural scenes of heritage. Figure 2.36

[36] Oxford University Museum of Natural History (2007), Source: http://www.chem.ox.ac.uk/oxfordtour/universitymuseum/#
[37] The World Wide Panorama (WWP) website (2007), Source: http://geoimages.berkeley.edu/worldwidepanorama/wwp604/map/index.html

showcases some of the results of the photographers' efforts from the World Wide Panorama association website. The usability of Panorama VR in the "sense of being there" is applied successfully in this application.


Figure 2.36: The World Heritage recorded by Panorama VR online (WWP, 2007)

### 2.8.4 Geography

People are impressed with integrated Panorama VR in Global Positioning Satellite (GPS) systems, as it allows users to really see all of a location, up close. Panorama VR lets users look all around as they move through streets, buildings, or grounds. When linked to GPS, one window shows a map of where users are, and updates as users move through the space in the adjacent Panorama VR window.

Kimber et al (2001) have investigated integrating Panoramic Video with GPS map (see Figure 2.37) system, FlyAbout, spatially indexed for interactive navigation. In the system, the location data is retrieved from a GPS receiver coordinated with Panoramic Video. The Panoramic Video was captured by moving a 360-degree camera along continuous paths. Figure 2.38 shows Emerald Bay in Lake Tahoe, California on the system displayed on the web. The left segment of the window displayed the current position, view direction and the path to head to. The right part of the window is a Panoramic Video showing the present view, and can be conducted by mouse or keyboard for navigation and interactivity purposes (Sun, et al. 2002).

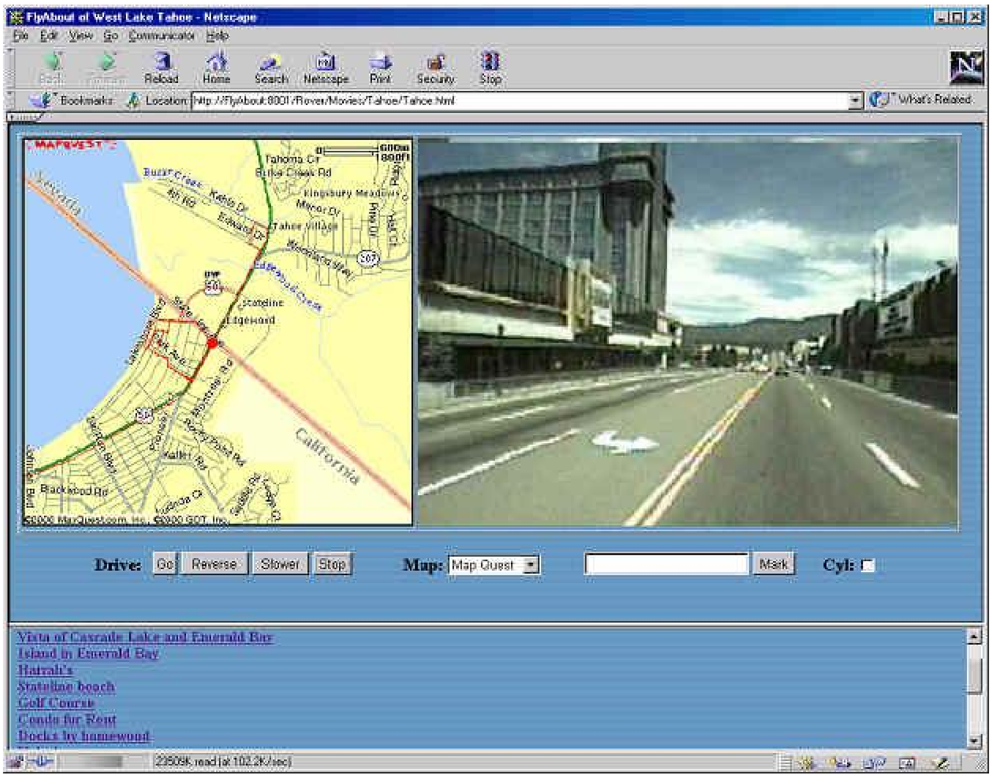



Figure 2.37: FlyAbout interface (Kimber et al, 2001)


Figure 2.38: Emerald Bay on the FlyAbout system displayed on the web interface (Sun, et al. 2002)

One of the popular examples of the integrated application is the Google Maps Street View (see Figure 2.39), 360-degree panoramas integrated into Google Maps on the web. On May 2007, Google released a new feature of Google Maps, which provides 360 degree panoramic street-level views. Google added panoramas to the Google Maps services for web users to experience being there. The technology of Google Maps is provided by Google and it is a free web mapping service. Users manipulate the Google Maps Street View to explore neighbourhoods at street level virtually, and use Street View to view street level photographs, take a virtual look around and a close-in look using pan and zoom, can explore cityscapes, landmarks and points of interest, and find shops, restaurants, parks, hotels and more (see Figure 2.40). Google Maps offers street maps, a route planner, and an urban business locator covering over 70 nations (Wikipedia, Nov., 2007), and the number keeps growing. Initially, the Google Street View provided various U.S. cities, but has expanded to cover most U.S. cities and is expected to spread to other nations' cities.

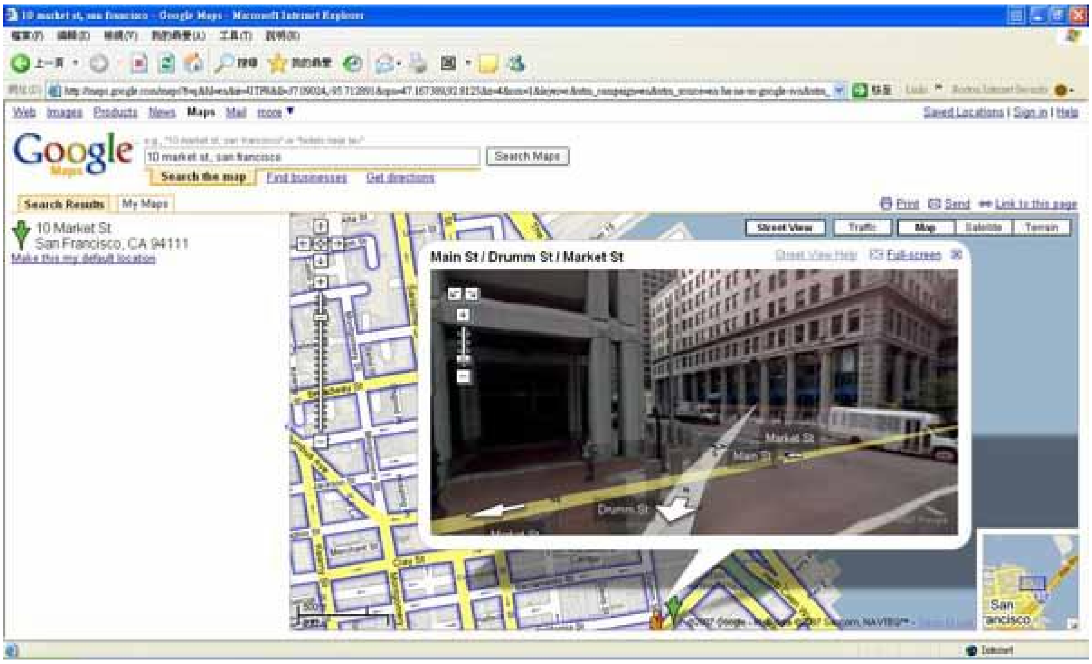



Figure 2.39: Market Street of San Francisco displayed on Google Map Street View (Google Map, 2007)

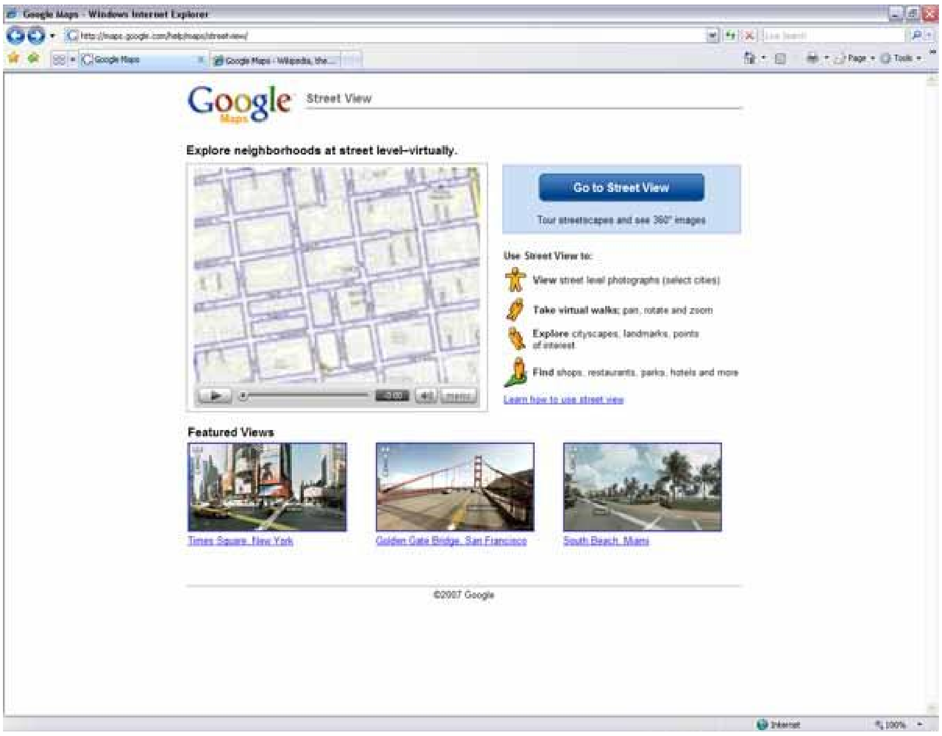



Figure 2.40: Google Map Street View Introduction page (Google Map, 2007)

### 2.8.5 Medical

A study with regards to the application of virtual reality technologies was conducted by Rizzo et al (2004) for medical therapy on memory assessment. Virtual Reality technologies provide selections for neuropsychological assessment and cognitive rehabilitation. Rizzo et al revealed that virtual environments could be of benefit to people with cognitive and functional impairments caused by traumatic brain injury, neurological disorders, learning disabilities and other forms of Central Nervous System dysfunction. The study focused on two studies that investigated memory performance in two virtual environments. One of the virtual environments created by Panoramic Video compared healthy young persons' memory for a news story delivered across three different display formats. The result of the study indicated that the Panorama VR could be the most reliable and valid of methods used in the medical field. Figure 2.41 shows an example of the screen output with a full 360-degree still image extracted from the video for testing. The study also presented that the Panorama VR created the sense of "being there" or "presence" is of benefit to participants.

Figure 2.41: 360-degree Panoramic Video image extracted from video footage taken at the Los Angeles Coliseum (Rizzo, 2004)

There are more and more Panoramic Video applications that have been applied to the medical field. Another recent research is using Panoramic Video to induce self-reported anger (Macedonio et al, Aug 2007). Macedonio et al's study assessed "immmersiveness" and physiological correlates of anger arousal, such as heart rate, blood pressure, galvanic skin response, respiration, and skin temperature. The result proved that Panoramic Video virtual scenarios are very useful for physiological arousal.

2.8.6 Education and other examples

The educational use of panorama VR can be seen as one of the main applications (Xiao, 2000; Noritaka et al, 2004; Ouglov and Hjelsvold, 2005). The message of knowledge communication is through the observation of the virtual environment. Sun et al (2001) and Foote and Kimber (2001) used a high resolution and wide-angle video system, FlyCam, and stitched together Panoramic Video recorded in the front of a seminar room. Rui et al (2001) had used the Panoramic Video system to allow people to re-experience face-to-face meetings. Those results pointed out the usefulness of Panoramic Video on education applications.

More and more Panorama VR applications have been applied, such as musical acts. David Bowie, a rock singer, used the FullView camera system in 1999 to capture a 360-degree video of him working in a studio. The Rolling Stones hired L.A.-based Incited Media to capture a concert in Amsterdam in 2003. Spincam, an Irish company, made a 360-degree video of live performances by Jamiroquai and U2. Britney Spears employed Enroute's technology and services to capture 360-degree video footage for use on a game for Sony PlayStation 2, in 2005. One recent use is creating sequences of fictional environments, Warner Brother's (2007) Harry Potter and the Chamber of Secrets for instance. The users are taken on virtual tours of Hogwarts, the Chamber of Secrets, and Dumbledore's office by operating the Panoramic Video.

## 2.9 Web-based integrated applications

Information provision in the web-based integrated application can be seen from experiencing the visualization of the images. The image conveys (visual) information about the world, which facilitates knowledge of the world. This general function of information delivery has been assigned to images from the beginning. This function has been considerably developed and enlarged since the beginning of the modern age with the emergence of "documentary" types, such as landscape (Aumont, 1997). Besides the native function of the information provision of the panorama technologies, investigators develop several elements: annotations for interpreting additional information about interesting objects in the virtual environment, and tags with texts and maps with orientation guidance for enhancing spatial recognition in the web-based integrated application. Moreover, the sound of the environment is recommended to enlarge the immersive perception.

The elements can be easily embedded in the web-based integrated application of Panoramic Video by Multimedia technologies and tools. The technologies and tools offer versatile support for web-based media, and easy content authoring and editing allow the possibility to build and embedded any suggested element (see 2.8). These elements, however, are facing several issues, and will need to be tested for their feasibility and necessity any project created here.

### 2.9.1 Suggested embedded elements

The recommended elements, such as sound, tags, and annotations, are for users to enhance presence and additive information acquirement. Sound, as one of the Multimedia elements (Mourkoussis et al, 2003; Karoulis et al, 2006; Michel et al, 2008) is recommended to be embedded in the web-based application of Panoramic Video, to enhance presence and create a more believable and immersive reality (Kamberg, 1998;

Ijsselsteijn and Riva, 2003; Douceur et al, 2007), as is fundamental of VR systems.

Tags with text overlays on a video have been introduced as an essential feature of obtaining more information about the environment (see 2.8). They have the potential, when used in the application, to increase memory and information provision, raise users' interest when navigating in the virtual environment, and help users perform real world tasks (Rekimoto and Nagao, 1995; Azuma, 1997; Kourogi et al, 2000; Liu, 2003; Pea et al, 2004, Pea, 2005; Kerremans, 2007). A Panorama-based application with tags conducted by Kourogi et al in 2000 is one example. The research retrieved the image alignment parameters between an input frame and the panoramic image, and then maps the positions of tags from the panoramic image to the input frame, and displays the input frame overlaid with those tags.

Kourogi's experimental results show tags attached to image-based Panorama VR in real-time are achievable. Figure 2.42 (a) illustrates the position of tags overlaid on panoramic image of Kourogi's research. Figure 2.42 (b) shows the overall ideas of tag Panorama VR of Kourogi's research. There are two basic interactive designs of tag in the web-based Panorama VR. One is visible (see Figure 2.43); the other is invisible but will appear after mouse rollover (see Figure 2.44). Those tags give the direction guidance of the next panorama location. A famous example of tags embedded design in the Panorama VR is Google Maps (see Figure 2.39). The tags are invisible and will appear when mouse rollover occurs, to give the direction information and move to the next panoramic view after clicking. Annotations of detailed information of interesting objects or targets are normally displayed beside the image for interpretation in a pop-up window (see Figure 2.33).

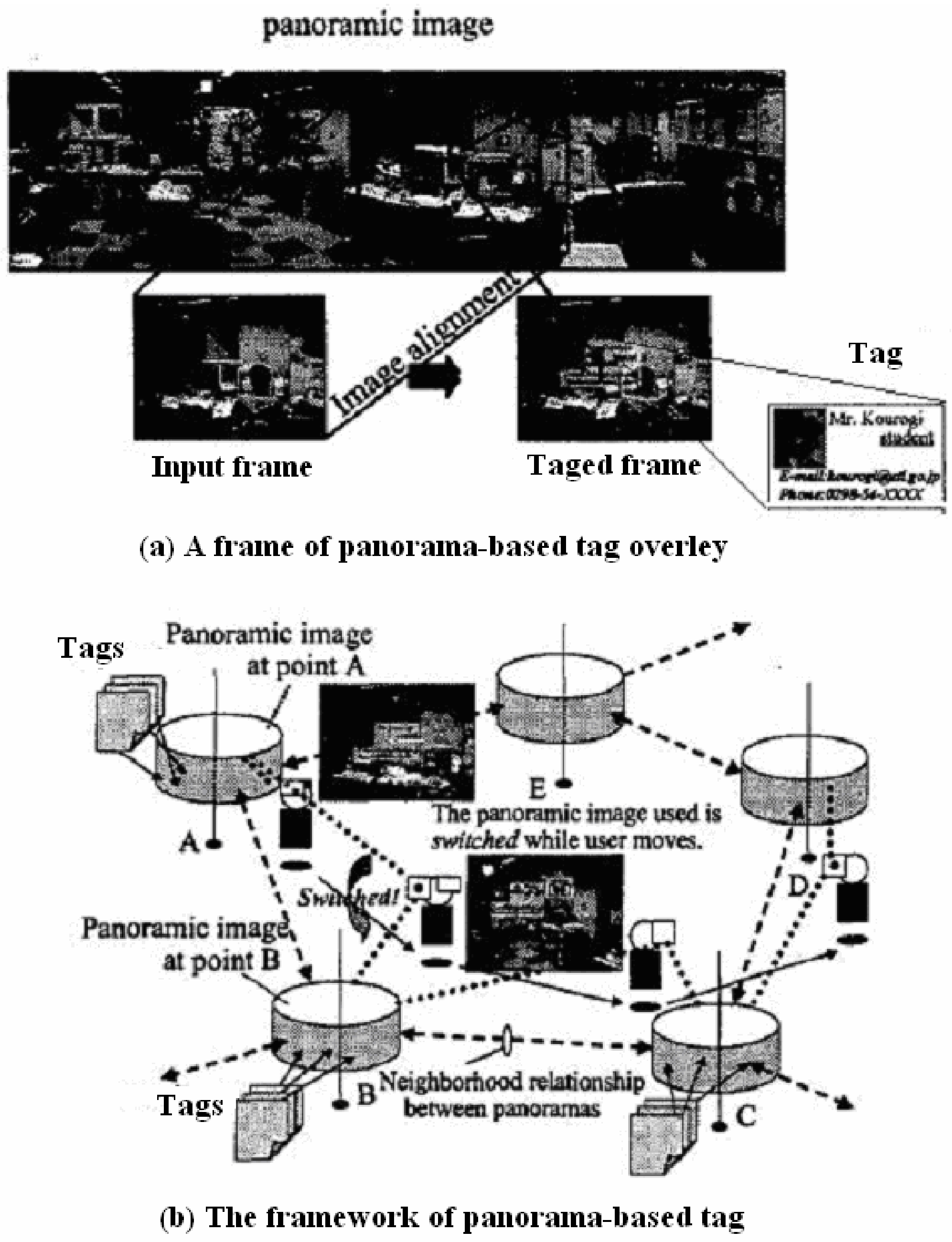



Figure 2.42: Overview of panorama-based tag method (Kourogi et al, 2000)

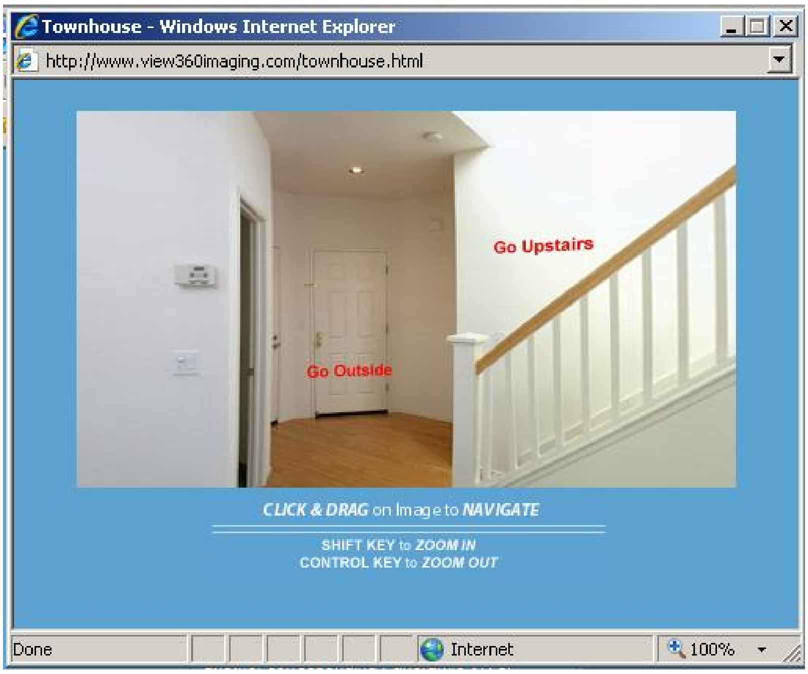



Figure 2.43: Visible tags attached on the panorama image providing environment information (VIEW 360 Imaging[38], 2003)

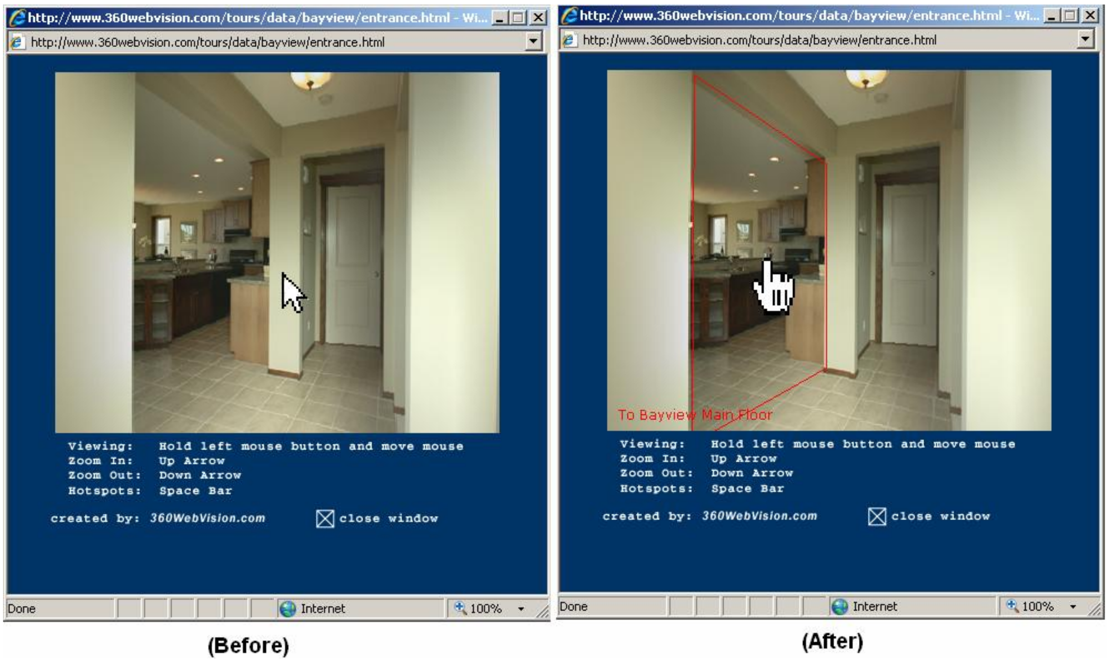



Figure 2.44: An interactive design of tags for information acquirement (360WebVision[39], 2009)

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38 VIEW 360 Imaging is located in the San Francisco Bay who provides high end VR photographic Services for the development of Interactive Media, Source: http://www.view360imaging.com/

39 360WebVision is a web service included Virtual Reality tours and/or Web Development Services, Source: http://www.360webvision.com/clients/index.html

Sound and tags have been shown to be desirable elements to increase immersive awareness and memory when navigating in the virtual environment, and annotations to obtain additional information are desirable, and should be included in any web-based integrated application of panoramic video.

### 2.9.2 Maps and orientation guides

Jul and Furnas (1997) indicate the importance of the navigation function as it is the process of moving around an environment. This is the vital function requirement of VR environment applications and has been identified as the default behaviour, which users return to (Kaur, 1998). Ruddle and Lessels (2004) point out the difficulty of users finding their way around, and position in, the virtual world. Guidance may provide effective navigation and orientation by landmarks and maps (Haik et al, 2002).

A guide such as a dynamic map with direction guidance (see Figure 2.32, 2.38, 2.39, 2.45 and 2.46) embedded into the interface of a web-based integrated applications, web-based VR exhibition "Brancusi's Mlle Pogany" (McCall and Graber[40], 1998) and web-based accommodation tour (virtualpix[41], 2009) are examples, may fulfil the requirement but have the apparent problem of disturbing a viewer's observation. The between-scene navigation relies on integrated maps with an interactive arrow to perceive position and orientation (see 2.8.4), and may transfer the focus of the user, losing their sense of immersion in the environment and possibly reducing the enjoyment of the immersive and brilliant environment visualization of the panoramic video. Panorama VR application designers have noticed the potential solution, which used Multimedia technologies to integrate Panorama VR with dynamic maps and orientation guides, as a continually used method allowing users to recognize where he or she is. However, maps with direction guides seem to be a good idea to assist the user in recognizing the position and way-finding and are achievable as embedded elements, but need to be tested for their necessity and feasibility in any web-based integration of Panoramic Video. They also consume valuable screen space.

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[40] Source: http://www.philamuseum.org/press/releases/1998/218.html

[41] Virtualpix was lunched in 2000 offering virtual tour technology to produce interesting website with good content. Source: http://www.virtualpix.co.uk/index.html

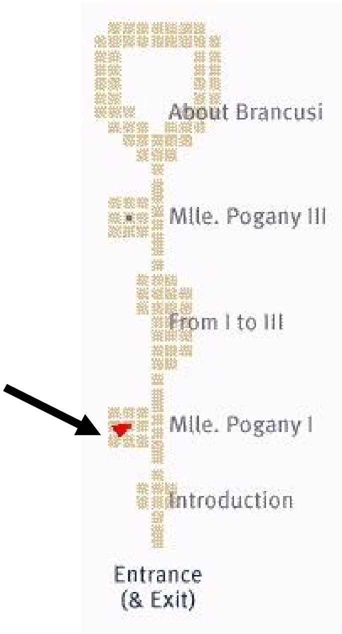


Figure 2.45: Screenshot of the dynamic map of the online exhibition of Brancusi's Mlle Pogany at the Philadelphia Museum of Art on June 1, 1998. The red triangle showed the direction that users faced in the VR exhibition


Figure 2.46: Screenshot of integrated dynamic map beside the panorama for viewer to understand position and view direction (virtualpix, 2009)

## 2.10 Current issues in Panoramic Video

Panoramic Video has the capability to reproduce presence and deliver the information about the natural environment, but is facing major issues that need to be dealt with, including the composition method and disorientation problem. In addition, the recommended embedded elements of any proposed web-based integrated application need to be determined for their feasibility and acceptance in the interface design.

### 2.10.1 Resolution defects

Resolution defects, or reduction, of the created Panoramic Video have been continually revealed whether the Panoramic Video is created by single camera system or multi camera system (Foote and Kimber, 2000; Fritz, 2004). Single camera systems, fisheye lens or PAL, or point to mirror for instance, are able to deliver large Full Of View (FOV) images at video rate, but have limited resolution by the videos composition method.

Fisheye lenses have been used many times (Zimmerman and Kuban, 1992; Xiong and Turkowski, 1997; Downs, 2000), for example, have changeless distortion for close-by objects and have different viewpoints for different portions of the FOV (Boult et al 2000). The greater criticism of this is that it squeezes objects close to the camera. Figure 2.47 illustrates the phenomenon for reference. Terrance Boult (Fritz, 2004), a pioneer in the development of immersive technologies who teaches computer science at the University of Colorado at Colorado Springs, pointed out an issue of single camera video capturing system, “Fisheye lenses have a worse image around the centre than out on the periphery”. This raised resolution issues of the single camera system when transforming the video to create Panoramic Video.

The single camera system with a non-planar mirror had the same issue with created Panoramic Video as well. The single camera systems that use a curved mirror (Ishiguro et al, 1992; Peleg, 1997; Hicks and Bajcsy, 2000; Chahl and Srinivasan, 2000; Peleg et al 2001) to map a panoramic view was able to achieve a single viewpoint at video rate, but has the same limitation on resolution as fisheye lens-based systems. The resolution varies significantly with the viewing direction across the FOV (Tan et al, 2004). The resolution reduction of the created Panoramic Video by a single camera system has poor display performance (Foote and Kimber, 2001; Tolba et al. 2001; Dorta and Perez, 2006). TX Immersive Ltd. (2008) has practically examined the single camera systems and points out that “designs that use a single stationary camera normally provide lower resolution immersive images”.

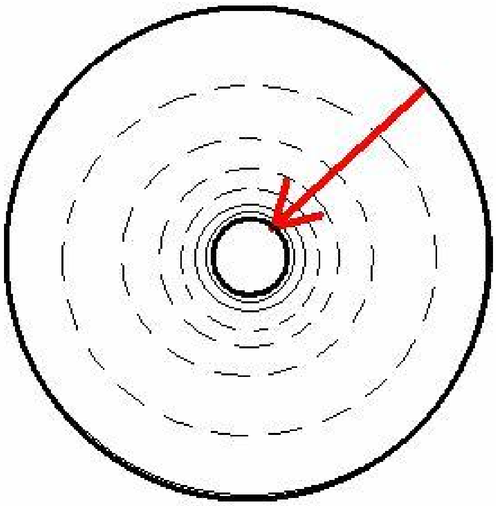

Figure 2.47: The squeezed image illustration of single camera lens

Although a multi camera system using adjacent cameras pointing in different directions to achieve a large Field Of View (FOV) is capable of achieving better resolution of Panoramic Video than single camera system, they still face similar defects of the existing composite method, whereby resolution is reduced (see 2.3.3.2) compared to the original video (Foote and Kimber, 2000). The performance of panorama VR in image display category is listed in Figure 2. for reference.

| System | Camera/s | Image source | Motion image | Resolution | Description | Examples |
|---|---|---|---|---|---|---|
| Static | Single camera | Photo | No | Excellent | A series of sequential photographs' panorama VR moves the photographic image from the flat 2D world into the immersive experience – complete with 3D imagery and interactive components by using nothing more than a computer and mouse, no cumbersome goggles, headsets or gloves required. The panorama VR allows the creation and viewing of photographically captured through images taken at multiple viewing angles of one single camera. | IPIX[42] (Minds-See-View, Inc.2007), QTVR[43] (Apple Inc., 2007) |
| Dynamic | Multi-cameras | Video | Yes | Good | Several cameras mounted in fixed positions. Cameras are mounted in adjacent positions relative to each other; the same composition function can be used for all frames. Thus only composite the first frame of each camera, the following image can be done quickly and efficiently by output the same video rate. | Polycameras[44] (1999), FlyCam[45] (FX Palo Alto Laboratory, 2006), (Tzavidas and Katsaggelos, 2005), Pyramid-shaped system[46] (5-camera array, 2003) |
| | Single cameras (Omni-directional/fish eye lens) | Video | Yes | Poor | One camera and using curved/planar mirror (hyperbolic and parabolic mirrors or fish-eye lenses) to capture omni-directional video. For omnidirectional camera is usually intended a vision system providing a 360 degree panoramic view of the scene. Such as enhanced field of view can be achieved by either using catadioptric systems, obtained by opportunely combing mirrors and conventional cameras, or employing purely dioptric fish-eye lenses. | OMNICAMERA[47] (Single camera, 1997), Panoramic Imaging[48] (Single camera, 2006), Unmanned Monitoring System[49] (Single Camera, 2007) |

Table 2.3: The performance of Panorama VR system

[42] Immersive technology places the viewer inside the image, enabling you to significantly enhance situational awareness and providing the highest level of functionality for viewing capturing and analyzing visual data. http://www.ipix.com/index.html

[43] QuickTime VR enables viewers to explore virtual worlds using nothing more than a computer and mouse—no cumbersome goggles, headsets or gloves required. http://www.apple.com/quicktime/technologies/qtvr/

[44] This work was supported in parts by the VSAM effort of DARPA's Image Understanding Program and an ONR/DARPA MURI grant under ONR contract No. N00014-97-1-0553; http://www.cs.columbia.edu/techreports/cucs-013-99.pdf

[45] http://www.fxpal.com/?p=flycam

[46] Pintaric, T., Rizzo, A., and Neumann, U., (2003), Video-based virtual environments, International Conference on Computer Graphics and Interactive Techniques

[47] Samsung Electronics Co., Ltd., US Patent 20070035617, http://www.freepatentsonline.com/20070035617.pdf

[48] Panoramic Imaging Ltd. : http://www.panoramic-imaging.com/

[49] Unmanned monitoring system and monitoring method using omni-directional camera

### 2.10.2 Panning control

That speed of redirection when panning the Panoramic Video should be well designed is accepted as a basic qualification of any VR system (McNeill et al, 2002; Cramer, 2004). The Panoramic Video should be able to rapidly change its region of interest. For example, in order to track a moving person, the region of interest must be moved along fast enough to avoid losing the target (Nicolescu and Medioni, 2000).

The study of Nicolescu and Medioni investigated vision-based systems, and the specific requirements of the intended application for choosing the appropriate type of video input. Nicolescu and Medioni indicated the system is visually aware of a larger part of the scene, but usually concentrated on a certain region, where the activity of interest is in progress. The criteria of determination of vision-based system included the quality of resolution (see 2.10.1), the precision of location (see 2.10.3), and the speed of redirection. The ease of manipulating the panning control should be determined as a standard feature of composed panoramic video, but has so far failed to get attention. The operation of panning will latently influence the determination of any integrated applications using an improperly designed panning speed. An example of a current improperly designed panning control for web-based Panoramic Video was created by Panoramic Video[50] © (2009) and presents a practical operation and redirection problem - when dragged right, the panoramic video turned left, indicating the problem still widely exists.

### 2.10.3 Disorientation

The Hotspot design is the common method used to navigate in scenes of panorama VR, including panoramic video, and has spatial recognition issues. Navigation is the process of moving around an environment, deciding at each step where to go (Jul and Furnas., 1997). Navigating in scene is the central functional requirement for VR environments and has been identified as the default behaviour to which users return (Kaur, 1998).

[50] Panoramic Video © is a company which used panoramic video in multitude of areas enhancing customers' website with the innovative and interactive media. Resource: http://www.panoramicvideo.com.au/index.php#/home/

When exploring VR environments, navigating the virtual world can raise problems as well. It is more difficult for users to find their way around, and their position in, the virtual environment than in real life (Ruddle and Lessels, 2004). Users may potentially become disorientated and effectively get lost in the VR environment if the navigation design is not done properly. Locations of items of interest can be difficult to find or remember for the users (McNeill et al, 2002; Cramer, 2004). The traditional navigation style of panoramic video, which is using Hotspot (see section 2.6.3) to jump from current panorama to another, is facing a disorientation defect. Recent research conducted by Bartneck (2007) investigated the hotspot navigation style and found the rotated interaction style is perceived as easier to navigate with than the straight interaction style. This result has a noticeable problem in that the Hotspot navigation style is included most within interactive applications, and is not at all similar to walkthroughs in human daily life.

### 2.11 Multimedia integration and web-based panoramic video

The term “Multimedia” was coined by Bob Goldstein to promote his show “LightWorks at L’Oursin” which opened in 1966 at Southampton in Long Island, America. In the intervening fifty years, the word has taken on different meanings but was used to describe presentations consisting of multi-projector slide shows timed to an audio track. Much of the content on the web today falls in the definition of a delivered combination of media including video, still images, audio, text, animation into a single form as understood by millions (Aromic Rom Productions[51], 2006; Wikipedia[52], 2009).

A good website created by Multimedia tools was made with a specific purpose and a site with good interactivity and new technology can also be useful for attracting visitors to visit (Chisholm et al, 1999). Multimedia technologies and tools are noticed and used to develop web-based Panoramic Video and integrate different media with interactive design (Furht, 2005). The applications (see 2.8) and the recommended embedded elements integration (see 2.9) studies emphasise the potential employment of using Multimedia integration with Panoramic Video. The Integrated Media System (IMS) is

[51] Aromic Rom Productions (2006), Writing for Multimedia: A Guide, Source: http://writing.atomicmartinis.com/
[52] Wikipedia (2009), Multimedia, Source: http://en.wikipedia.org/wiki/Multimedia

an good example of multimedia integration created by VRPSYCH[53] lab, who published several papers (Neumann et al, 2000; Rizzo et al, 2001; Rizzo et al, 2002; Rizzo et al, 2003; Pryor et al, 2003; Rizzo et al, 2004; Macedonio et al, 2004) successively increasing the potential development of Multimedia technologies and tools to develop the integrated application of web-based Panoramic Video.

### 2.12 Conclusion

This chapter has presented a wide range of studies on relevant literature relating to the technology development in order to gather knowledge of the Panorama VR, including Panoramic Video, and identifies the existing problems of the creations.

Panoramic Video has been shown to have many advantages when navigating in a dynamic scene compared to 3D CG VR. The general review of the technologies and the evolution of the Panorama VR (see 2.4) has also shown the advantage of Panoramic Video compared to a static one (see 2.5), and identified the key characteristics of Panoramic Video (see 2.7). The literature review concerning technology development and applications, identified the existing problems (see 2.10) of panoramic video in terms of resolution impairment caused by the videos composition methods, disorientation caused by traditional Hotspot style scene navigation, along with a need for web interface design.

The web-based application studies (see 2.8) also reveal the performance improvement potential from integration of panorama VR and multimedia elements (see 2.9) and indeed some work has already been done in this area by former researchers. The key desirable elements appear to be: enlarging the extra information acquirement by annotation provision, enhancing way-finding when exploring by using tags with texts embedded, increasing spatial recognition such as position, and the way that the user is facing, using maps with orientation guidance integration, and reinforcing the feeling of

[53] VRPSYCH lab is the laboratory for Virtual Reality, Psychology, Rehabilitation, and Social Neuroscience at the University of Southern California's Institute for Creative Technologies is engaged in a broad program of research on the brain mechanisms that underlie neurocognitive functioning and emotion regulation in used of panoramic video system. Source: http://vrpsych.ict.usc.edu/

immersion feeling by adding audio.

Panoramic Video has been available to the public for years, but it is clear that the field of Panoramic Video is still in its early stages (Fritz, 2004). As Ortiz[54] said (Fritz, 2004), "It's going to be a few years until Aunt Jane is using 360-degree video to record the family Christmas".

The next chapter will discuss methodology and the method framework of the study, to implement the research aims (see 1.3) and to make advances in the design of Panoramic Video systems.

[54] Joseph, L. Ortiz is VP and general manager of iPIX Corporation's Info Media division

# Chapter Three: Methodology

## 3.1 Introduction

The last chapter described the major research question of this study: the need for a new method to composite Panoramic Video with optimal resolution of editing and stitching, along with an intuitive panning system control during operation, a creative idea for the improvement of disorientation issues when navigating in scene, with practicable interface design. In order to provide solutions to the research question to enable the aims of the research including the proposed potential integrated application to be achieved, this chapter is going to feature the rationale for choosing a set of research methods suitable for this research study, and the research framework. The general data analysis strategy of the research results will be elucidated afterward.

## 3.2 The research methodology

Methodology has been defined as a particular procedure or set of procedures. It is a kind of analysis of the procedures of inquiry in a particular field (Dictionary.com[55], 2008). Creswell (1994, 1998, and 2003) had a further explanation, that methodology is the entire research process from problem identification to data analysis; it is a strategy or plan of action that links methods to outcomes. Creswell also showed that literatures provide a foundation to the entire study plan, by including the research question in the literature review section as the first phase of research. Dictionary.com indicates that methodology is not only a simple set of methods, but also refers to the rationale and the philosophical assumptions of a field of study. The methodology section does not outline the researchers' methods, such as we conducted a survey of 50 people over a two-week period and subjected the results to statistical analysis, and so on, but it could be an interpretation of the researchers' ontological or epistemological view. The successful use of methodologies is dependent on selecting the appropriate methods and managing them correctly (Saarinen, 1990 and Allen et al, 2007).

[55] Dictionary.com (2008), "methodology", Source: http://dictionary.reference.com/browse/methodology

### 3.2.1 Proposed "Twin-Cycle" method

According to the research question, the studies involved multidisciplinary areas: web-based Panoramic Video creation with spatial disorientation solutions (Multimedia technologies integration), and the application development (zoos' domain). In terms of web-based Panoramic Video creation, the investigation deals with proposing new editing and stitching methods, which provided optimal resolution and easy panning control of the Panoramic Video (aim one of the research). Regarding the spatial disorientation solution, the study deals with improving the traverse in the scene to offer better location and direction recognition with practicable web interface design (aim two of the research). Furthermore, concerning the integrated application (that virtual zoo) approach, the research deals with zoos' study in creating a product that fitted to the requirements of the integrated application (aim 3 of the research).

Common methods that have been used to conduct an investigation into Panoramic Video and its application, are field-trials with developers' self-evaluation and informational user testing in exhibitions or shows of their creations (Rizzo et al, 2001; Rizzo et al, 2003; Rizzo et al, 2004; VRPSYCH Lab[56], 2009). These methods face several pragmatic defects, such as subjective bias, factors of weather and lighting, the complexity of video capturing facility design, and distrusted data collection. Moreover, the viewpoints of experts in the application area of the evaluation of the production need to be presented (Michel et al, 2008).

In addition to the above, the reduced resolution issue in Panoramic Video still remains and there is need of a practical panning control will influence the evaluation of the performance level of application productions. The research therefore proposes to modify the common methods into a proposed Twin Cycle methodology, which included a technology developing cycle (Tech. cycle) connected to an application building cycle (App. cycle). Figure 3.1 illustrates the concept of the Twin Cycle methodology. The

[56] The Laboratory for Virtual Reality, Psychology, Rehabilitation, and Social Neuroscience (VRPSYCH) at the University of Southern California's Institute for Creative Technologies is engaged in a broad program of research on the brain mechanisms that underlie neurocognitive functioning and emotion regulation in persons throughout the life course, resource: http://vrpsych.ict.usc.edu/about.html

feature of the modified and adopted methodology is that the cycles can exist independently to investigate any proposed panoramic video system by Tech. cycle, and to study any emerging integrated application by App. cycle if the adopted panoramic video system has been approved as practicable and acceptable, e.g. videos composition and panning control.

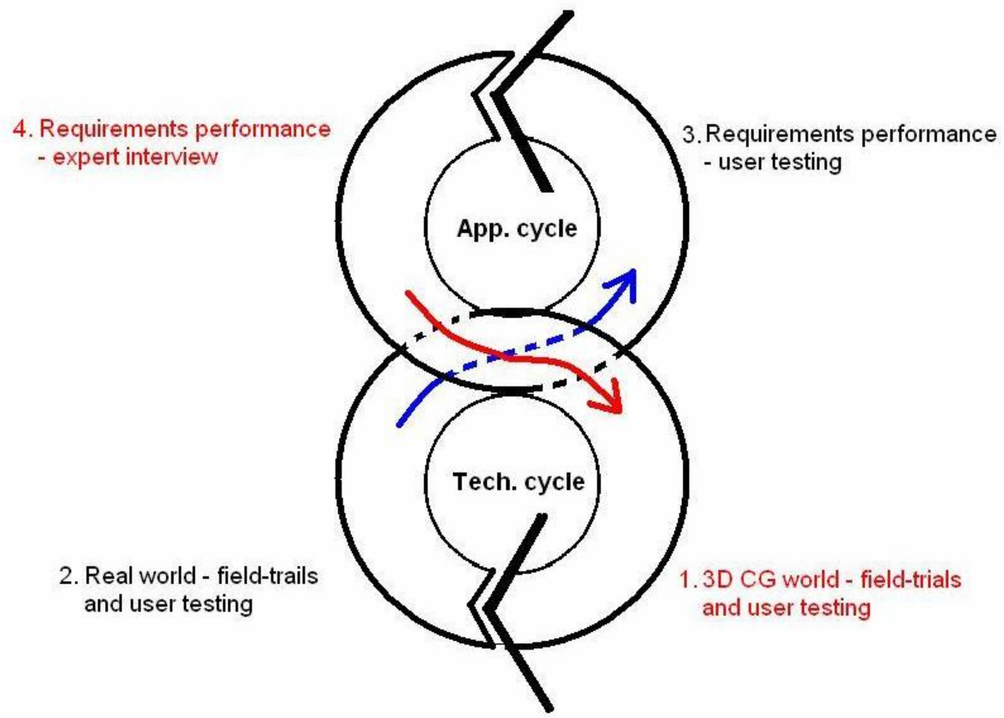


Figure 3.1: The adopted twin cycle method of the research. The steps 2 and 3 (in black text) were the traditional methods. The step 1 and 4 (in red text) are the added methods to have complete panoramic video development, application design, and evaluation

The Tech. cycle proposed in this thesis will include a proposed idea for simulation of the production method and implementation using three-dimensional computer graphics (3D CG). Figure 3.2 shows the design work of Tech. cycle is a circle of development, testing, and refinement including two inner design cycles to ensure the panoramic video is well designed.

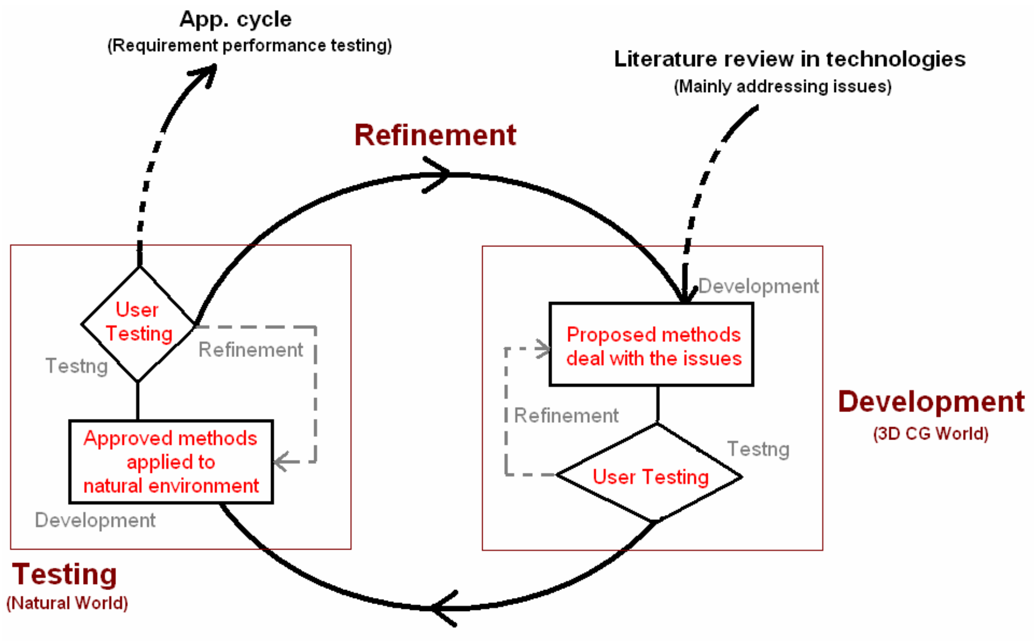


Figure 3.2: Design work in Tech. cycle

The App. cycle has adopted common methods and is designed specifically to contain experts' viewpoints on the application domain, to obtain the requirements of the application and to evaluate the product, in order to have confidence in the research findings (Clarke and Dawson, 1999).

3.2.2 The advantage of the adopted methods

There are potentially seven apparent advantages in using the Twin-Cycle method:

1. Time effective: any proposed method in creating panoramic video is tested prior to videos obtained in the product simulation environment
2. Cost saving: the video capturing system design is tested virtually in the tech cycle.
3. Filming factors control: the weather and lighting, which are the constraint to the field-trials, are mastered.
4. Simulation scenes can be re-used: avoid such factors of weather influencing the filming and provide different location for filming

5. Erasing bias of the product-evaluating result: the result of integrated application determination obtained by end users and experts will help add to the credibility, and the make findings stronger.
6. Eliciting more potential employments in the application field: the expert evaluation provides opportunities to enlarge the panoramic video utilizations.
7. Technology and integrated application development can independently exist: the flexibility can be used in developing panoramic video or integrated application separately.

In this thesis the Twin-Cycle method has been further subdivided into five phases as follows:

### 3.3 Overall research framework - five phases

A research framework defines the categories of outputs that research can produce. It also defines a set of different research activities. Moreover, it defines what kind of research can be used to produce specific outputs (Jokela, 2001). The research framework outlines all the developed five phases of the research process, which involved the Twin-Cycle method, as shown in Figure 3.3.

**Phase One: Chapter Two**

**Literature Review (I) – technology review**

- Panorama technology studies included evolution, performance, and applications in addressing the research question and forming the research objectives

↓

**Phase Two: Chapter Four**

**Testing design method – in 3D CG**

- Proposing hypothetical methods to deal with the problems in developing and improving the panoramic video
- Identifying the needs in adopting video/s obtained by 3D CG world
- Generating web interface by analyzing the applications discussed in phase one
- Conducted selected experiments for testing the proposed methods by field-trials and user testing (step 1 of twin cycle methodology) deal with generated hypotheses

↓

**Phase Three: Chapter Five**

**Literature Review (II) - application domain - zoo**

- Proposed application domain studies included zoos and visitors on current technologies used to present animals and their habitats to address the requirement of the integrated application as criteria in determination.
- To ensure the requirements have no bias on only papers' review, there emerged a need to visit existing zoos for practical viewpoint.

↓

**Phase Four: Chapter Six**

**Proposed integrated application development**

- Zoos visiting for exploring practical requirements of the production
- Video/s capturing system designed and created by the setting in 3D CG world to acquire video/s in selected animal's habitat
- Integrated application, that virtual zoo, creating by tested proposed methods in phase two
- Pilot test to the creation before mass evaluation

↓

**Phase Five: Chapter Seven and Eight**

**Production evaluation and conclusions with recommendations**

- User testing in created panoramic video (step 2 of twin cycle method) and requirement (step 3 of twin cycle method) of the integrated application
- Expert interview in requirements (step 4 of twin cycle method) of the integrated application
- Providing overall conclusions of the research and direct recommendations from the evaluation participants for future works

Figure 3.3: Phases of the research framework and design works

### 3.3.1 Phase 1 – Documentary research on the technologies and problems to be addressed (Qualitative Method)

The phase was to review the relevant literatures to acquire knowledge of, and issues concerning the technology, and has detail presented in previous chapter of the thesis. Briefly, the problems were identified as being the need of panoramic video to adopt a new method to deal with defects in resolution and panning manipulation, an innovative technique to improve orientation issues when navigating in scenes, with a practicable web interface design in terms of recommended elements integration.

### 3.3.2 Phase 2 – Experiments to test the proposed methods to deal with the issues by using videos obtained in 3D CG simulation environment (Qualitative and Quantitative Methods)

Phase two is concerned with using CG VR to experiment with (step 2 of Twin-Cycle method) some proposed technology improvements for the generation of panoramic video and web-based integration. Having established a way of working, the stage also tests some proposals relating to navigation and application design, again using simulation videos obtained in 3D CG. The proposed improvements will be qualified and later subject to objective testing in Phase Five, end user testing (quantitative method) and expert interviews (qualitative method) to the final production.

The design work of developing, testing, and refinement of the created panoramic video is obviously defined in this phase (see Figure 3.2). The approaches of the phase are expected to expose a time and cost effective method in testing and experiencing the proposed design method, dealing with addressed issues in last phase. Details of the works in this phase will be outlined in the next chapter of the thesis.

### 3.3.3 Phase 3 – Studying the interest and the emergent application domain to obtain the production requirement (literature review II; Qualitative Method)

This phase is to deal with exposing the need and requirement of the proposed production to the application domain through a wide literature review. The review of the proposed integrated application domain in relevant literatures is aimed at understanding the contemporary zoo's roles and intentions, and understanding what visitors to zoos wanted. By considering the direct client (zoo management) and the visitor end-user of the technology, the above knowledge will provide the theoretical foundation and requirement of the proposed integrated application, that virtual zoo. The expected outcome of this phase is receiving theoretical requirements as criteria for evaluating the creation of the integrated application. The details of the phase will be interpreted in Chapter Five of the thesis.

### 3.3.4 Phase 4 – Developing the production

This phase is concerned with understanding the practical requirements of the integrated application and creating the proposed production. This will include the visit to zoos, video/s acquisition hardware creation and filming in the selected animal's habitat, and the building of the integrated application production. Methods identified from the 3G CG tests will be directly used to develop the production in this phase. This will be done to form a representative test-bed for real world use of the proposed filming and application development method.

Initial pilot testing of the creation will take place before any main evaluation, to ensure proper parameter setting and experience evaluation process. Pilot testing is an experiment, which is often used to test the design of a full-scale experiment and is frequently carried out before large-scale quantitative research in an attempt to avoid time and money being wasted on an inadequately designed project. The pilot test is usually carried out on members of the relevant population, but not on those who will form part of the final sample. This is because it may influence the later behaviours of research subjects if they have already been involved in the research. Normally, the pilot experiments of the applications are used to provide success evidence on a larger scale. Also, it is used to decrease cost, as they are much less expensive than the large-scale systems, and prevent primary errors from happening in the main research (Haralambos and Holborn, 2000).

A visit to the zoos is essential to fully understand the problem domain and has the benefit of exploring the possible employment of the creation, and obtaining practical data of the requirements of the proposed integrated application from the employment domain. Due to the limited knowledge transfer between the fields of web-based panoramic video technologies and zoos, the meeting at this phase and the results of the determination of the integrated application in the next phase is expected to fill this gap. The overall details of this phase will be discussed in Chapter Six of the thesis.

#### 3.3.5 Phase 5 – Evaluation of the created production (Quantitative and Qualitative Methods) and giving recommendations and identifying future investigations

The final phase of the study is mainly concerned with evaluating the created integrated production developed in previous phase. The phase will comprise end user testing and the expert interviews, and can be seen in the adopted App. cycle (step 3 and 4) of the Twin-Cycle method (see Figure 3.1). The combination of the two sets of evaluation methods will give the research more confidence in the obtained results, after data analysis (Karoulis et al, 2006). In addition, the end user testing will include testing the proposed design method, which is now in the real environment (step 2 of the Twin-Cycle method).

The necessity of the visits to zoos that took place in Phase 4 will be further justified in this phase, particularly the diversity of the interviewees and their recruitment for this phase.

This final phase will conclude the two sets of evaluation of the creation, in relation to the implementation of the research aims and to the research achievements. The details of the created production evaluation will be described in detail in Chapter Seven. The overall conclusions, with the achievements and the recommendations of the research, will be stated in Chapter Eight.

### 3.4 General methods of data analysis

The data is received from the process of the Twin-Cycle method located in the research framework, including quantitative and qualitative evaluation methods for analysis, to obtain the research results.

### 3.4.1 Quantitative data analysis

There are two kinds of quantitative data that are expected to be obtained from analyzing the user testing evaluations (see Figure 3.1) of the research. One is received by the determination of a single design; the other is a comparison of two related designs by the same participants. The quantitative data of the single design will be received in part of Phase 2, whereby the data is obtained by evaluating the proposed method, and in Phase 5 whereby the data is obtained by determining the requirements of the production of the integrated application, that virtual zoo.

The quantitative data of the comparison of the two designs will be obtained in part of user testing in Phase 2, whereby the data is obtained by evaluating the design method of proposed navigation method compared with traditional one and embedded recommended elements.

As is common in such studies, the questions will be scored on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) for all user testing (Sulaiman et al, 2007; Kraljic, 2008). This is the most commonly used question format for assessing participants' opinions of usability (Dumas, 1999), and is easy to use because people often enjoy completing a scale of this kind (Robson, 1993; Neuman, 2000; Hilary, 2003). The range is also not so large that users have an ambiguity in selecting a response.

The results' average point on the Likert Scale will be expressed along with a 95% confidence interval calculated in Microsoft Excel for the single design. This will aid in initial visual comparison and exploratory data analysis.

Where two sets of results are being compared, from alternative designs, the Wilcoxon[57]

[57] Wilcoxon signed rank test, also known as the Wilcoxon matched pairs test, is a non-parametric test

signed-rank test offered by software called SPSS for Windows will be used. This test assumes little about the underlying data distribution and is appropriate for ordinal data. Experiments will be randomised where appropriate, to minimize the bias of the two designs' assessment. The subjects will be equally divided into two groups at random and the testing order of the two designs is: one group tested the first design, and then the other. The other group tested in reverse order.

### 3.4.2 Qualitative data analysis

The qualitative data received in the phases of the research framework will occur during both cycles of the Twin-Cycle method: the added comment portion of the questionnaires on user testing tests and the received opinions from expert interviews.

The Tech. cycle consists of two processes, step 1 and 2, for evaluating the proposed design method by end user testing, which added a comment portion on the questionnaire to receive qualitative data.

The App. cycle comprises two qualitative data, including a comment section at the end of user testing (step 3) and designed semi-structured expert interviews (step 4), which have open-ended questions with a list of topics. The topics of the expert interview will be designed to avoid biased questions, questions that assume what participants ask, double-barrelled questions, confusing or wordy questions, and questions that do not relate to the research (Creswell, 1994; Drever, 1997; Creswell, 1998; Creswell, 2003; OWL[58], 2009). The qualitative data of end user testing will be organized so as to relate to the research question, and are expected to elicit further applications, the integrated application improvement and suggestions, and mainly, the requirement determination opinions.

The qualitative data of the expert interview will be received from interviewees. This

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used to test the median difference in pared data. This test is the non-parametric equivalent of the paired t-test. The main difference is that parametric techniques make distributional assumptions, usually that data follow a normal distribution (Crichton, 2000; Wikipedia, 2009, on Wilcoxon signed rank test)

[58] OWL (2009), *Creating Good Interview and Survey Questions*, The Purdue Online Writing Lab, resource: http://owl.english.purdue.edu/owl/resource/559/06/

data analysis is mostly for understanding the level of performance on the requirement of the product from experts of the application domain. Besides this, the evaluation of the production, that virtual zoo, using qualitative and quantitative methods will help add to the credibility of the research and the make findings of the production of the integrated application stronger (OWL[59], 2009).

### 3.5 Summary

This chapter has presented the overall research framework which consists of five phases of research in order to address the research question: the need for a new method to composite Panoramic Video with optimal resolution of editing and stitching, along with an intuitive panning system control during operation, a creative idea for the reduction of disorientation issues when navigating in scene, with practicable interface design, and a practicable web-based integrated application, that virtual zoo (see 3.1). In order to resolve the research question, a developed Twin-Cycle method (see 3.2.1) will be applied through the use of proposing and testing the design method in 3D CG idea, and data collecting and analyzing in both qualitative and quantitative methods to the final production. The potential advantage of the method was stated as controlling the work factors, erasing bias of product evaluation, enlarging the range of potential employments of the technology in the proposed field and others, and effecting cost and time (see 3.2.2). The design work of each phase (see 3.3) was introduced and discussed in terms of the adopted method in order to achieve the formulated research objectives and the aims of the research.

The adopted method, which is modified from traditional methods in panoramic video and application development, is all about breaking the problem down into technology and application related issues and seeing how, once a technology has been chosen, an application can be built that meets the needs of the specific and challenging proposed production, the virtual zoo. The method has also identified ways in which the performance of the system can be objectively measured and take into account the views of subjects who experience using the proposed system. The general methods of data

[59] OWL (2009), *Analyzing Your Primary Data*, The Purdue Online Writing Lab, Source: http://owl.english.purdue.edu/owl/resource/559/09/

analysis throughout the study were stated in the final section (see 3.4) for the works in 3D CG and the production evaluation strategies.

Based on this overall research framework, the contents of the next phase, which is described in detailed in the next chapter, is going to focus on proposing and testing the design method to deal with the problems identified, using the 3D CG idea.

# Chapter Four: Testing of the proposed solution – in 3D CG

## 4.1 Introduction

The literature review of Panoramic Video technology in the last phase (see Chapter Two) identifies issues such as resolution defects, panning control, and disorientation while navigating in scene, influencing the performance of the Panoramic Video, and how it will affect the performance of any application. In addition, the information enhancement of the recommended elements investigated by former researchers to obtain more environment information and to increase spatial recognition, needs to be tested before a web-based integrated application is made. These issues present the requirements for developing new solutions to deal with the issues, and to determine the elements before creating any integrated application. This chapter is to propose the latest and considered best design method, as solutions and as guidance to develop the proposed integration.

The opening section presents the reasons for, and advantages of, adopting the concept of a multi camera system to acquire videos. Before developing the video capturing system, the research is facing a number of practical problems in designing the rig and acquiring videos. These elicit the idea of proposing a virtual camera setting (see Figure 4.1) in a selected 3D CG world that simulates the proposed environment of the integrated application as a solution, and the reasons and benefits of this will be given in the next section. This idea of using CG was to have a controlled test environment, in order to develop the production of the videos, the optimal method of presentation, and navigating in scene.

The selected tool for creating the Panoramic Video will be elucidated before the research goes to the next stage, which is submitting the proposed concept of a new design method in video editing and stitching, and an innovative idea of navigating in scene. As there is no existing web interface design, which integrates Panoramic Video and the recommended elements available for reference, a design model will be investigated and illustrated to develop the web interface and stated in the next section. The displacement analysis of stitched videos obtained in the 3D CG world will be undertaken to test the videos composition method.

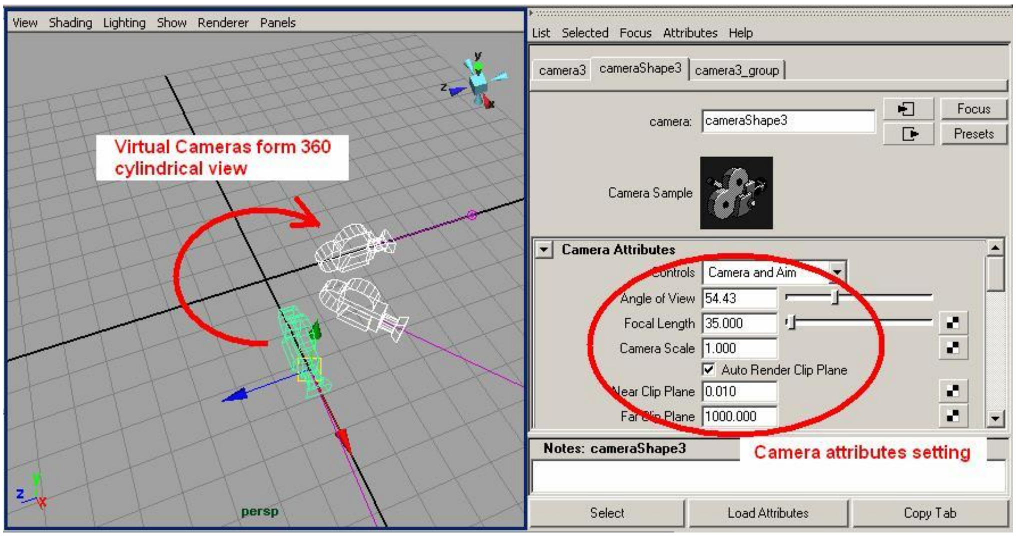



Figure 4.1: Virtual cameras built into 3D virtual environment to simulate multi-camera system

Four experiments were designed in order to test some hypotheses relating to the identified issues. The questionnaire design used during the experiments was intended to uncover an optimal technology (e.g. editing and stitching, and panning control), improve the disorientation of way-finding and determine the feasibility and necessity of the embedded elements for enhancing information acquirement by the generated web interface. The results will be evaluated through the usability tests to guide development of the proposed integrated application.

### 4.2 Multi cameras system - justification

There are two types of video capturing system available to acquire video/s for Panoramic Video creation, single camera system and multi camera system (see 2.4.3). That the concept of multi camera system has better resolution performance was shown in section 2.10.1 and concluded in Table 2.3. Based on the better resolution of the videos analysis, the research therefore adopted the multi camera video capture system concept to acquire videos for creating the panoramic video. In addition, less distortion being obtained in the image is also a benefit of the multi camera video capture system (see Table 4.1).

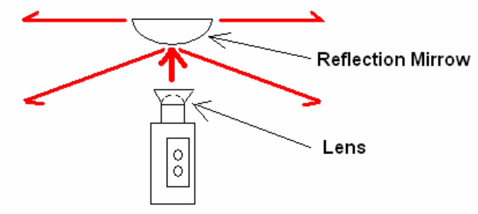
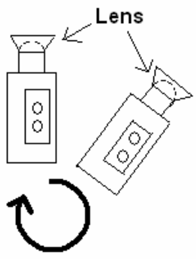
| Category | Video capture facilities | Distortion(s) |
|---|---|---|
| Single - camera |   | Lens + Reflection Mirror |
| Multi - camera |   | Lens |

Table 4.1: Image distortion analysis between the two video capturing systems

### 4.3 Testing panorama production parameters

Having decided on the video capturing system selection, the research faced several practical problems in filming and building the rig. Consideration of these problems led the research to the idea of adopting an environment simulation created by 3D CG software to control certain factors and obtain the videos. Specific problems in real-world experimentation are now presented.

#### 4.3.1 Problems of videos acquirement

Researchers are generally using field-trials to test the video capturing system and the panoramic video that they create. This caused several practical problems, such as weather issues, managing lighting, video camera selection, filming experience, cost and refinement of making the design of the rig for filming, and control of the walking path in acquiring videos (see 3.2). Also, the performance parameters of panoramic video created by the multi-cameras system included a number of cameras, stitch overlap placement, lens distortion and so on.

Table 4.2 shows a different number of multi camera systems for reference. There are a number of digital video cameras on the market that allow good quality recording and easy operation. Considering cost effectiveness and performance, the digital video cameras chosen for the study to obtain videos for composing Panoramic Video are Panasonic, type AG-DVX100B, supplied by the University. The camera was also chosen because the maker makes the camera easy for one person to operate more than two cameras through remote control, and they have superior image quality. The quantity of cameras needed for composing Panoramic Video is obtained by practically measuring the horizontal view angle (see Figure 4.2) of the camera lens. As the level angle of camera lens is around 50 degree, this means we need 8 cameras at least to form a 360 degree view, as the basic number of cameras for the filming.

| Multi camera system | No of camera | Source |
|---|---|---|
| Dodeca 2360 | 11 | http://www.immersivemedia.com/#30 |
| Ladybug®3 | 6 | http://www.ptgrey.com/products/spherical.asp |
| FlyCam | 6 | http://www.fxpal.com/?p=FlyCam |
| Geoview | 5 | http://www.imoveinc.com/geoview.php |
| CAMEO | 5 | http://www.cs.cmu.edu/~mmv/papers/04icra-cameo.pdf |

Table 4.2: References of Multi camera system on the number of cameras used

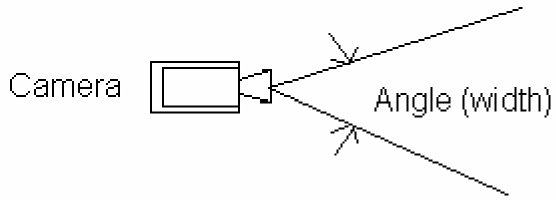
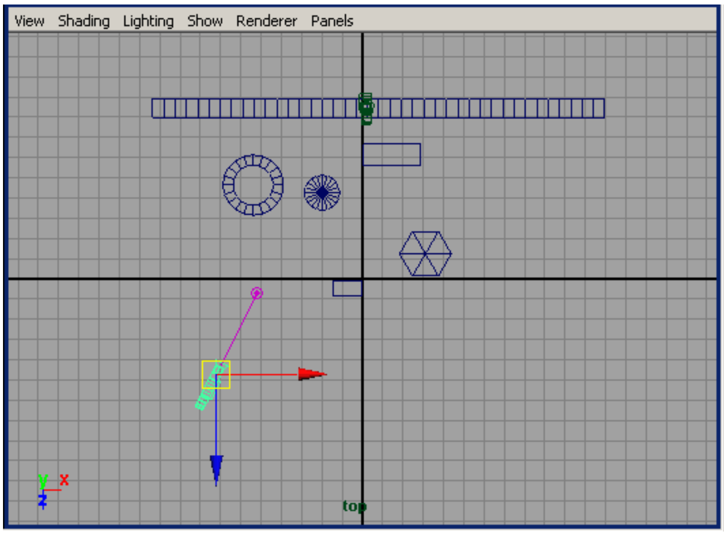
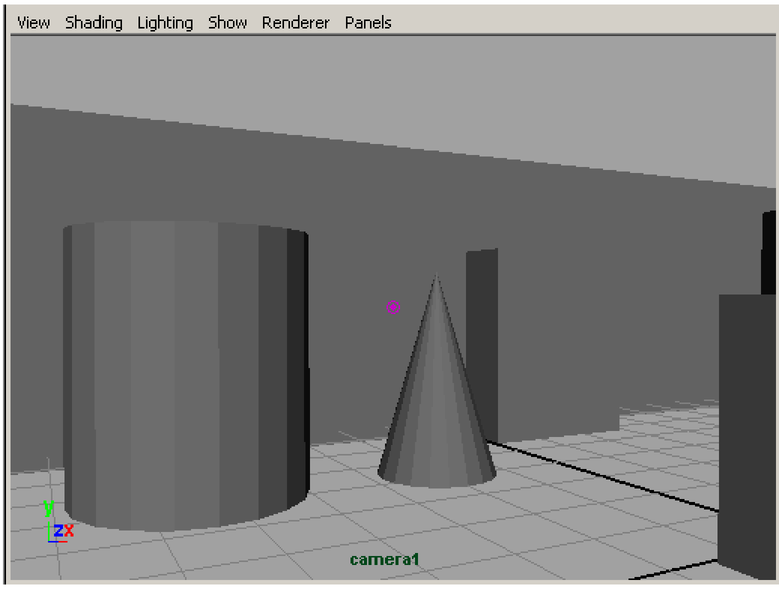



Figure 4.2: Top view: Measure the angle of lens of digital video camera to know how many cameras to form a Panoramic Video

For controlling the factors mentioned in videos acquirement, 3D CG simulation world for acquiring videos is proposed as the solution. The 3D CG generated environment has tremendous advantages in complex simulations (Engelberg, 1994; Ware and Lowther, 1997; Matsubara, Y. and Yamasaki, T. 2002; Makanae, K. and Nakahara, 2005), which has been used to create many dynamic videos, including animated movies, for example. Cameras can be easily located and set in the virtual environment, and used to output the image footage. The camera parameter settings and quantities on the filming rig can be simulated and determined (see Figure 4.1). Figures 4.3 (a) and (b) show a virtual camera located in the geometry-based environment and the view from the virtual camera lens.




(a) Virtual camera positioned and virtual objects in the geometry-based environment




(b) Virtual objects viewed by the lens of camera

Figure 4.3: Virtual camera sitting and viewing in a 3D CG environment

The advantages of adopting 3D CG simulation is not only to eliminate the practical problems and to properly generate videos for experiments and tasks involving expensive equipment, but also to simulate the digital video camera supplied by the University, model: AG-DVX100E, for parameter set-up of real filming. In addition, the videos can be synchronized and recorded accurately frame by frame for the timeline provided (see Figure 4.4). This has the benefits of no editing requirement after filming and easy operation, and points out the necessity of testing the synchronization filming of the adopted digital video cameras. The disadvantage of adopting videos acquired in 3D CG simulation world is that the virtual scene building process takes a long time (Aguinis et al., 2001; Qiu and Hubble, 2002). However, when considering the high cost of building the video capture rig and the previously highlighted practical problems, the benefits far outweighed the disadvantages. Moreover, researchers can perhaps use an off-the shelf virtual world environment to lessen the time taken in building.

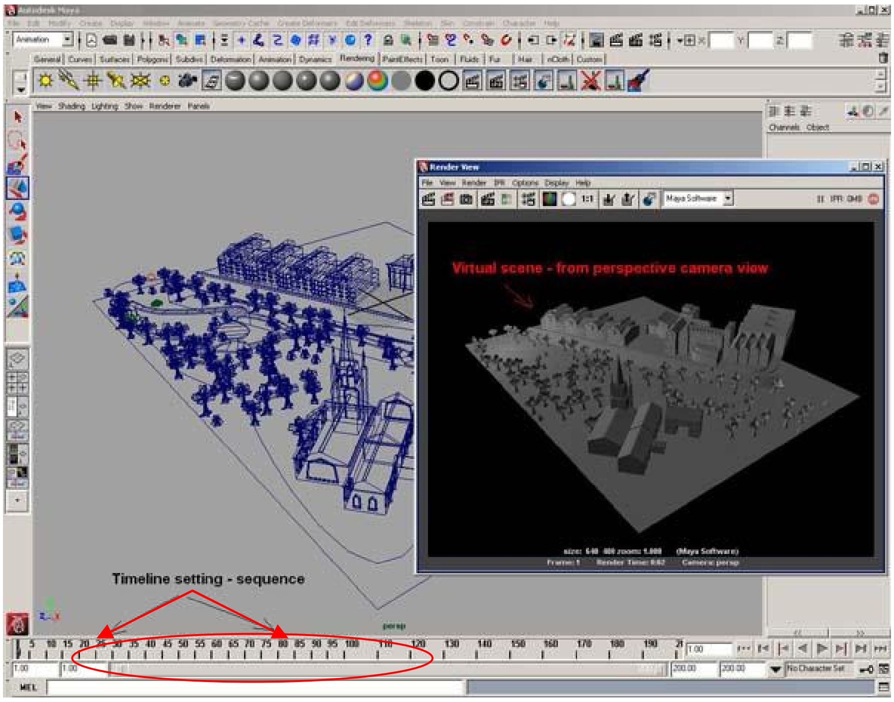



Figure 4.4: The timeline setting of Autodesk Maya

### 4.3.2 3D Software selection

There are several choices of 3D software to build the CG virtual environments for acquiring videos. Autodesk Maya is an award-winning software that provides powerful, integrated 3D modelling, animation, visual effects, and rendering solutions, and is familiar to the author. Figure 4.5 shows a complex virtual environment created in Autodesk Maya (Autodesk, 2009) for reference. The research, eventually, adopted Autodesk Maya as the 3D CG tool to create the simulating environment for generating videos.

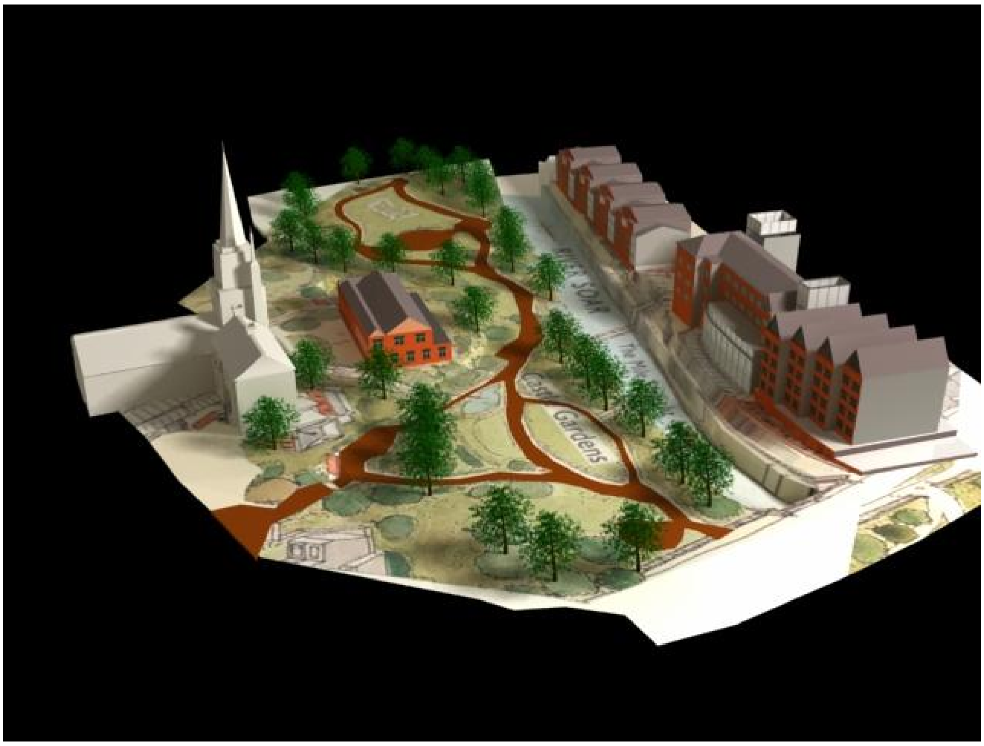


Figure 4.5: Maya model of Castle Park Leicester

## 4.4 Multimedia integration

The proposed integrated application not only contains videos, but also combines different media, such as texts and images. This apparently, meets the feasibility of adopting Multimedia technologies, which have the capability to integrate different media and post the final creation in web format. In addition, section 2.11 had identified that multimedia integration was considered desirable. This section is going to introduce the integration tool's selection and its advantage.

4.4.1 Multimedia software selection - Adobe Flash

"If you are looking to incorporate things like complex video – Flash is the way to go." SAMSA[60] (2008).

Flash is Multimedia technology, portable across browsers and platforms, and is used to create more visually appealing interfaces, and has been featured in well-publicized award competitions. Flash has the capability to integrate different kinds of media. Figure 4.6 shows the use of the timeline frame layer tools of Flash to integrate the sound as part of the creation. The evolution of Flash has helped it become a ubiquitous multi-faceted tool for deploying all kinds of content on to the Word Wide Web. More than 95% of Internet users worldwide installed Flash player (NPD online survey, 2004), offered freely online. As opposed to the other methods to develop web-based panoramic video, no specific plug-in is required (see 2.4). The three apparent benefits of Flash are the ability to integrate different media, including videos, in an efficient Flash Video format.  It is a free player plug-in and has wide usage, and the ability to rapidly post in web format, these benefits motivated the research to eventually utilise Multimedia software, Adobe Flash, as the system development tool to build the proposed web-based panoramic video.

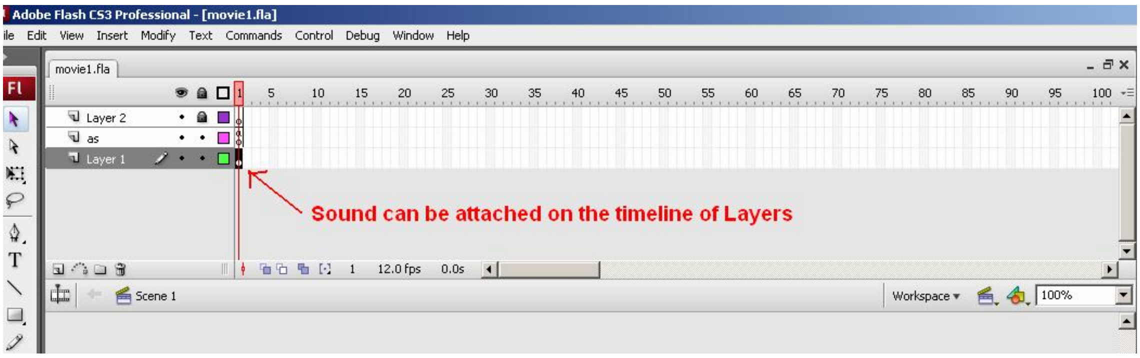



Figure 4.6: Layers help the project designer organize the artwork in the document, and the designer can draw and edit objects on one layer without affecting objects on another layer, and can also attach sound files in separate layers to play the sound (Adobe Flash interface)

[60] SAMSA is a company who providing WEB and Internet-based solutions. Resource: http://www.samsa.com/internet/multimedia.html

4.4.2 Advantages of Flash

Besides the three benefits stated in last section, Flash can provide a number of useful advantages over traditional web development tools (Dev Articles™[61], 2005; SAMSA, 2008: SmallBusinessBible[62], 2008):

- Potentially makes a web site more attractive, interactive and dynamic
- Can be stored in small file sizes
- Player plug-in updates automatically
- Speed and ease of modelling (see Figure 4.7 and Figure 4.8)
- Actionscript[63] program of Flash could not only add interactivity to the application, but also cope with some of the experimental interface work that would be needed.

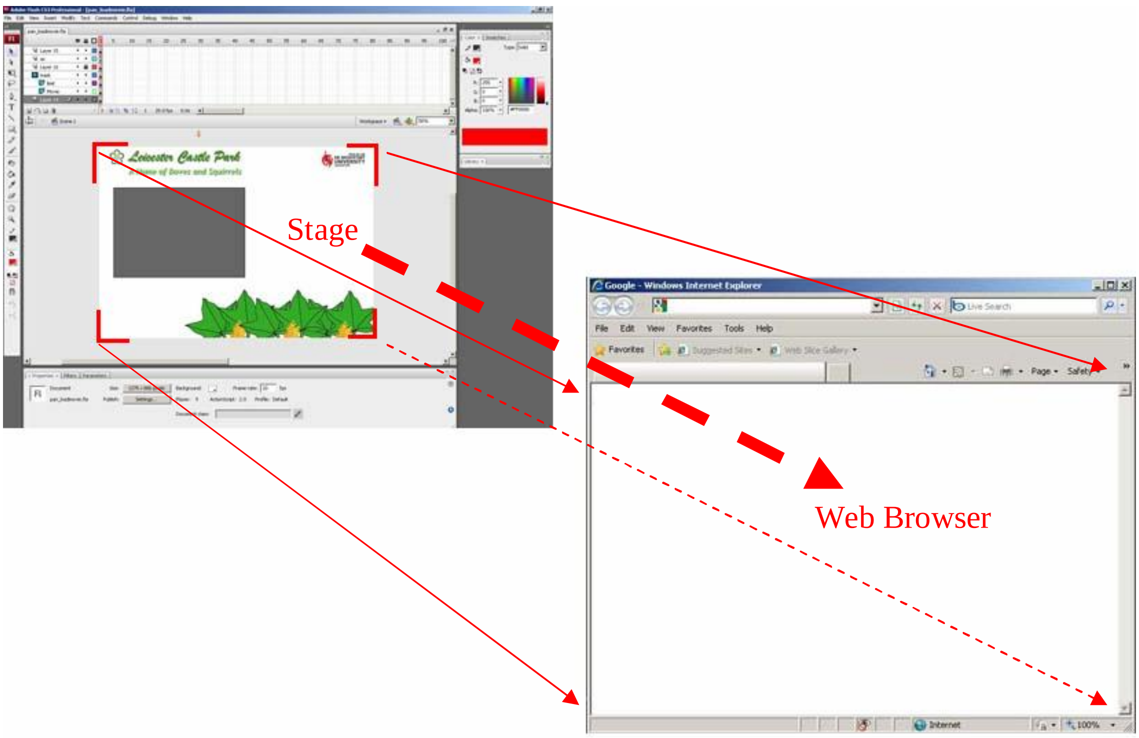



Figure 4.7: The stage frame dimensions are the same as output webpage

[61] Dev Articles is forums which open widely for people to post their viewpoints. Source: http://www.devarticles.com/c/a/Flash/What-is-ActionScript/
[62] SmallBusinessBible is a company who serves people to start online home-based business. Source: http://www.smallbusinessbible.org/whatadvantages_flashwebdesigning.html
[63] ActionScript is the object-oriented programming (OOP) language used in Flash. The language has its own rules of grammar and punctuation that determine which characters and words are used to create meaning and in which order they can be written.

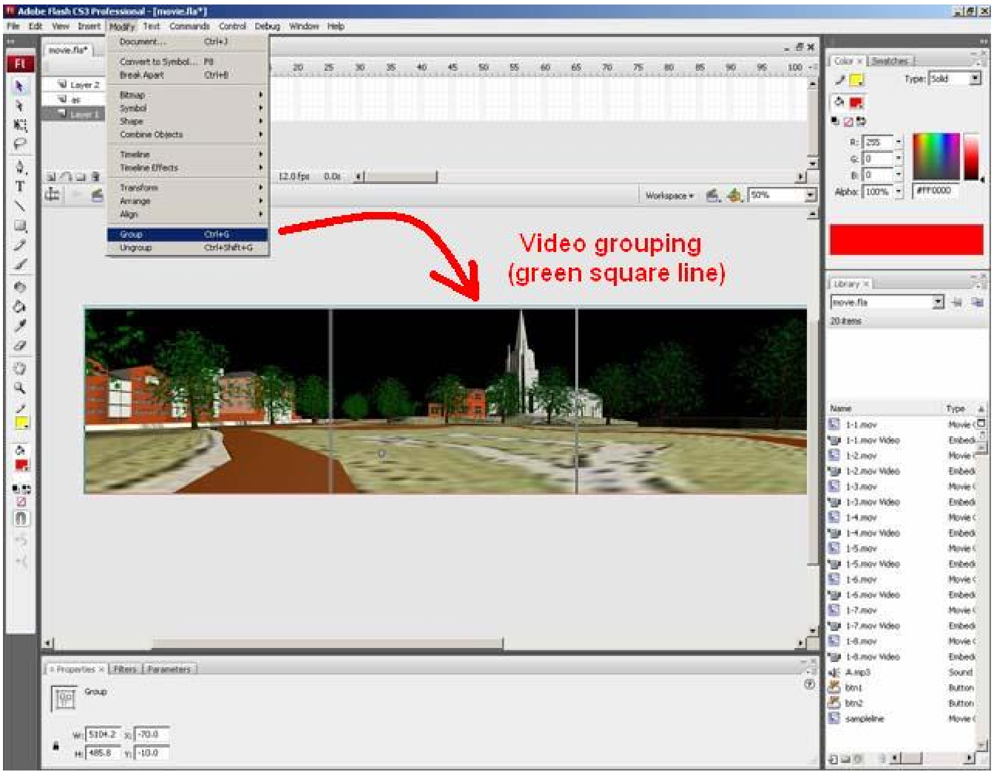



Figure 4.8: Video grouping after optical stitching to form a wide screen video

### 4.5 Proposed improvements and Hypotheses

In this section, the research proposed two theories for developing and improving the technology. One is a direct editing and stitching method, named **Direct Overlap (DO)** to obtain optimal resolution, and the other is an innovative concept, named **Image Channel**, to replace the traditional jumping navigation style called Hotspot, in order to have better orientation perception. In addition, a web-based interface is generated for proposed integration by adopting the process of Multimedia Design Model. Hypotheses are generated to correspond with the identified problems (see 2.10) of the technology in Chapter Two as criteria.

The hypotheses are as follows:

**Hypothesis One:** The videos editing and stitching method proposed work well enough to ensure that users see negligible visual discontinuities in the environment.

**Hypothesis Two:** The panning control method proposed works well enough that users are able to effectively control pan movement within the environment.

**Hypothesis Three:** Image Channel gives a better perception on position, orientation, and walkthrough effect than Hotspot alternative.

**Hypothesis Four:** The interface and interactive design of the embedded elements work well enough to create an efficient navigational method, as indicated by users understanding their location and orientation in the environment and being engaged in the process.

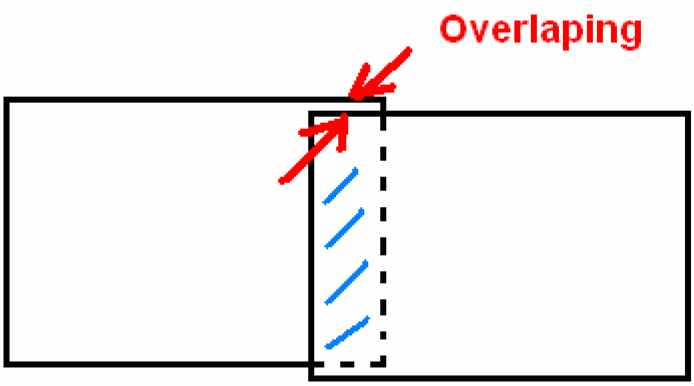
The relationship of the hypotheses and the aims of the research are listed in Table 4.3

| The research aims | Hypotheses |
|---|---|
| Aim 1 | One and Two |
| Aim 2 | Three |
| Aim 3 | Four |

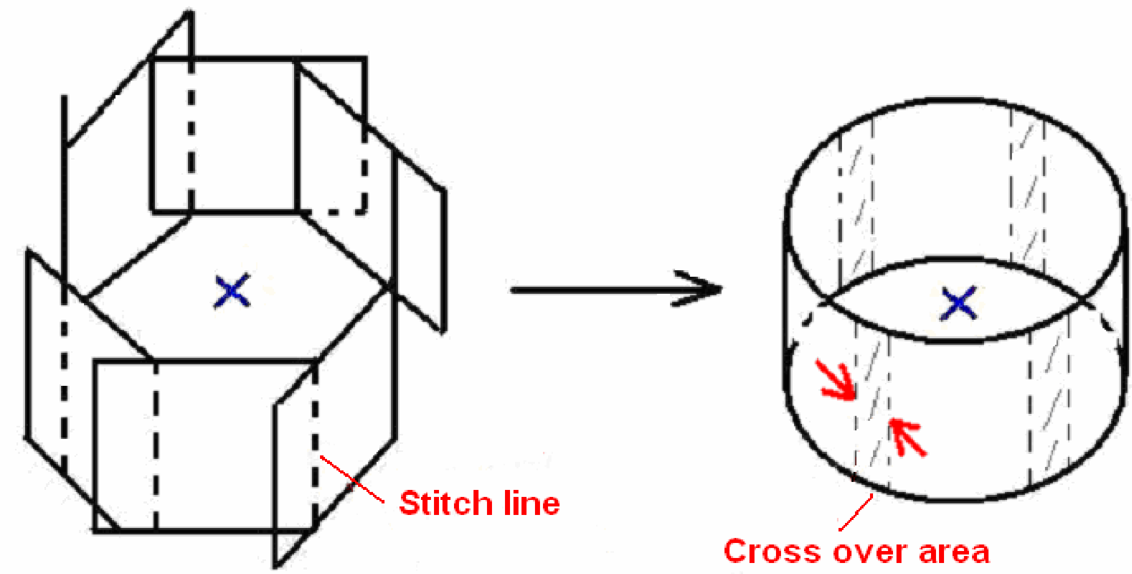
Table 4.3: Hypotheses in this chapter and the research aims

### 4.5.1 Editing and stitching the videos - The Direct Overlap (DO) method

Section 2.4.3 indicated there are many different methods to create a Panoramic Video, but the vital issue constantly mentioned, is the images' distortion correction (see 2.10.1). This is noticed and caused several investigations to correct it, for example, transforming and reconstructing. The image, after surgery, consistently diminishes in resolution compared to the original one (see Figure 2.24). Based on this defect caused by the distortion correction, the research proposed a new stitch method, namely Direct Overlap (DO, see Figure 4.9, which has no treatment through transforming and reconstructing, and involves the overlapping and pasting of the double filming fields of adjacent videos. The idea is of benefit not only in avoiding complex video process procedures, but also in retaining optimal resolution to the created production, in that the videos before and after the process have the same resolution. The resolution issue of the creation of the video is dependent only on digital video camera selection and not on the technique, if the overlapping area and stitch line can be acceptable by the proposed design method. Thus, the proposed stitching concept is facing two challenges, namely "will the cross-over area look natural?" and "will the stitch line be accepted?"




(a) The Direct Overlap (DO) concept to the double filming fields of two adjacent videos




(b) The DO concept to compose seamless stitching of Panoramic Video

Figure 4.9: The proposed DO method in videos editing and stitching

4.5.2 Navigation style - The “Image Channel”

Traditionally, the Panorama VR designers use Hotspots, a jumping navigation style, to link several panoramas and travel the scene (Chen, 1995; Singer, B and Singer D, 2006). Section 2.10.3 discussed that the Hotspot jumping method (see Figure 4.10) in navigating the scene, has less spatial position and orientation recognition. This causes the disorientation when users travel in the virtual environment. Although there are several efforts to enhance spatial information (see 2.9), the disorientation issue of Hotspot navigation style still exists. This research therefore, proposed an “Image Channel” method as a new interactive navigation style (see Figure 4.11) and expected to have good spatial perception. The concept of the Image Channel uses two sequences of images that pre-videoed the path back and forth, and positioned them between two panoramic videos for traversing (see Figure 4.12) achieved by coding. The obvious queries into the proposed navigation method will be whether this style provides better position recognition, orientation perception, and walkthrough perception.

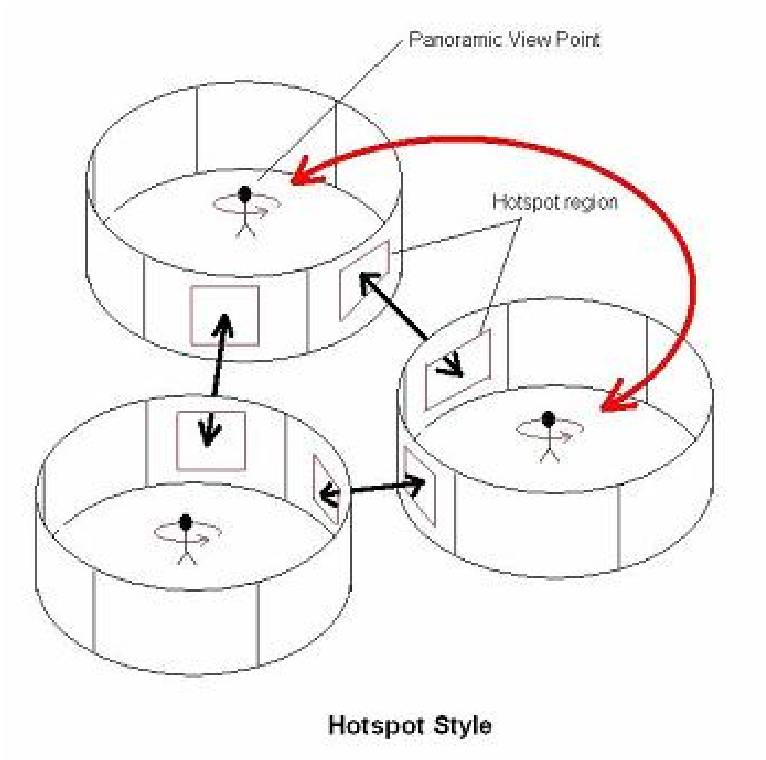



Figure 4.10: Jumping navigation style - users easily get lost when moving in scene

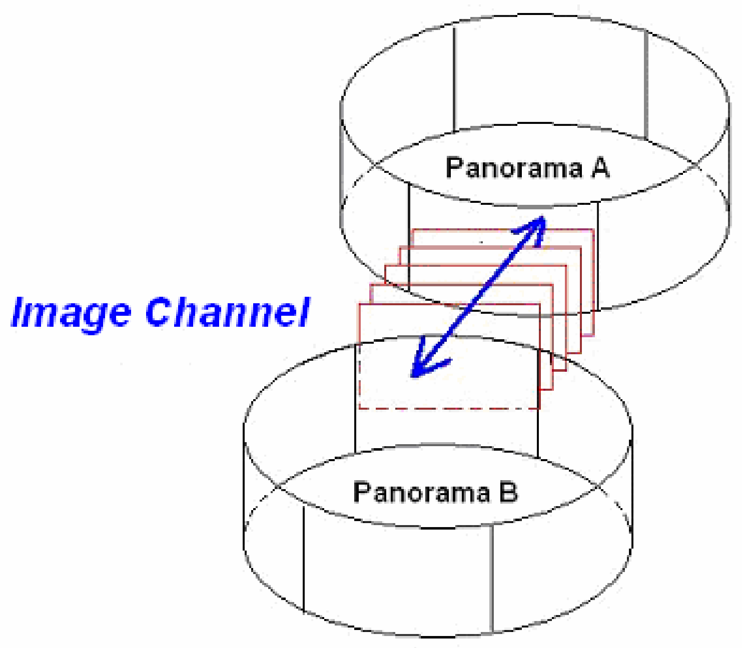



Figure 4.11: The proposed navigation style, Image Channel, positioned in two panoramas

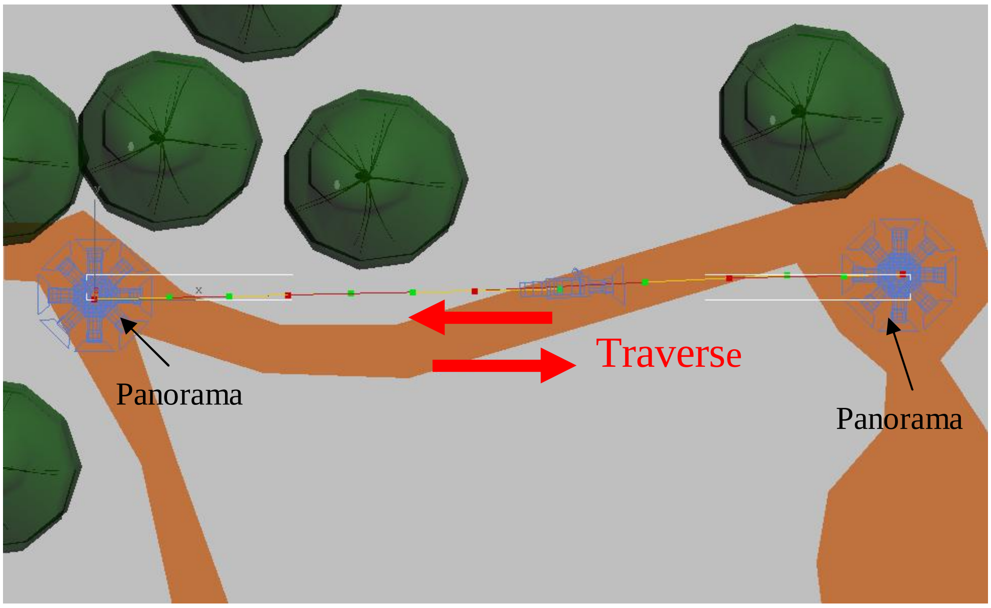



Figure 4.12: Traverse in panoramas by Image Channel concept

4.5.3 Web integration by Multimedia Design Model

There are many web sites' designers who build beautiful pages, but the reason why they constructed the particular page in a certain way, is simply justified in that it looked good to them. This somehow is bearable and even comprehensible coming from beginners, but is quite unacceptable from experienced professionals (Gervasio, 2009). This section is to elucidate the method of the research in generating the web interface design, adopting a Multimedia Design Model.

#### 4.5.3.1 Multimedia Design Model and interface

A design model is a design method that enables designers to organize the content based on appropriate approaches in order to achieve the desired goals. As there is no current design model specifically for developing the web interface of the proposed integrated application, the Multimedia Design Model (Reeves, 1994) is considered to be the most appropriate model to be adopted for the development of a theoretical design reference model for creating the web integration. The model includes four phases, which are analysis, design, production, and evaluation, similar to the ADDIE model[64] (Defazio, 2001). The analysis and design phase are located in the next section for designing the interface for testing the proposed design method, and deal with the research question by analyzing the application proposed in Chapter Two. The two phases forming the design work start from analysis to obtain the basic design of web interface. The interface design will be tested and the analyses will help to refine the design into the production phase. The production, which is the proposed web-based integrated application of Panoramic Video, will be created and described in Chapter Six, and the evaluation phase will be stated in Chapter Seven. The process and main activities of the phases of the adopted design model are listed in Table 4.4.

[64] ADDIE model: The ADDIE model is a systematic instructional design model consisting of five phases: Analysis, Design, Development, Implement, and Evaluation.

| Design process | Chapter | Activities |
|---|---|---|
| Analysis | Four | • Applications study<br>• Web page layout design principles |
| ↓ Design | | • Web interface generation<br>• Testing proposed design method and embedded elements |
| ↓ Production | Six | • Virtual Zoo creation |
| ↓ Evaluation | Seven | • Acceptance/Practicable determining |

Table 4.4: Adopted Multimedia Design Model for generating the web interface

4.5.3.2 Web layout

The study of the application of web-based panorama VR (see 2.8) shows that the web page layouts are quite varied. There are however, three noticeable common regions, title, panorama display area, and information display area. These essentially exist on the page and the main interactive design is on the panorama, corresponding with the information area, Figure 2.32 (Tourism - Virtual Tour) and Figure 2.38 (Geography application) as examples. The information display area can consist of an interactive map or additional data. The position of the panorama and information area can be switched depending on their purpose. Some page layouts of the application employed pop up windows, Figure 2.33 (Virtual tour of 10 Downing Street), Figure 2.34 (online HR Giger Museum), and Figure 2.39 (Google Map street), and are increasingly complex, and opposed to the fundamental design principles of web page layout which is based on simple, easy-to-understand pages, that manage layout principles to focus users' attention (Palme, 2005; Gervasio, 2009).

In considering the contents of the proposed integrated application, that virtual zoo, includes names of the displayed animal and habitat (Title), virtual environment (Panoramic Video), and embedded elements (additional information), the research eventually adopts the layout (Figure 4.13), generated by the application analysis as the design of the web interface for testing the proposed design method in improving the technology, identifying the feasibility and necessity of the embedded elements, and guiding the layout and interactive design of the proposed web-based integrated application, that virtual zoo. The bias in personal analysis of the adopted web interface design will be minimized in the evaluation of the production phase (see Chapter Three).

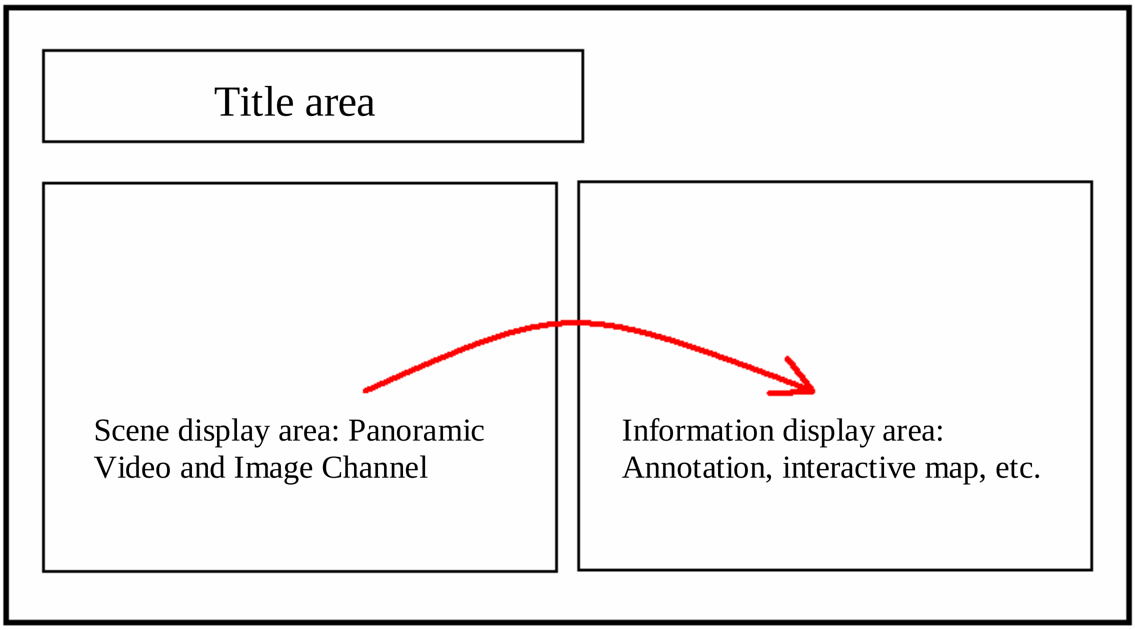



Figure 4.13: The adopted web page layout with interactive elements' position

### 4.6 Videos stitching and overlap displacement analysis

As described earlier, in developing a panoramic video using the multi-camera video capture system it is unavoidable to face the problem of video alignment, and to deal with the overlap displacement (Foote and Kimber, 2001).

To test the extent of alignment issues, a virtual test scene containing a bounding virtual mesh, is used to analyze the camera placement and stitch process. An encircling mesh (see Figure 4.14) is located in the 3D CG world, surrounding the virtual multi-camera system to generate videos for the purpose of analyzing the displacement of alignment. The parameters setting of the virtual cameras are simulating the real digital video camera provided by the University for building the final production. That there are ten equally divided sections on the mesh can be seen in the lens of each video for displacement analysis (see Figure 4.15) of the DO method.

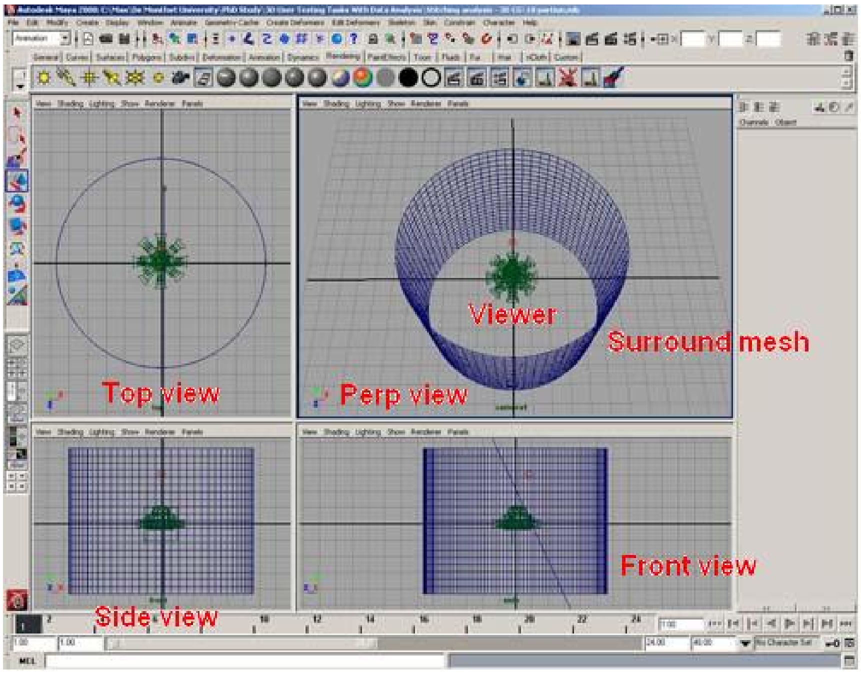



Figure 4.14: Designer can decide mesh structure by changing parameters setting

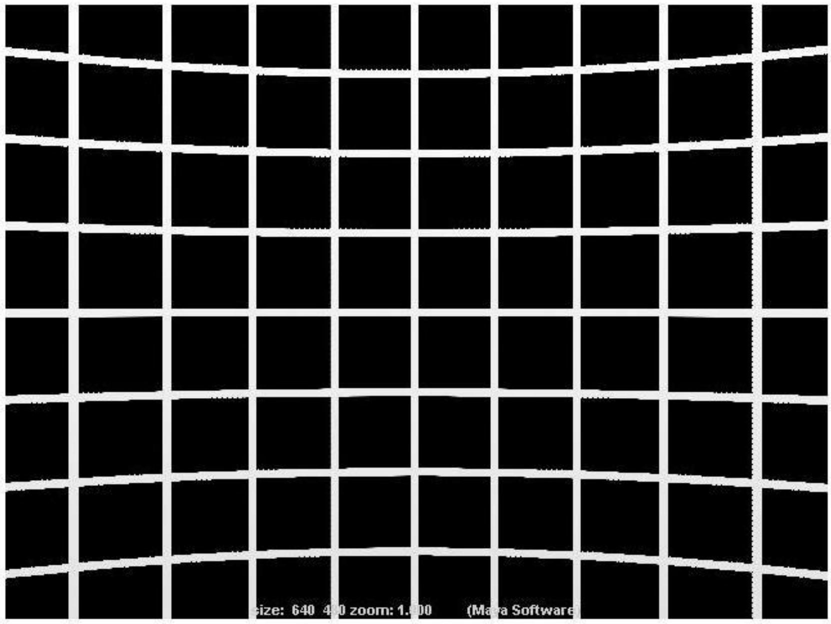
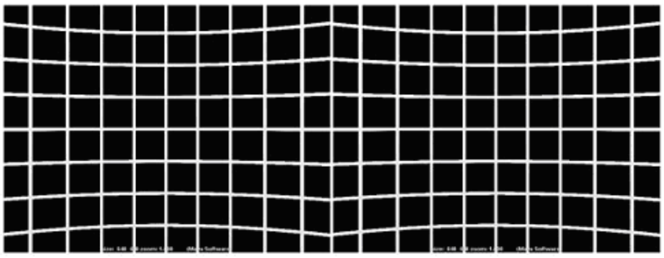
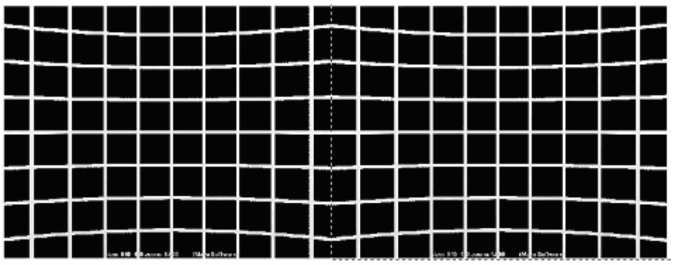


Figure 4.15: View of the virtual mesh from one camera lens

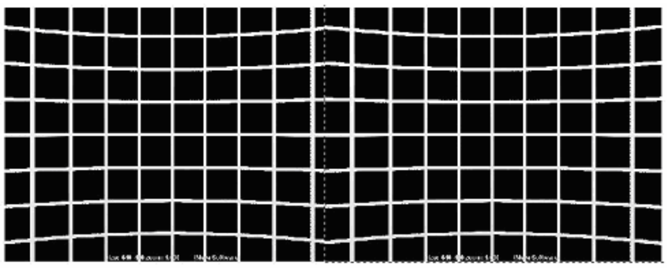
The sequence of aligning two adjacent videos analysis is displayed in Figure 4.15. It is obvious that between 0% and 8% direct overlapping (see Figure 4.16 (a), (b), and (c)) is an acceptable range of displacement because of the horizontal lines of the adjacent mesh are matched. Although the lines are diverging after 9% overlapping (see Figure 4.16 (d)) and increasing separation (see Figure 4.16 (e), the result gives evidence that the DO method is potentially workable. Red points are positioned on the mesh for identifying the divergence areas (see Figure 4.16 (d) and (e)).



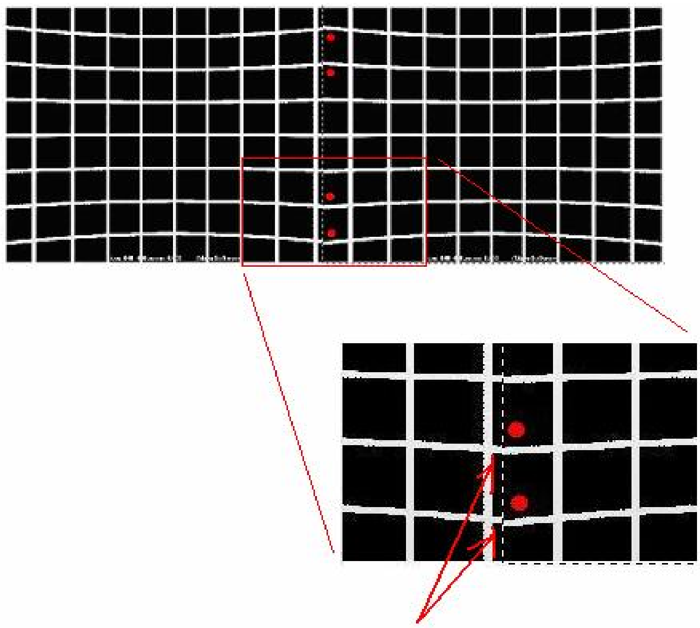
(a) 0 % overlapping



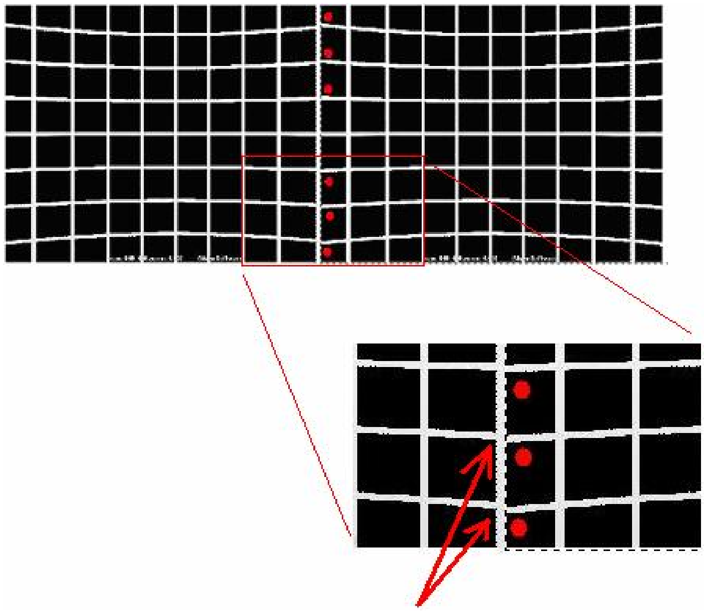
(b) 5% overlapping



(c) 8% overlapping



(d) 9% overlapping



(e) 10% overlapping

Figure 4.16: The overlap displacement analysis of two adjacent videos

### 4.7 Experimental evaluation

The experimental evaluation was mainly aimed at testing the usability of the design method. Four experiments were designed, each with the purpose of testing the technologies built that related to the hypotheses generated by the research. The first and second experiments are to assess the videos composition (Hypothesis One) and panning control (Hypothesis Two) of the created panoramic video. The next experiment is to appraise the proffered new navigation-in-scene method, Image Channel, compared to the traditional jumping, Hotspot, style (Hypothesis Three). The last experiment is to focus on evaluating and obtaining the essential elements such as tags and annotations, interactive map, and environmental sound of the generated web interface (Hypothesis Four).

The virtual environment for the experiments, with the exception of experiment (2), was a simulation of Leicester's Castle Park recommended by the Tourism Centre of Leicester City, which is inhabited by squirrels and pigeons. A submitted determination method with a designed virtual scene to deal with the panning control was proposed in the experiment (2).

A questionnaire was developed as part of the test task, as it is an effective way to gather data from a potentially large number of respondents. Also, questionnaires are a feasible way to allow statistical analysis of the results. The questions are mainly collected from the queries (see 4.5.1 and 4.5.2) about the design method and are directed toward the experiments' purpose and hypotheses. The questions usually elicited opinion of an aspect of the design using a five point Likert Scale, ranging from 5 = strongly agree to 1 = strongly disagree (see 3.4.1).

### 4.7.1 Sample size and population

In other research, the testing of the panoramic video system design is generally by field-trials of developers' self-evaluation (Pintaric et al, 2000), or informal demonstrations conducted with visitors to the laboratory and exhibitions (Rizzo et al, 2001) before being put into any proposed application. This presents bias of a single standpoint (the developer's) and unreliable data (due to the complexity of the users testing environment), and has practical problems in filming factors (see 3.2). Nielsen (2001) suggests that usability can be measured and recommended from 20 users for each design on quanitative measurement, and still provide a reasonably tight confidence interval for numerical data. By examining the variance in the initial sample of 20 it could be determined if further sampling would be needed to get a narrower confidence interval.

Rosenstein (2001) indicates the reliability is not at all related to validity, although the larger the size of the sample, the more reilable the study will be. The costs of increasing the sample size and the reliability of a study should be balanced against the increase's potential return on investment. In addition, Rosenstein reveals the acceptable probability level for making a claim is usually set very high at 95% or 99% confidence interval in scientific studies, and suggested the predicted general population will act the same way at least 95% of the time. Thus, the research eventually adopted 20 subjects as a sample size, with means and 95% confidence interval for estimating the population statistic.

4.7.2 Hardware setting and operation process

The projects of each experiment are presented on a desktop computer. The projects were presented in a 1280 X 1024 pixel window on a 19 inch TFT LCD screen. The desktop computer (an Intel Core 2 Duo CPU desktop with 150GB hard drive and 2GB RAM) is placed under the desk, and the participants seated directly in front of screen (see Figure 4.17). While the subjects are doing the experiments, the researcher would sit by the subject in order to offer help if asked.

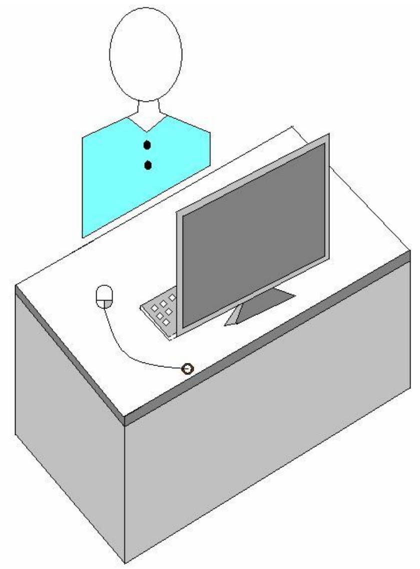


Figure 4.17: Setup of the experiment

After entering the room, the participants were given the questionnaire, which included a short oral introduction to the experiments, and are also given the opportunity to ask questions. There were two steps in each experiment, first to allow participants the opportunity to play with the project that the research wants the users to look at, and the second giving the participants a task to complete. After completing the task, the participants are asked to answer questions by filling in the questionnaire for this experiment and then, after recording any additional comments, carry out the next experiment. The total time for the experimental process was around 40 minutes.

The sequence order of the tests is varied from subject to subject, as the experiments' were numbered one to four, to minimize the chance of bias caused by the order of the experiments. The participants could stop the experiment at anytime in case any comfort issue is taking place. In considering the factors in the testing order of two different navigation styles in experiments (3) and (4), the participants were divided randomly and equally into two groups. One group tested the Image Channel first, and then the traditional jumping style. The other group tested projects in the reverse order.

The evaluation process is summarized by following the Standard Operating Procedure (SOP) of undertaking the testing, to make sure the participants have the same operation procedure, carried out without any deviation or modification, to maximise consistency and chance of a sound experimental outcome (Stup, 2001; U.S. EPA, 2007). The participants were mostly Masters and BA students recruited randomly from the University and there were no specific group or time limitations. The participants have the opportunity to provide their opinions by filling in additional comments thereafter. The questionnaire is attached in the Appendix I (1) for reference. A pilot test with three subjects was undertaken before starting the experimental evaluation. The result of pilot testing is not included in the result analysis of the experiments, but is for finding any improper set-up of the testing process and projects themselves.

### 4.7.3 Experiment (1) - Hypothesis One: evaluating the DO method

#### 4.7.3.1 Purpose and questions

This experiment is designed to test that the crossover between video fields looked natural and the stitching is acceptable to the users, in the proposed editing and stitching method, the DO. Hypothesis one is generated as criteria (see 4.5). The following questions are asked, based on the interrogations of the proposed new design method (see 2.10.1 and 4.5.1):

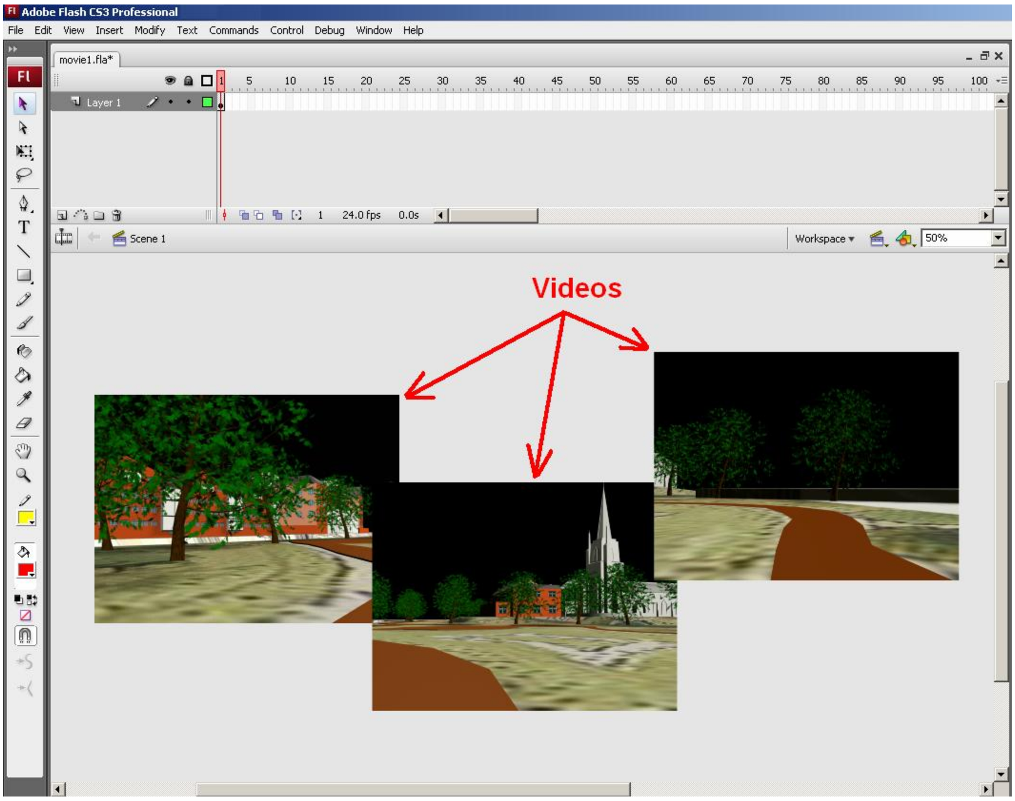
Q1: The perspective looked natural
Q2: The stitching of videos was generally acceptable

#### 4.7.3.2 Project creating and task

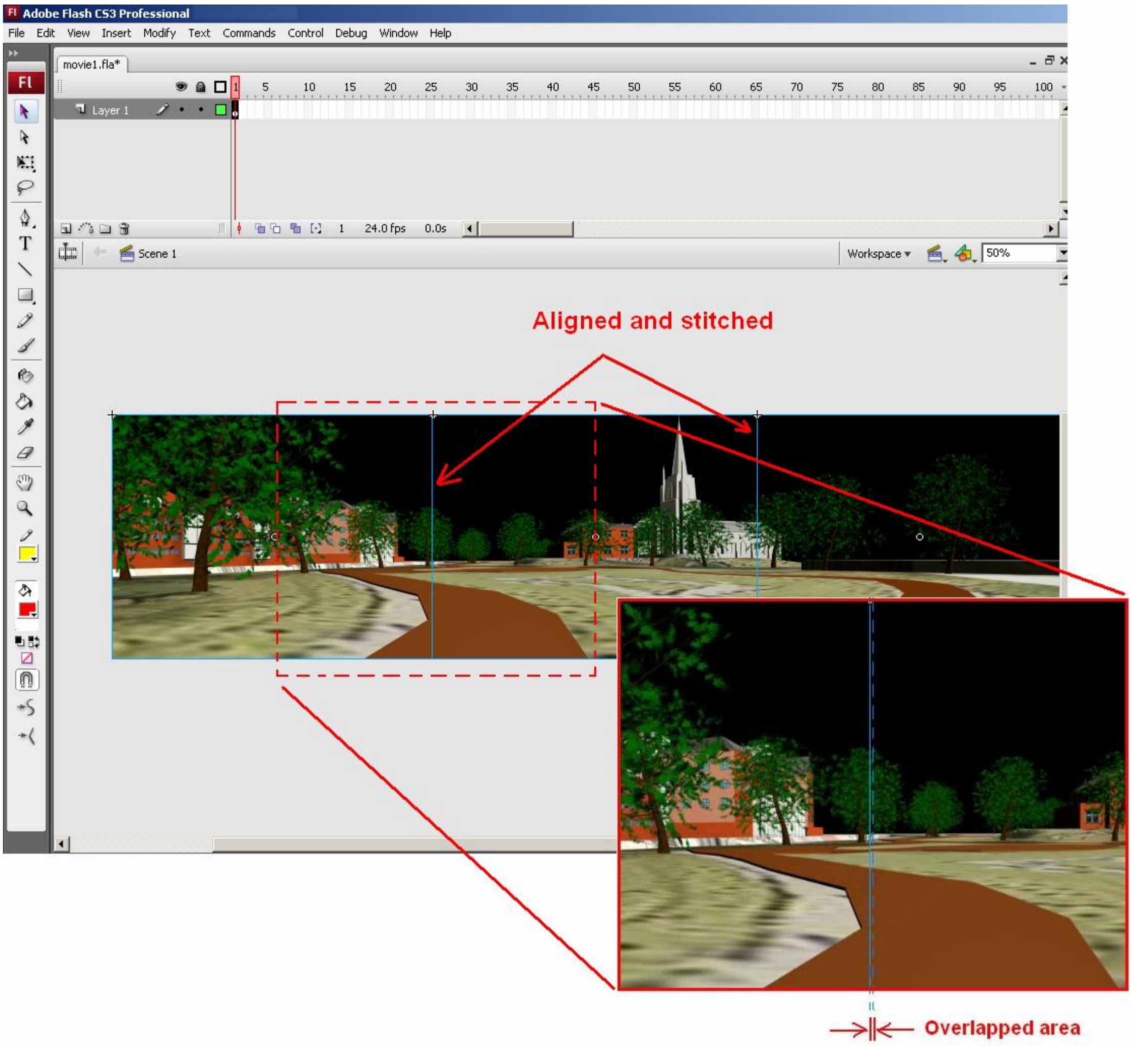
The project was created using the selected Multimedia integration tool: Adobe Flash (see 4.4.1). To illustrate the panoramic video using the proposed DO method (see 4.5.1), the videos for the project were obtained from the Castle Park CG simulated world (see Figure 4.4), created with the selected 3D Software, Autodesk Maya (see 4.3.2.3).

Figure 4.18 shows the process of the composition works of Panoramic Video by the DO method using the tool to create the project, and the screenshot of the project for reference. In the DO process, the right side of the leftmost frame is cropped to match as close as possible to the left side of the rightmost frame as can be seen in the diagram (see Figure 4.18(b)). The degree of the overlapped (cropped) area is very tiny in this case.

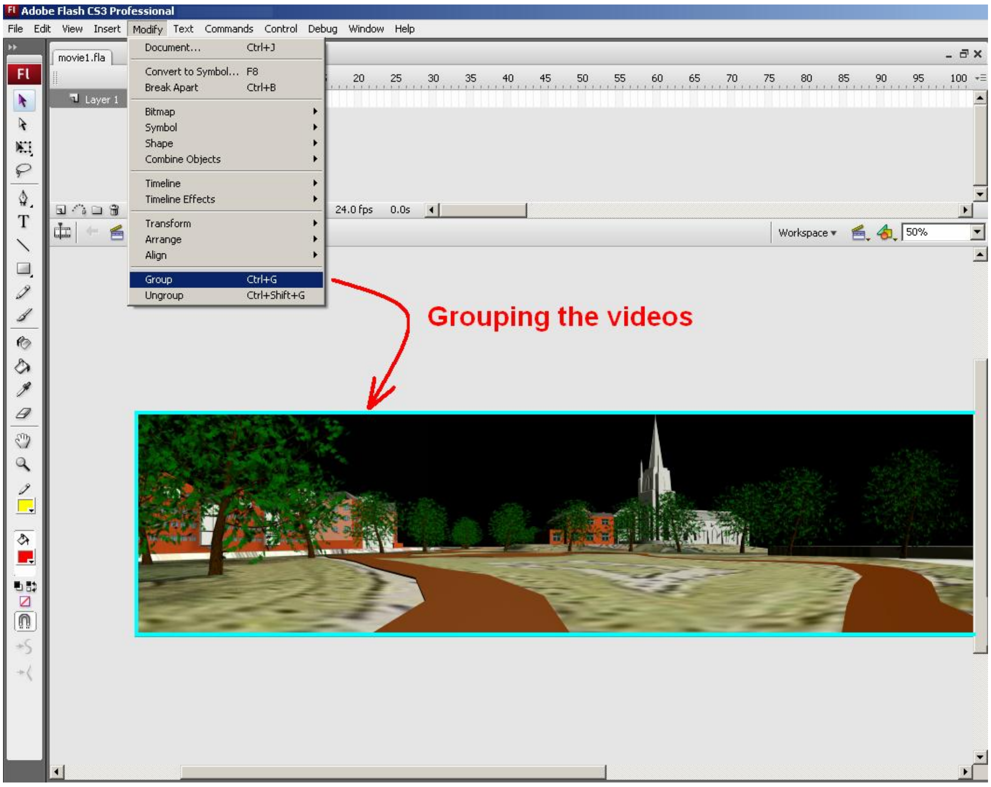
The task of the experiment was simply asking participants to operate the panoramic video to test the stitching after a short introduction to the operation. The task is given five minutes for completion, and can be extended if asked. The questions on the questionnaire of this experiment were presented to answer. Participants can freely give comments after responding to the questions.



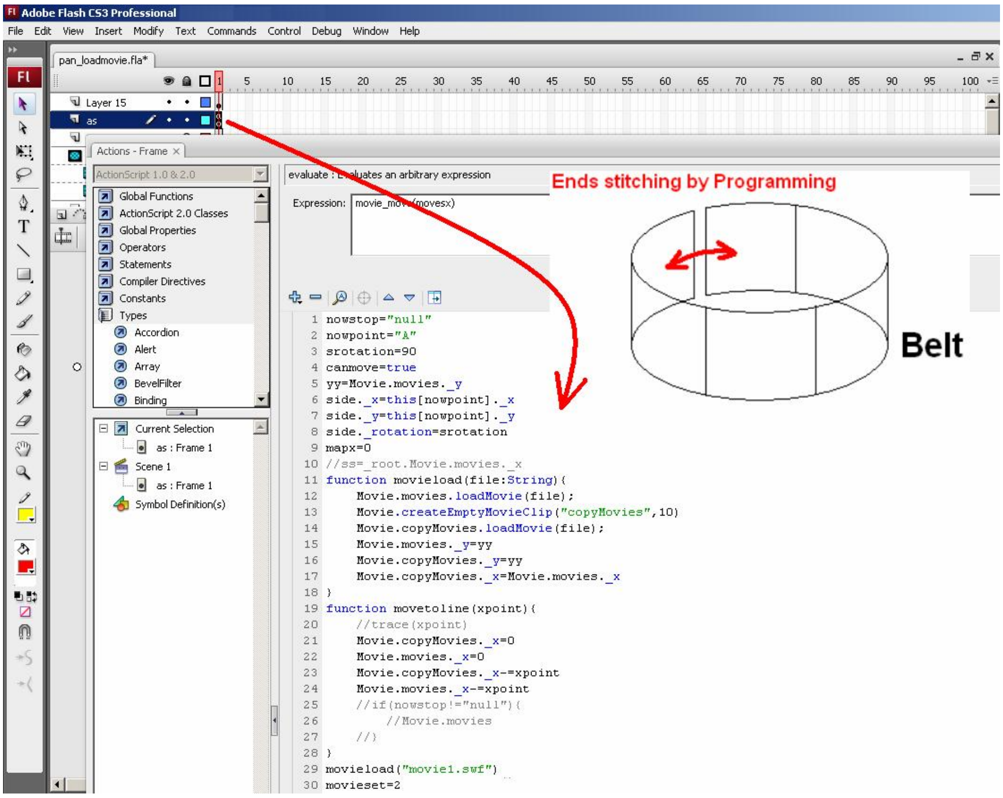

(a) Step 1: Videos import to Flash




(b) Step 2: Videos aligned and stitched by eyes




(c) Step 3: Grouping the videos to form a belt by Flash's existing function




(d) Step 4: Programmes (see Appendix II (1)) to stitch ends of the belt to form Panoramic Video and to create panning function

Panoramic Video


(e) Step 5: Output the webpage format (project of experiment (1))

Figure 4.18: The process of proposed DO method to the project

4.7.3.3 Result

The result is obtained at a 95% confidence interval and means were calculated in Microsoft Excel (see 3.4.1). Figure 4.19 indicates that there is a strong agreement within the group that the perspective obtained looked natural and is generally acceptable to a level close to "strongly agree". There is a higher level of rating and agreement still for the stitching quality, obtained on the Likert Scale.

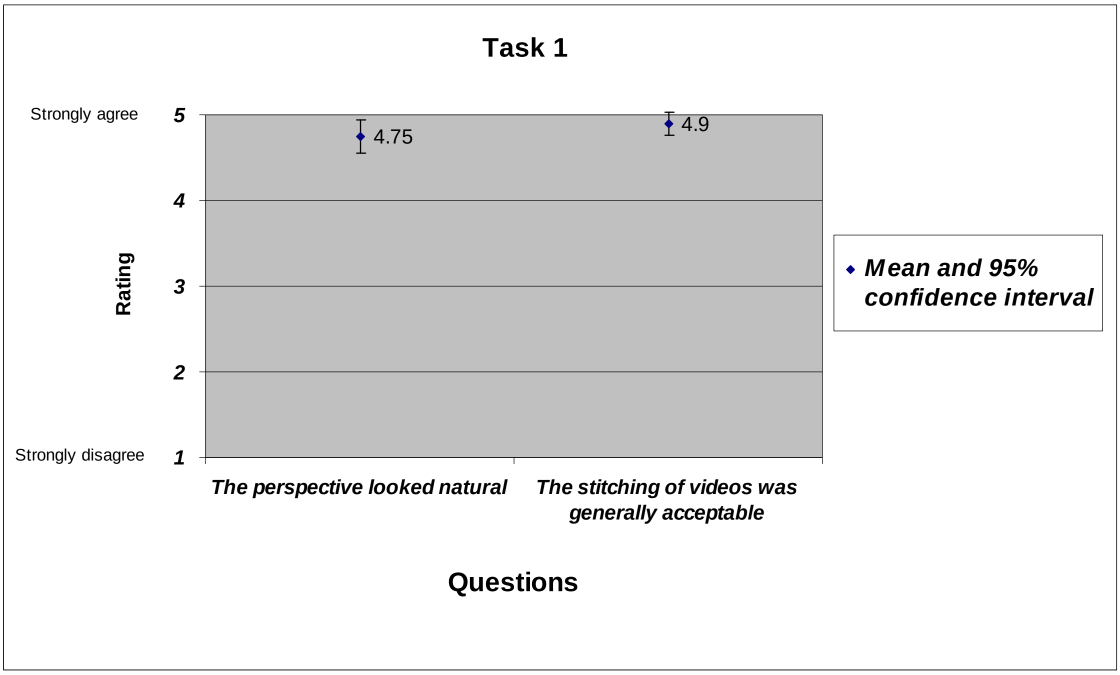



Figure 4.19: Performance of proposed editing and stitching method

The comments of the participants are obtained, listed as follows:

"*The technology shown to me was really great and amazing.*"

"*Everything looks pretty natural.*"

A specific comment indicated the reason why the result did not achieve 100% strong agreement to the questions that were asked:

"*It will look more nature if the video was captured in real environment.*"

4.7.4 Experiment (2) – Hypothesis Two: determining the panning control

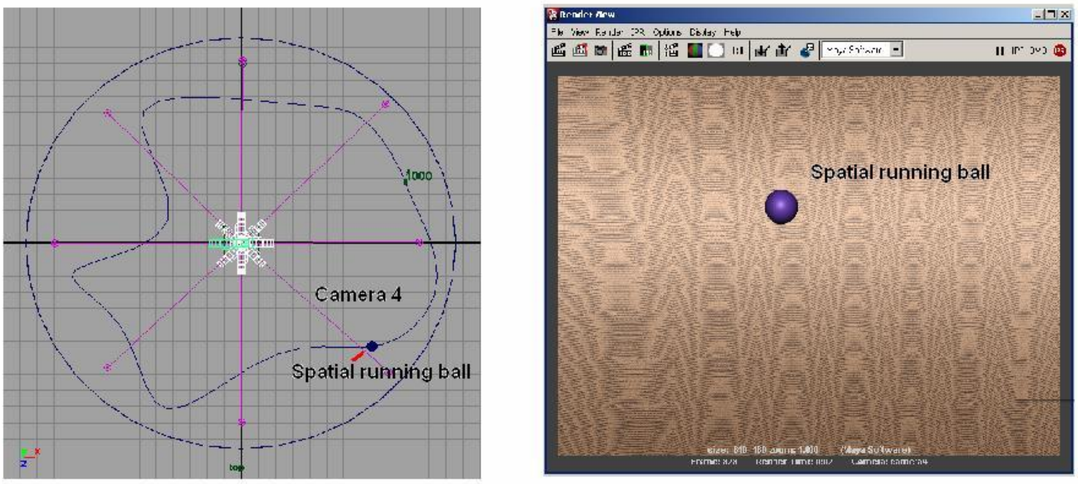
4.7.4.1 Purpose and questions

The experiment was designed concerned with testing the manipulation of the panning control. The panning control issue is noticed, but research falls short of investigation into the practicality and usability (see 2.11.2 and 4.4.2). The dynamic scene of panoramic video (see 2.4) reveals the operation of panning will probably not only enable looking around the surrounding environment, but also has the intention of tracking interesting objects. The tracking prospect generates the idea of submitting a design, named Ball Tracking (BT), which is used for tracking a designed virtual spatial ball to determine the ease of the panning control. Hypothesis Two is generated as criteria (see 4.5) that is, the panning around control work well. Three questions included two (Q1 and Q2) for panning operation and one (Q3) for the submitted BT method, are generated to ask:

Q1: I can keep the ball in the area
Q2: Manipulating the movement of the ball was easy
Q3: Tracing the running ball provided fun and engagement in the scene

4.7.4.2 Project creating and task

A created virtual environment, which utilized a simple background, included a virtual ball moving around the virtual multi camera system to obtain videos to create the project (see Figure 4.20). The simple background has the advantage in controlling the factors, e.g. lighting and complexity objects, which distract users, and focuses on the operation of the movement. The panoramic video was created by the DO method with the designed parameter of panning speed.




(a) 8 virtual cameras levelled in the middle of the scene to capture videos

(b) The screen shot of camera 4 faces the spatial running ball

Figure 4.20: A spatial ball created in the virtual environment for developing the project assessment

A vertical line (grey line) marking the starting mark was fixed on the panoramic video, and will move synchronously when panning. There were two vertical lines (red lines) compartmenting the viewing area of the panoramic video into three portions (see Figure 4.21).

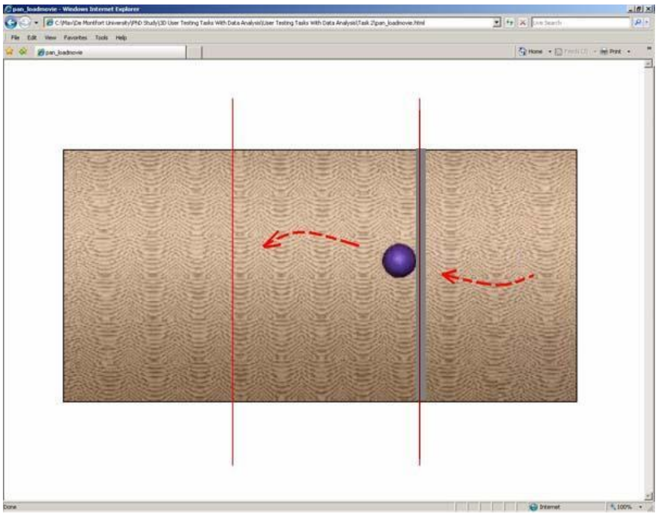


Figure 4.21: A running spatial ball project of the experiment (2) to evaluate the panning operation

The operation process of the task is as following:

1. Position the vertical grey line to the right vertical red line by moving the panoramic video and wait until the virtual spatial ball runs between the two vertical red lines
2. Start panning the panoramic video to keep the ball in the area between the two vertical red lines
3. The operation runs until the vertical grey line is aligned to the vertical red line again.

The task is completed in a running circle of the virtual ball. Participants can freely give comments after the set questions have been answered.

4.7.4.3 Result

The result was obtained by using means and 95% confidence interval calculated in Microsoft Excel (see 3.4.1). Figure 4.22 indicates to the level of "strongly agree", that there is a strong agreement within the group that I can keep the ball in the area, and a higher level close to "strongly agree" of rating and agreement that manipulating the movement of the ball is easy, and tracing the running ball provided fun and engagement in the scene, as obtained on the Likert Scale.

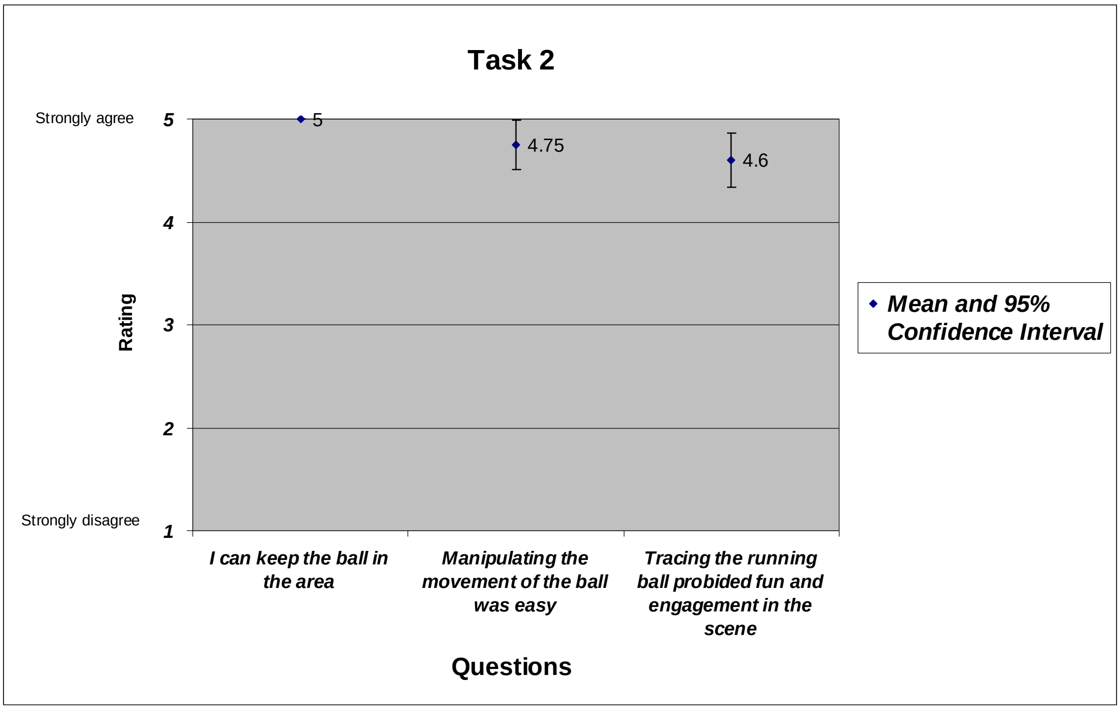



Figure 4.22, Performance of panning speed design and the method

The comments of the participants were obtained listed as following:

"*The experience of engaging in this particular experience was fun.*"
"*Very interesting and enjoyable.*"
"*The ball control movement task was fun and good.*"
"*It is like an interesting game. I like it.*"

### 4.7.5 Experiment (3) – Hypothesis Three: determining the benefit of an "Image Channel"

#### 4.7.5.1 Purpose and questions

This experiment is concerned with testing the proposed new in scene navigation style, the Image Channel (see 4.5.2), as a solution to the disorientation issues which occur due to the traditional Hotspot navigation style (see 2.10.3). The Hypothesis Three is generated as criteria (see 4.5) that is, Image Channel has better perception on position, orientation, and walkthrough effect than Hotspot. The following questions are mainly acquired from the queries about the design method (see 4.5.2) and are asked:

Q1: This style gives me a good feeling of my position
Q2: This style made me feel I was walking through the scene
Q3: This style gives me a good feeling of my orientation

#### 4.7.5.2 Project creating and task

There are two projects, Image Channel navigation style of panoramic video and Hotspot navigation style of panoramic video, created for the experiment. These two projects included the same three panoramic videos (see Figure 4.23) created by the DO method with designed panning control parameter, and adopted the 3D CG simulation environment, Leicester Castle Park (see Figure 4.4) to acquire videos for the composition. The navigation action happens when the invisible tag is clicked (see Figure 4.24). Two clues are designed in to the projects to show the navigation direction;

the ground path and the invisible tag (see Figure 4.24). Code is developed in the invisible tag area so that when the mouse rolls-over the invisible tag, the shape of mouse cursor will be changed from arrow to hand to provide a hint.

Figure 4.25 shows the difference between the two navigation styles in traversing two adjacent panoramas. Footage of three traverses are captured and used in the Image Channel project. The operation process of the task has considered how factors in the order of operating the different navigation style would affect the result. The participants recruited to do the project testing are randomly divided into two equal groups, with a different testing order; one group did the Image Channel style first then Hotspot style, the other group did the test inversely (see 3.4.1). The task was simple, asking the participants to experience the assigned project. The questions on the questionnaire are provided after testing assigned project. The given time to the task is five minutes but can be extended if necessary. Participants are free to give comments after the task implementation.


Figure 4.23: The wide screenshots of the three panoramas and invisible tags (green squares) for interacting to navigate in panoramas

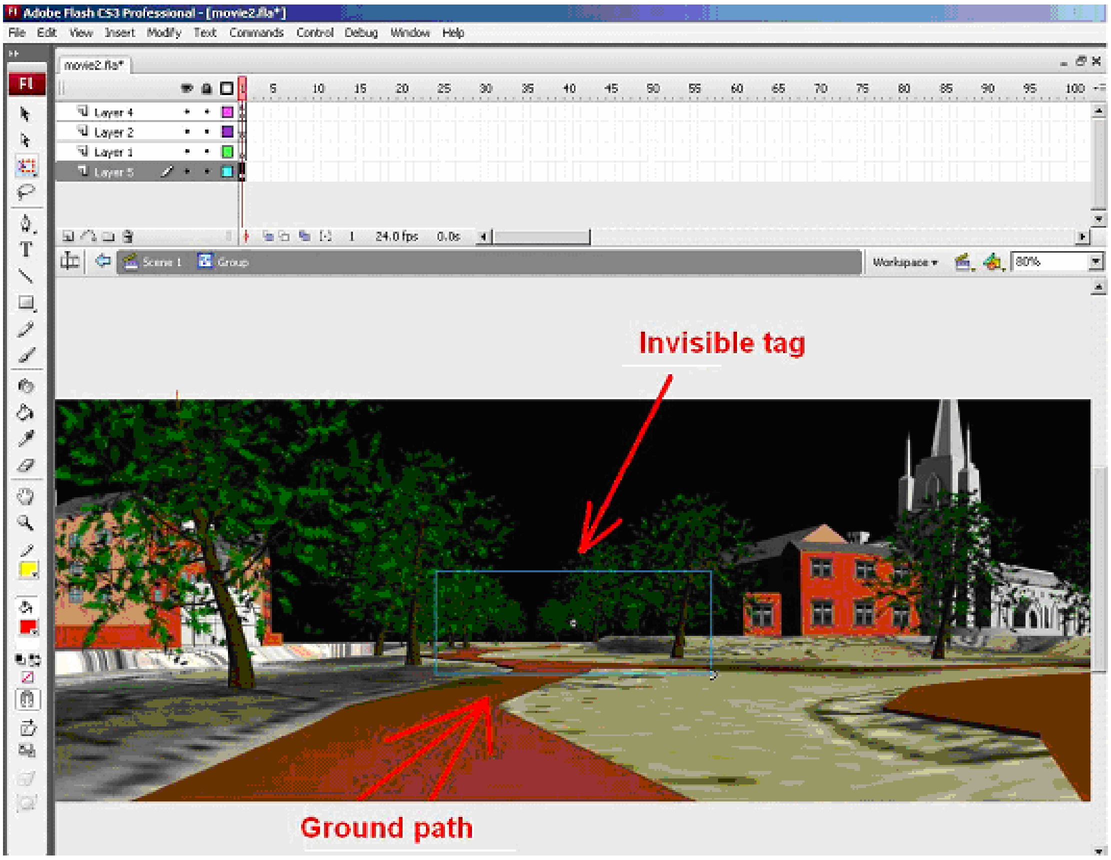



Figure 4.24: The clues to know the direction for navigation

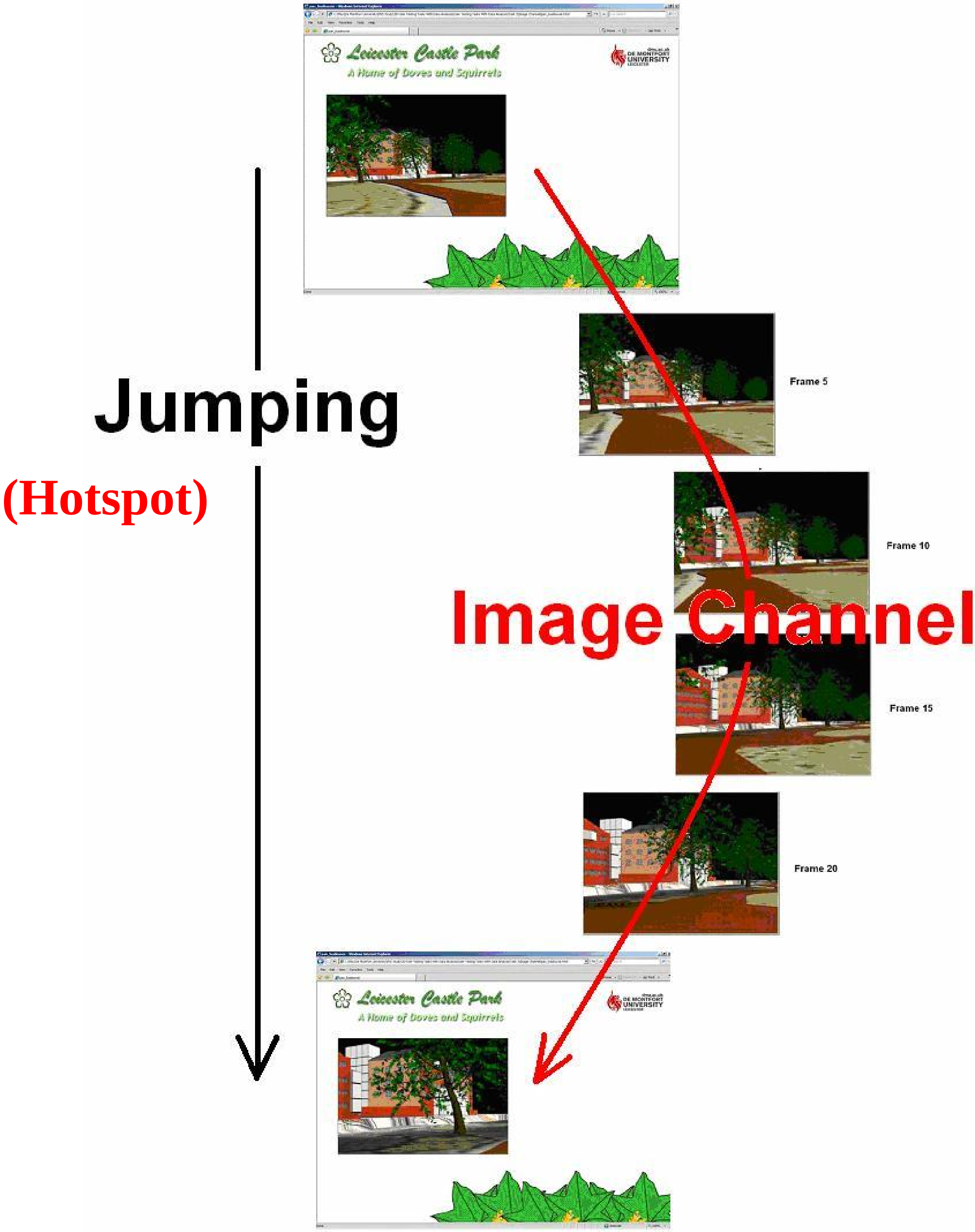



Figure 4.25: Two different navigation style projects were created for testing position and orientation recognition, and walkthrough performance

4.7.5.3 Result

The result of the comparison of the two navigation styles obtained using 95% confidence interval was compared using Wilcoxon signed-rank test offered by software called SPSS (see 3.4.1). The Wilcoxon test makes no assumption about underlying distribution and is appropriate for ordinal data.

Table 4.5 shows there are highly significant differences ($p<0.0001$) in the comparison of the navigation styles for all three questions by the Wilcoxon signed-rank test. Means are obtained by calculations in Microsoft Excel, and displayed in Figure 4.26. The means of each of the two different navigation styles show no areas of overlap. The means of Image Channel indicates that there are very close to strong agreements within the groups that this style gives me a good feeling of my position, this style made me feel I was walking through the scenes, and this style gives me a good feeling of my orientation (the way I am facing), whereas the means of Hotspot were obtained on the contrary using the Likert Scale.

**Test Statistics[b]**

| | ICQ[c]1 - HQ[d]1 | ICQ2 - HQ2 | ICQ3 - HQ3 |
|---|---|---|---|
| Z | -3.959[a] | -3.974[a] | -3.976[a] |
| Asymp. Sig. (2-tailed) | .000 | .000 | .000 |

Notes: a: Based on negative ranks; b. Wilcoxon Signed Ranks Test;
ICQ[c]: Image Channel Question; HQ[d]: Hotspot Question

Table 4.5: The result of Wilcoxon signed-rank test to the navigation styles

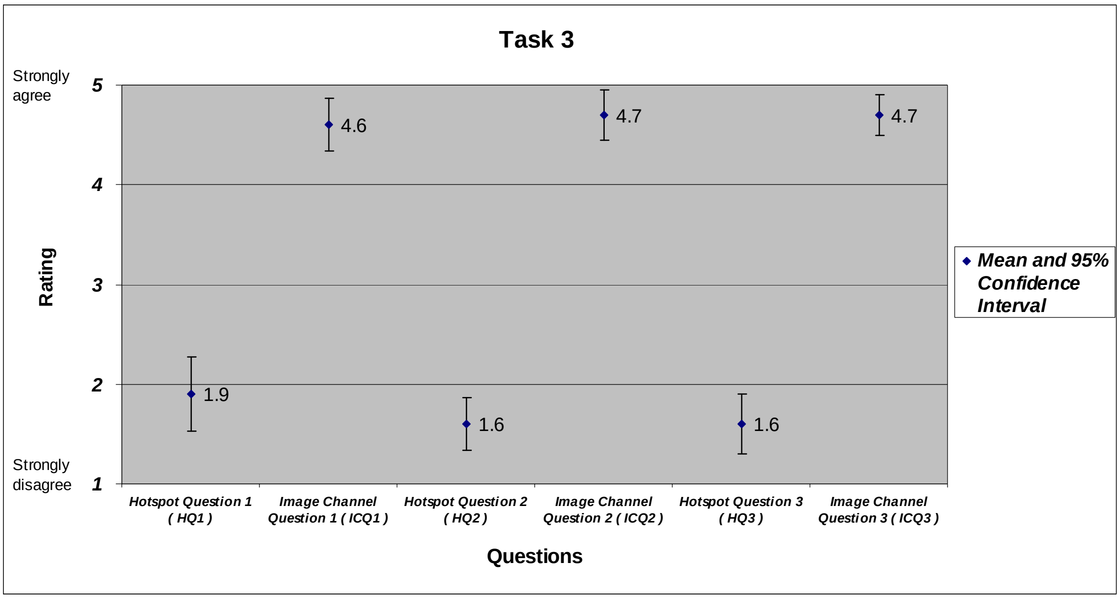



Figure 4.26: The means of the navigation styles calculated by Windows Excel

There are many comments, positive and negative, about the navigation styles on position, orientation, and walkthrough perception, and a suggestion: "Recommended Image Channel following the paths to walk through, not direct approach". The general comments of participants to the navigation styles are sorted in three topics listed in Table 4.6 for reference.

| Comments' category | Comments | Notes |
|---|---|---|
| Position recognition | *"Image Channel is more realistic because when I was using it I actually knew where I was going and had a good idea where I was."* | Positive to Image Channel |
| | *"Hotspot is very confusing as you can't see how you get from point to point. Image Channel is more natural."* | Positive to Image Channel and negative to Hotspot |
| Orientation perception | *"Image Channel generalise clarity whilst hotspot generalise confusion."* | Positive to Image Channel and negative to Hotspot |
| | *"Image Channel style provides good angle-direction feeling."* | Positive to Image Channel |
| | *"Image Channel makes me know clear orientation; however, hotspot may make me confused."* | Positive to Image Channel and negative to Hotspot |
| Presence (in Walkthrough) | *"Image Channel gave me a better feeling than hotspot."* | Positive to Image Channel and negative to Hotspot |
| | *"Image Channel made me feel engagement and immersive."* | Positive to Image Channel |
| | *"Hotspot doesn't be good as I think. It doesn't like walking through the scenes."* | Negative to Hotspot |

Table 4.6: The comments of the performance on the navigation styles (3D CG)

#### 4.7.5.4 Objective assessment

An objective assessment to compare the two navigation projects (Image Channel and Hotspot) was undertaken. Performance of each method could be indicated by comparing the total time in the environment to complete the task (duration) and the number of stops: an indicator for the user getting lost or loosing their way in the environment.

The data of time and passed stops for the assessment were obtained by videos filming the participants in the user testing and using the video timecode to record the time and stops. Table 4.7 lists the recorded data (Table 4.7 (a)) and calculated averages of time and passed stops (Table 4.7(b)) for reference and further data analysis. Subjects are marked numerically for confidentiality.

| Subject | Image Channel | | Hotspot | |
|---|---|---|---|---|
| | Duration (sec) | Stops | Duration (sec) | Stops |
| 1 | 27 | 2 | 78 | 7 |
| 2 | 38 | 2 | 110 | 15 |
| 3 | 35 | 3 | 45 | 4 |
| 4 | 30 | 2 | 52 | 5 |
| 5 | 34 | 3 | 70 | 9 |
| 6 | 35 | 3 | 47 | 7 |
| 7 | 40 | 3 | 68 | 7 |
| 8 | 28 | 2 | 30 | 4 |
| 9 | 40 | 3 | 76 | 9 |
| 10 | 30 | 2 | 86 | 10 |
| 11 | 65 | 5 | 125 | 20 |
| 12 | 40 | 3 | 68 | 7 |
| 13 | 32 | 2 | 52 | 6 |
| 14 | 33 | 2 | 55 | 7 |
| 15 | 28 | 2 | 80 | 11 |
| 16 | 56 | 5 | 68 | 8 |
| 17 | 26 | 2 | 28 | 4 |
| 18 | 42 | 4 | 45 | 6 |
| 19 | 30 | 2 | 38 | 5 |
| 20 | 32 | 2 | 43 | 5 |
| Total | 721 | 54 | 1264 | 156 |

(a) The received data of duration and passed stops of subjects to the two projects

| | Duration (Average) | Stops (Average) |
|---|---|---|
| Image Channel | 36.05 | 2.7 |
| Hotspot | 63.20 | 7.8 |

(b) The calculated averages of duration and passed stops

Table 6.7: The data of time and passed stops of completing the task to the two projects

The results of the comparison obtained using 95% confidence interval, and paired T test for the time and Wilcoxon signed-rank test for the number of stops offered by software called SPSS. The paired T test was appropriate for continuous data likely to be normally distributed (WINKS, 2007), and the Wilcoxon signed-rank test makes no assumption about underlying distribution and is appropriate for ordinal, number of stops, data (Easton and McColl,1997).

Table 4.8 shows that there is highly significant difference ($p<0.0001$) in the comparison of the navigation styles to the completing time (duration) by paired T test. Means are obtained by calculations in Microsoft Excel, and displayed in Figure 4.27. The means of time in the two different navigation styles are 36.05 seconds to Image Channel and 63.20 seconds to Hotspot. This result has high practical significance as it indicates that users spend 1.75 times as much time in the system without the image channel. This is a high value considering that there are times when the user cannot choose to move around in the image channel environment because the image channel transition is playing and takes around 5 seconds per transition. It indicates that the image channel is far more efficient as a means to navigate between scenes.

Table 4.9 shows there is highly significant difference ($p<0.0001$) in the comparison of the navigation styles to the passed stops (Panoramic Videos) by Wilcoxon signed-rank test. Means were acquired by calculations in Microsoft Excel, and display in Figure 4.28. The figure shows no areas of overlap to the means of the passed stops in the two different navigation styles (2.7 stops to Image Channel and 7.8 stops to Hotspot), and showing Hotspot has nearly 3 times as many stops than Image Channel: again indicating the superiority of the Image Channel approach.

**Paired Samples Test**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | Lower | Upper | | | |
| Image Channel - Hotspot | -27.15000 | 21.27582 | 4.75742 | -37.10739 | -17.19261 | -5.707 | 19 | .000 |

Table 4.8: The result of paired T test of time to the navigation styles

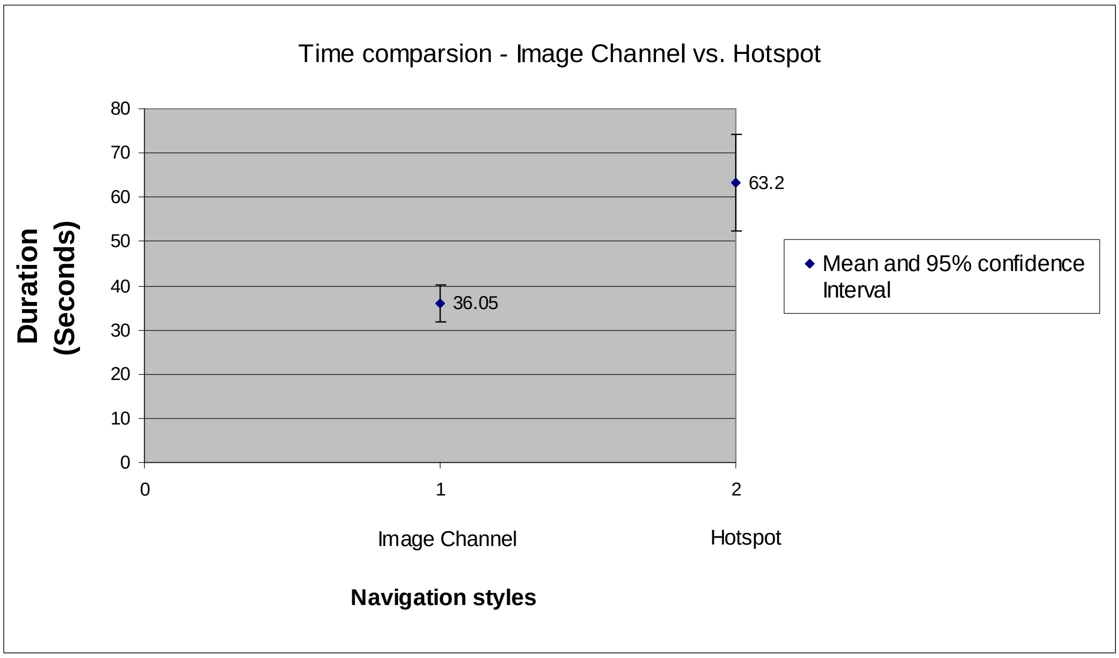



Figure 4.27: The means of time of the navigation styles calculated by Window Excel

**Test Statistics[b]**

| | Hotspot - Image Channel |
|---|---|
| Z | -3.929[a] |
| Asymp. Sig. (2-tailed) | .000 |

Notes: a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

Table 4.9: The result of Wilcoxon signed-rank test of passed stops to the navigation styles

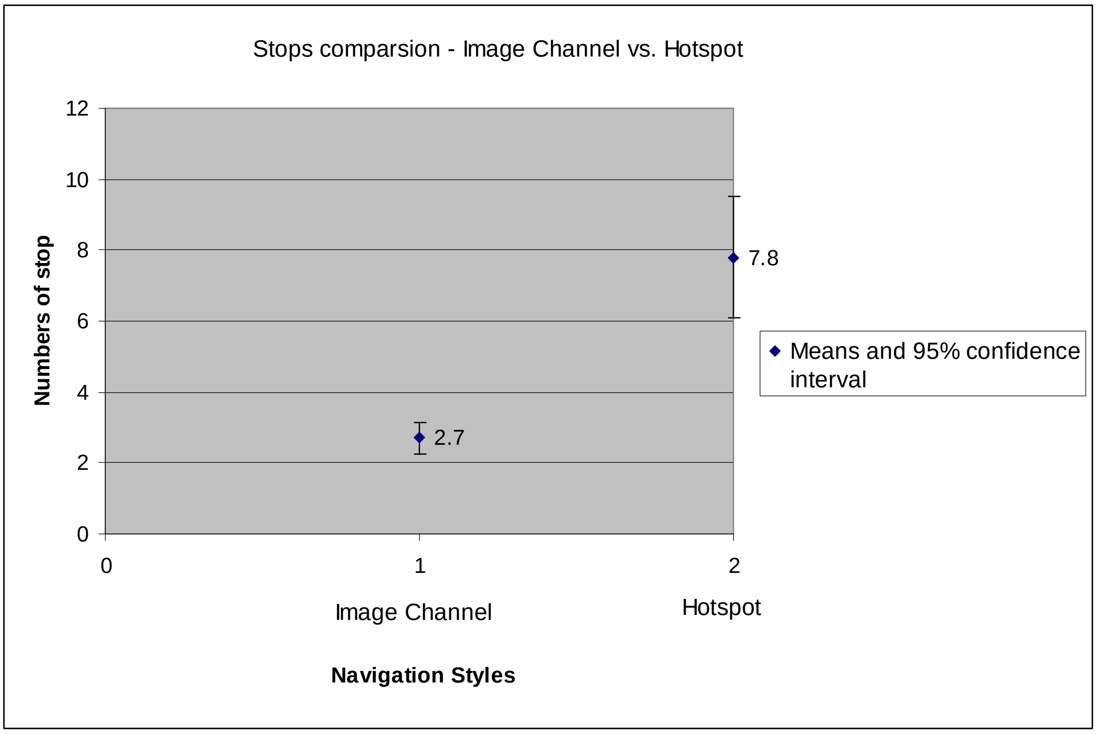



Figure 4.28: The means of passed stops of the navigation styles calculated by Window Excel

4.7.6 Experiment (4) – Hypothesis Four: testing the interface design and the suggested elements

4.7.6.1 Purpose and questions

This experiment is designed, concerning testing the recommended embedded elements (see 2.9) in the generated web page format, with the interactive design (see 4.5.3) in the two projects of navigation styles, the Image Channel and the Hotspot. Hypothesis Four is generated as criteria (see 4.5), that is the interface and interactive design of the embedded elements work well. The following questions, including testing the suitability of the recommended embedded elements (Q1, Q2, Q3, and Q5) and of the overall web interface design (Q3, Q4, and Q6), are asked:

Q1: This style, with the map helped me to recognize my position

Q2: This style, with the map helped me understand my orientation (the way that I am facing)

Q3: It was easy to find the object

Q4: I enjoyed experience of being in the environment

Q5: The sound made me feel I was in the environment

Q6: Please rate your overall experience of using this project out of 5, 5 is good

4.7.6.2 Project creating and task

Similarly to experiment (3), the projects of this experiment adopted the 3D CG simulation environment, Leicester Castle Park (see Figure 4.4) to acquire videos and to compose panoramic videos. The differences between experiment (3) and (4) were that the projects allowed users to explore the simulated virtual environment completely with full functions and recommended elements, e.g. panning, zooming, information searching by tags and annotation cooperation, and an interactive map (see Figure 4.29) for enhancing position and orientation recognition, as the prototype of the proposed web-based integrated application. Figure 4.30 shows the tags cooperated with the annotation design of the project. There are seven panoramic videos created for the projects. Figure 4.31 shows the locations of the panoramic video created by the DO method on the printed map provided by Leicester' City Tourism Centre. Figure 4.32 shows the pre-filmed image footage routes, which were used in Image Channel navigation style for travelling the scene. Figure 4.33 shows the additional information of the environment presented by the tags corresponding with the annotations display. Figure 4.34 shows the screenshot of the complete project, which adopts the developed webpage layout, (see Figure 4.12) for reference.


Figure 4.29: The interactive map embedded on the information area for enhancing spatial recognition


Figure 4.30: The annotation will replace the map display when the mouse rolls over the tag on the panoramic video

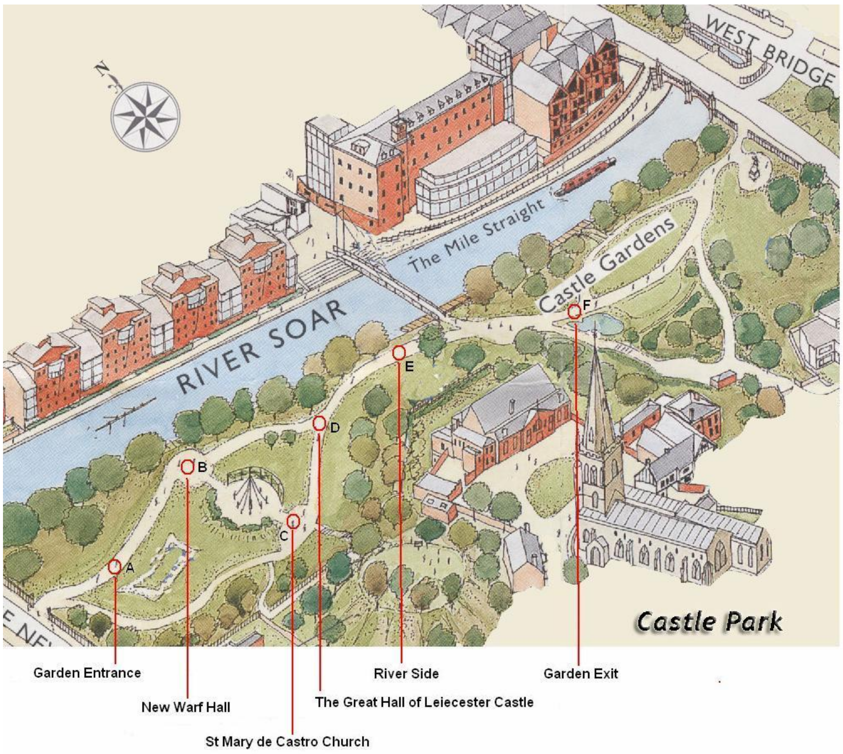



Figure 4.31: The panoramic videos' location on the virtual Castle Park of Leicester

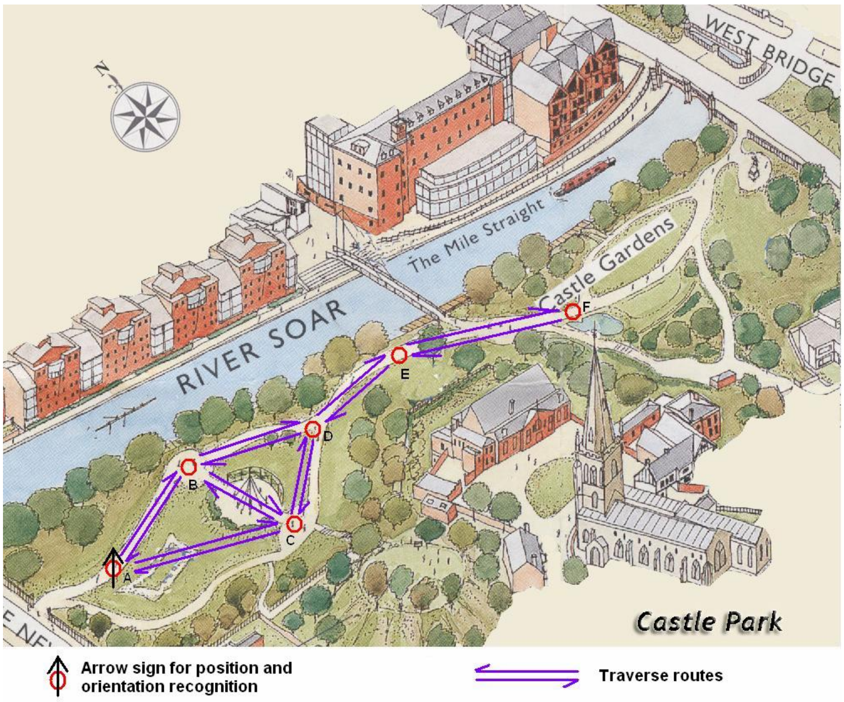



Figure 4.32: The traverse route arrangements of the Image Channel style

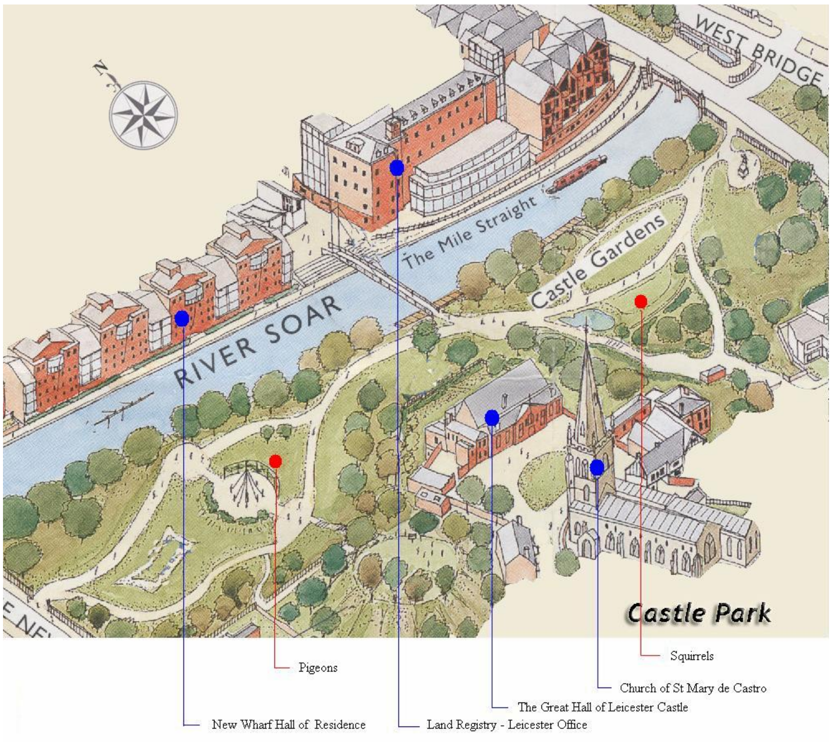



Figure 4.33: The displayed information of the projects


Figure 4.34: The completed project for determining the necessity of embedded elements (videos generated by 3D CG world)

In considering that the purpose of the proposed web-based integrated application is to communicate information, the task was designed to be an information-searching one, in order for participants to experience the projects. The time allowed for the task is ten minutes and can be extended if asked.  No pressure was given to the participant in finding the information during the task. The participant could stop the task at any time without reason. The questions on the questionnaire are provided after experiencing each project. Participants are freely able to give comments after task implementation. The operation process of the task has considered how the order of operating the different navigation styles would affect the result (see 3.4.1). The participants recruited to do the project testing were randomly divided into two equal groups with a different testing order; one group did the project with Image Channel project first then with Hotspot project, the other group did the test inversely.

#### 4.7.6.3 Result

The results of testing were analysed with Microsoft Excel (see Figure 4.35) and a 95% confidence interval was constructed.  Again, a Wilcoxon signed-rank test offered by software called SPSS (see 3.4.1) used to the data analysis. Table 4.10 shows there is statistical significance ($p<0.05$) to the questions that the map helped in understanding the orientation (the way I am facing) (Q2), enjoying the experience of being in this environment (Q4), the sound made me feel I was in the environment (Q5), and rating the overall experience of using the Image Channel project was better than Hotspot project (Q6), and there is no statistical significance ($p>0.05$) in the map helping recognition of my position (Q1) and it was easy to find the object (Q3) of the Image Channel project was better than the Hotspot project, as evidenced by the result of Wilcoxon signed-rank test. Looking at the general level of the means and confidence interval shows great areas of overlap and were all located in the level of between 4 (agreement) and 5 (strong agreement), and close to maximum score 5 within the group to the questions on the Likert scale.

| Test Statistics[c] | | | | | | |
|---|---|---|---|---|---|---|
| | ICQ[d]1 - HQ[e]1 | ICQ2 - HQ2 | ICQ3 - HQ3 | ICQ4 - HQ4 | ICQ5 - HQ5 | ICQ6 - HQ6 |
| Z | -1.414[a] | -2.333[a] | -.447[b] | -2.111[a] | -2.000[a] | -2.496[a] |
| Asymp. Sig. (2-tailed) | .157 | .020 | .655 | .035 | .046 | .013 |
| | No significant (>0.05) | Significant (<0.05) | No significant (>0.05) | Significant (<0.05) | Significant (<0.05) | Significant (<0.05) |
| Notes: a: Based on negative ranks; b: Based on positive ranks; c. Wilcoxon Signed Ranks Test; ICQ[d]: Image Channel Question; HQ[e]: Hotspot Question | | | | | | |

Table 4.10: The result of Wilcoxon signed-rank test to the embedded elements and overall design

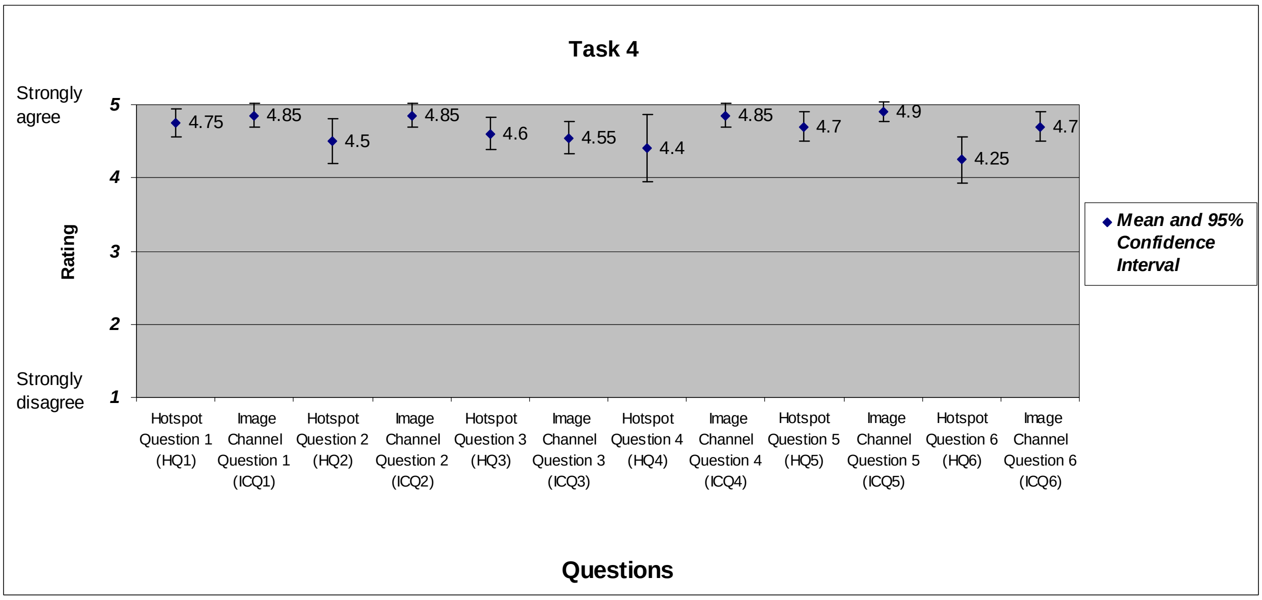



Figure 4.35: The mean responses to questions in experiment 4

There are many comments, positive and negative from the participants after the projects' testing. The comments are sorted by four topics: interactive map, tag and annotation, sound and the overall experience, listed on the Table 4.11 for reference.

| Comments' category | Comments | Notes |
|---|---|---|
| Interactive map | "*More difficult to use and a bit more confuse of Hotspot without map. Map is very useful to Hotspot, without it, it will be very confusing.*" | Negative to Hotspot project |
| | "*I preferred using Image Channel as surf the map, because I can walk through the paths to feel immersive the virtual environment.*" | Positive to Image Channel project |
| Tag and annotation | "*The annotations were very clear and helpful to in information approach.*" | Positive to the design of tag and annotation on the projects |
| Sound | "*There could be more sounds such as wind blowing and fluttering of the leaves.*" | Negative to sound quality embedded on the projects |
| Overall experience | "*Comparing Image Channel with Hotspot, the operation feeling of Image Channel is more natural than Hotspot.*" | Positive to Image Channel project |
| | "*There was a sudden change in the pitch (sound) in Hotspot, but Image Channel had a smooth transition.*" | Positive to Image Channel project and negative to Hotspot project |
| | "*The immersive experience of Image Channel will increase if the environment is in real. I would play more if the environment is real.*" | Suggestion and expecting to have real environment experience |

Table 4.11: Comments on the performance of the created project of experiment (4)

### 4.8 Discussion

The participants recruited to the experimental evaluation started with great curiosity after the introduction of the experiment, and ended with more queries about the projects created by videos editing and stitching. Several participants inquired to the identity of the scenes which were not CG VR. This was answered by presenting the videos individually and the stitching technology by the research.

Participants were in very high praise of the created projects, and are expecting to see the production by using videos filming in real world (see Table 4.11). The aims of the experiments are achieved by the testing of the created projects: the videos editing and stitching tested in the experiment (1) indicates that the DO method is workable in a practical analysis (see Figure 19). The panning operation of the panoramic video created by the DO was optimised by proper parameter setting by the proposed Ball Tracking (BT) design of experiment (2) and can be seen in statistical and practical analysis (see question 1 and 2 in Figure 22).

This above suggests that the design method of panning control manipulation is successful and acceptable. In addition, the submitted BT design, which is used for tracking a designed virtual spatial ball to determine the ease of the panning control, received high levels of agreement in providing fun and engagement when operating the project (see question 3 in Figue 22). This indicates the BT method in determining the panning control is acceptable and effective as a practical and creative idea, although the ball running path can be redesigned to suit different purposes.

The purpose of experiment (3), to examine the image channel idea, has been accomplished by statistical and practical analysis (see Figure 26). To the surprise of participants operating the proposed Image Channel project, the participants think that the Image Channel project is created by 3D CG because of the approach of the walkthrough perception is similar to 3D computer game. A suggestion of movement by following the path on the filming of the Image Channel was picked up upon at this stage and was later adopted in the development of the final production.

An interesting discovery in the experiment is that the responses to the Hotspot based project test gave a very negative feedback, with the means close to strongly disagree on the Likert scale for the spatial recognition, including orientation and position. This indicates that the Hotspot is a very poor navigation design.

The intention of the experiment (4), concerned with embedded elements, was achieved in that the embedded elements are appropriately designed for the Image Channel project and Hotspot project. Although there is statistical significance (4 out of 6 questions (Q2, Q4, Q5 and Q6)) and no statistical significance (2 out of 6 questions (Q1 and Q3)) to the two projects, the obtained mean of each question on the Likert scale are all positioned in the same level of closing strongly agree. The research does not consider the lack of significant difference here a problem as the purpose of the experiment was to test if the embedded elements were appropriately designed for the different navigation methods, and all the results fall within the high positive range. The designed elements do work effectively can be seen apparently on the Figure 35. The most important finding from participants' practical experience is that, although the map works with both styles, it is considered essential ONLY with the Hotspot project (see Table 4.11).

This practical result indicates that the embedded elements are all designed statistically and practically properly for the two projects. The suggestion, included the comment of sound quality by recording the environment sound when filming the videos, will be adopted and designed into the final production.

### 4.8.1 Finding - interactive map can be eliminated in the "Image Channel" design

It is found that the interactive map in the project of Hotspot navigation style is essential by cross analysis of experiment (3) and (4) on the questions related to position and orientation. Hotspot navigation style will lose the spatial recognition, including position and orientation, if the interactive map does not exist. On the other hand, Image Channel performs well with regards to spatial recognition whether the corresponding map navigator exists or not. This is a very significant finding and means that more screen space can be devoted to content and not navigational methods using the Image Channel approach.

4.8.2 Web layout and interactive design

The web interface is preliminary tested in Q3, Q4, and Q6, which is easy to find the object, enjoys the experience of being in the environment, and rates the overall experience of using the projects out of the experiment (4) and received a high level of acceptance on the Likert scale (see Figure 35). This supports the notion that the design of the web interface design be adopted to develop the proposed integrated application. The interactive design of the essential elements is tested, and identified the proposed Image Channel without a map is the best solution to the navigation in scene (see 4.8).

## 4.9 Conclusion

This Chapter started by identifying that multi-camera system was the best choice to create panoramic video (see 4.2), but it faced practical problems in filming and video capturing rig design. The videos obtained by 3D CG world (see 4.3) gives a possible solution to test any proposed multi camera capture method, and specifically the idea of direct overlap DO (see 4.5.1), and the Image Channel (see 4.5.2), and the embedded elements, as recommended by former researchers.

Findings from the preceding analysis of conditions and variables created by the experiments can feedback to the aims of this study, and can be concluded as follows:

Firstly, the design method in developing the web-based panoramic video is tested by experiment (1) and (2). As no treatment is needed to the videos before and after composing the panoramic video, the editing and stitching method, the DO, evidently eliminated the resolution issue at an observable level that are constantly mentioned by panoramic video researchers and developers. The statement in 4.5.1, that the resolution issue will be dependent on the video camera selection, not the technology process, is confirmed by the DO concept of being used for videos obtained in the 3D CG world.

The panning speed, which is known to influence the operation performance of the technology, again has been approached by developing a practical system of ball tracking (BT) to set up operational parameters. The method was highly accepted by the participants in a submitted design method, and when tested was found to be a suitable and practically effective approach to test the panning control operation (see 4.7.4).

The Image Channel approach to navigation style in panoramas has been proposed. It compared favourably to the traditional Hotspot (jumping) style in experiment (3). This is not the only result of the proposed design method, the testing showing it provided a much better sense of position and orientation, and walkthrough presence, but also gives a surprise result, namely that the Hotspot navigation style has a very negative response from the participants (see 4.7.5.3). Understandably researchers are trying to develop new methods to overcome this issue.

Lastly, the recommended elements (e.g. tag and annotation, interactive map, and sound) from the study of Chapter Two embedded in the generated web interface by the process of Multimedia Design Model (see 4.5.3) are tested by experiment (4), in the two navigation style, Image Channel and Hotspot, projects. The results show the elements are acceptable and properly designed for the generated web interface and essential whether integrated with Image Channel project or Hotspot project.

A great finding after cross-analysis of experiments (3) and (4) is whether Image Channel style would benefit from an embedded interactive map. The findings show that it allowed the same strong recognition of position, orientation, and walkthrough perception, providing very similar results with or without the map. On the other hand, the Hotspot style has completely opposite performance if the map does not exist. This finding has great benefit to the production design, by eliminating the interactive map and getting rid of the necessity and complexity to program integration of it.

The final production creation will be stated in Chapter Six, and be created by adopting the findings and the suggestions recommended by participants of the experimental evaluation, namely movement by following the path in Image Channel style, and of sound recorded in the filming environment.

The next chapter will review the emerged application domain, the zoo, to obtain knowledge and allow understanding of the current methods of communicating animals' related information, and acquiring the requirements as criteria of evaluating proposed integrated application, that virtual zoo.

# Chapter Five: Virtual Zoo as an idea integrated application - review of zoological data resource

## 5.1 Introduction

It cannot be ignored that zoos are the biggest zoological information provider. There are more than 600 million people who visit zoos of the World Association of Zoos and Aquariums Network each year (WAZA[65], 2007), accounting for more people than those who attend professional football, basketball and baseball games combined (Cohn, 1992). Hediger (1969), one of the world's foremost authorities on zoos, noted that:

"Every zoo is a mine of information about nature, and this storehouse of knowledge should be made available to all, particularly to school and youth groups; the information should be disseminated through the relevant organizations, by means of organized courses, club activities, staff training schemes, lectures, information sources and so on".

Zoos have found an increasing number of ways to undertake that dissemination. When compared with museums and galleries however, most zoos tend not to make full, if any, use of the web. Museums have been exploring the possibilities offered by the Internet, and as a result it has provided new formats for visitors to explore their collections (Taylor and Ryan, 1995).

Zoos traditionally focused on the demand from the public to be able to "get close" to wild animals in a controlled setting. The ways in which zoos responded to this demand is a reflection of scientific, social and cultural changes. Zoos also provide ways for the public to generate feelings of travel to the origins of the species they are viewing and to experience, to a degree, the conditions of each animal's wild environment.

A virtual zoo is basically a website that provides the opportunity to view exhibits about animals and their habitat (Wikipedia, 2009). The virtual zoo created by web-based

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[65] WAZA (world Association of Zoos and Aquariums), Source: http://www.waza.org/home/index.php?main=home

integration of panoramic video has the ability to recreate the experience of being in, and navigating in, the natural environments while seeing the dynamic animals, fulfils the curiosity of humans about nature (see Chapter Two). It also has the great potential advantage of upgrading the current zoos' web page, as well as virtual zoos created by education institutions which traditionally uses textual and photographic content to communicate the exhibits' information. In the context of this research, a virtual zoo must have a dynamic element to the content, not only static imagery and text, to be more in keeping with the aim of zoos and the demand of the public to "get close" to the animals and their environment.

This chapter broadly studies the field of contemporary zoos in seven sections to address the potential and necessity of adopting the proposed integrated application, that virtual zoo: 1) The roles of contemporary zoos; 2) What people learn at a zoo; 3) Zoological information given by zoos; 4) Motivation of visitors for visiting a zoo; 5) Virtual museum concept applied to online zoological resources; 6) Efforts in virtual zoological information delivery; 7) The advantage of a Virtual Zoo using dynamic Panoramic Video.

### 5.2 The role of contemporary zoos

"Professionals in the zoo field have long been aware of the importance of biodiversity to the world's wildlife and wild places." (Castro, 2003) Zoos play the main role in providing the protection of, and information about, animals and their habitats.

Zoos, as currently understood, have been in existence for over three thousand years. Alexander (1979 and 2007) revealed Queen Hatshepsut of Egypt was reputed to have had a vast royal zoological garden which was the first recorded zoo, and dates back to the 15th century BC. However, the first modern zoos were founded in Europe, in Paris and Vienna in the 18th century, and these were followed by major zoos in London and Berlin in the 19th century (Jamieson, 1985). In the early 1990s, there were more than 10,000 zoos worldwide (Kotler & Kotler, 1998), mostly in Europe, North America and

Australia. An increasing number are starting to be set up in developing countries (Andersen, 2003).

Zoos are a form of museum (Alexander, 1979; Hudson, 1990). The major difference between zoos and other forms of museum is that a zoo's exhibits are living (Alexander, 1979; Davis, 1996). However, zoos are similar to other museums in that they are essentially providing exhibits whose purpose is delivering information. Zoos have professional staff. Zoos are mostly non-profit making, and own and conserve concrete objects that are exhibited to the public (Alexander, 1979; WAZA, 2008). As Alexander stated, "A zoo contains a collection of labelled animals to be protected and studied while incidentally providing enlightenment."

AZA[66] (2002) interpreted practical reasons why zoos are an informative environment and that the learning process of visitors is through gathering zoological information by viewing the animals and additive interpretations. Visitors who came wanted to know more about the animals they were looking at. Teachers like to use zoos as a community classroom for their students. Visitors and students can ask the keeper questions and try to find out more about the animals while the keeper is there. Zoos have changed in these areas over the years, and now have a much wider curriculum. They implement programs and projects to focus on issues such as conservation education and have broadened this to issues of preserving the earth's biodiversity.

Zoos all over the world are committed to providing communities with a variety of educational programs. Through these programs, zoos expect to develop a better understanding and respect for the diversity of life and also encourage people to get involved in conservation through their lives with fun and joy (Santa Barbara Zoo, 2006).

[66] AZA is the abbreviation of the Association of Zoos and Aquariums founded in 1924 is a non-profit organization dedicated to the advancement. of more than 200 accredited zoos and aquariums located in the North America.

### 5.3 What do people learn at a zoo?

"The most important part of a zoo's educational provision is its making available to children and adults real animals to observe." (Bostock, 1993).

The problem of actually getting close to the animals has changed for the zoos and for the visitors. In the past, zoos provided far greater access to the animals, including trained animal shows, rides on elephants and camels, and animals had to be more subdued to allow the people to interact freely with the fewest dangerous species. These practices continue to be phased out by an increasing number of zoos, not only because every animal can be unpredictable but also because of changing demands from the public (BenBow, 1995).

There are more and more zoos, which have moved from animals in cages to species in fields whereby landscapes, plants and environments please the animals and encourage more natural behaviour displays. Zoos are increasing natural vegetation, and complex enclosures provide each species with cover and resources, the expectation being that animals behaved in more natural ways (London Zoo, Gorilla Kingdom Project, 2007)[67]. Thus, visitors must look more carefully to see the animals to gain the rewards of their discovery, a characteristic that can be said to enhance zoo visitors' experiences. People now have more knowledge and as a result are requesting more complex and realistic animal exhibits, and in particular more information about the animals and their habitats.

Zoos are a valuable educational experience no doubt. It has long been thought that zoos provide children with high levels of understanding of animals and thereby help to increase their knowledge of wild animals and natural habitats. Along with increasing people's knowledge, many people feel that zoos are valuable resources for helping to create and reinforce people's positive attitudes towards animals as well (Myers et al., 2004). There are some different judgements about zoos, including contradictory views about the methods used to obtain animals, the suitability of the exhibits for meeting the animals' needs, and whether it is justifiable to keep wild animals captive in enclosures

[67] Gorilla Kingdom is London Zoo brand new £5.3m enclosure that has taken almost 18 months to build and is now home to a colony of stunning western lowland gorillas

that people called natural environments. People often suppose that zoos can at least contribute positively to people's knowledge and conception of nature and animals (Swenson, 1980).

Aside from these judgements, zoos play a vital role in providing recreation/entertainment. Bostock (1993) indicates that most visitors go to zoos to be entertained. Shackley (1996) agrees with the point and further indicated that people often show their great interest in animals, but are less able to see them in their natural surroundings. Living animals produce excitement and enthusiasm (Birney, 1988). The animals living in their territory presented natural behaviour, and an animal in its natural habitat is better than one in a zoo (Bostock, 1993). The pleasures gained from looking at creatures in their habitats, encourages visitors to make return visits. The animals present in their natural habitat have the potential for people to observe them not only for entertainment, but also for education.

## 5.4 Zoological information given by zoos

> "Accurate information about the species exhibited must be available. This should include, as minimum, the species name (both scientific and common), the species' natural habitat, some of its biological characteristics, and details of its conservation solutions" (DEFRA, 2004).

The SSSMZP[68] requires that all zoos promoted public education and awareness in relation to the conservation of biodiversity, particularly by providing information about the species exhibited and their natural habitats. Zoos are asked to have a written strategy and active programme of information about the animals being exhibited. This active programme may take the form of formal education following the national curriculum and may involve dedicated education staff providing interactive activities (DEFRA, 2004).

[68] SSSMZP is the abbreviation of the Secretary of States Standards for Modern Zoo Practice, which accompany The Zoo Licensing Act.

BIAZA[69] (2005) has clearly stated to members that the zoological data provided for educational purposes should be in their written mission statement and that they should also have available a written educational policy, which identifies educational components, animal behaviour and global/local conservation for instance, and sets out the methods such as exhibit design, labels, interactive displays, etc. by which these components are directed towards the visitors, such as school groups, locals, tourists, etc. The educational policies of zoos have to be broad and cover not only formal teaching programmes, but should also include educational sources for all visitors. All animals on public display within the collection should be clearly and correctly identified. The conservation status should also be highlighted. The exhibitions can use audio and visual presentation to allow visitors to view areas normally hidden from public view.

Learning, transmission and relevant information provided by zoos to visitors, is subject to interpretation. Interpretation is defined as an educational activity which aims to reveal meaning and relationships through the use of original objects. Interpretation is new as a vital tool that helps to impress on visitors the critical link between environments, and continues to be developed. Interpretation is one of the tools and techniques used for learning and transmission of animal related information to visitors at a zoo. Raghunathan and Nareshwar (2005) suggested that interpretation can be made in different formats, such as signage and natural trails, the aim being to convert the visit of an increasing number of people to zoos into a learning opportunity, enhancing and enriching the visitors' experience through the information displayed.

## 5.5 Motivation of visitors for visiting a zoo

"I have become more concerned about the importance of the reservation/conservation of animals as a result of visit here today", (Roper Starch, 1998)

People visiting zoos are interested in learning about the animals, their habitat, behaviour, and conservation status. Zoos displaying live animals and natural habitats can capture the attention and affection of the public for wildlife and nature like no other institution.

[69] BIAZA: British & Irish Association of Zoos and Aquariums, Source: http://www.biaza.org.uk/

Zoos provide a range of opportunities for a great variety of people and groups of all ages and levels to learn about zoological data. Many diverse groups visit zoos including different age and educational levels and different social, ethnic and cultural backgrounds. There are many learning and interpretation facilities provided to enhance, educate and enrich the visitors' experience. In zoos, the provided multi-programmes help visitors understand the uniqueness of each animal and its relationship to its surroundings, the purpose being to reach the visitors behaviour in collecting information on animals. Information-based exhibits are deemed to be of great importance because of the messages that visitors conveyed regarding animals and ecosystem preservation are the prior expectation of the exhibitions (Dierking et al., 2002).

Dunlap and Kellert (1989) conducted a multi-site study designed to investigate the impact of informal learning at three zoological parks. Researchers at the Zoological Society of Philadelphia[70] (ZSP), the Sonoran Desert Museum[71] (SDM), and the Sedgwick County Zoo[72] (SCZ) investigated visitor motivations and expectations prior to a visit to one of these institutions. Researchers collected data before and after the visit to measure impact, asked incoming visitors about their motivations and expectations for going to the zoo, applying a variety of methodologies, including interviews and questionnaires. In all three zoological parks, visitors display their enjoyment, and the opportunity to see the animals and the habitats were rated among the most important reasons for visiting.

Visitors reported that they desired to learn about the animals, and learning about wildlife conservation was a reason to go to the zoo. Visitors to the three zoological parks had a significantly high rating on ecology and science. The scale provided evidence that people are interested in learning about the science and ecology of the animals from the zoological data provided by zoos.

Interaction with animals and seeing live animals provides visitors with learning tools. Visitors believed they learned about animals as well as conservation-related issues, such

[70] Zoological Society of Philadelphia, Source: http://www.philadelphiazoo.org/
[71] Sonoran Desert Museum, Source: http://www.desertmuseum.org/
[72] Sedgwick County Zoo, Source: http://www.scz.org/

as the impact of pollution on animals and ways people can help to preserve wild animals, and their habitats from the information provided (Roper Starch, 1998).

Falk et al. (2007) have conducted research for the Association of Zoos and Aquariums (AZA) to understand more about visitors. The researchers found that visits to zoos in North America have a measurable impact on the conservation attitudes and understanding of adult visitors. The AZA is using the study results to better understand and predict their member institutions' contributions to public understanding of animals and conservation. The investigation provided an analysis of how seeing wildlife at these institutions affects the way people think about conservation and their own role in helping protect the environment. The main results of the study are listed as follows[73]:

- Visits to accredited zoos prompt individuals to reconsider their role in environmental problems and conservation action, and to see themselves as part of the solution.
- Visitors believe zoos play an important role in conservation education and animal care.
- Visitors believe they experience a stronger connection to nature as a result of their visit.
- Visitors bring with them a higher-than-expected knowledge about basic ecological concepts. Zoos support and reinforce the values and attitudes of the visitor.
- Visitors arrive at zoos with specific identity-related motivations and these motivations directly impact how they conduct their visit and what meaning they derive from the experience.

The visitor impact study showed the zoo visitors' behaviour when visiting zoos, and the study also showed that zoos enhance public understanding of wildlife and the conservation of the places animals exist in.

[73] The key results of Why Zoos & Aquariums Matter-Assessing the Impact of a Visit to a Zoo or Aquarium, Source: http://www.aza.org/ConEd/WhyZoosMatterReport/

### 5.6 Virtual museum concept applied to online zoological resources

In many ways we have seen that visitor demands are contradictory: the desire to be up front and very close to the animals is balanced by the demand for the zoo to provide a realistic environment in which the animals often hide. It is clear that in general, rich multimedia applications, including panoramic video, could play a role in taking the visitor into these environments.

Indeed, institutions of informal education such as museums, have begun to utilize more new information technology for internal and external organizational purposes, while an increasing number of interactive exhibits are incorporated into galleries in order to improve the visitor experience. Museums understand that they are one among many components in an environment of cultural facilities, and that computer technology can help museums quantitatively and qualitatively expand, deepen, and enhance the museum experience for their visitors. A growing number of museum educators regard new media as tools that can offer unparalleled opportunities for learning. Through new multimedia technologies and information rich web sites, museums have enhanced their role as providers of informal education. Teachers respond to such efforts favourably, as these provide alternatives to restricted curriculum material and allow for more exploration and ownership of the learning process. The online museum visitors, especially the people who do not go to museums frequently and newcomer audiences, appreciate and benefit greatly from additional forms of information that make the museum a more accessible and attractive place for them to spend time in (Thomas and Mintz, 1998).

There are still very few ambitious and significant efforts that have taken place in museums worldwide that have used high-end technology to complement their exhibitions online. Museums such as the London Science Museum[74] have traditionally been the ones to adopt new media first and employ fascinating and highly developed interactive virtual reality technologies that go beyond the point-and-click of common multimedia and information positions. Much museum theory and practice suggests that

[74] London Science Museum, Source: http://www.sciencemuseum.org.uk/

technology, as incorporated in exhibitions, should generally evolve through two successful formats, inquiry-based educational activities and interactive hands-on exhibits. Hirose (2006) hinted the explosive development of information technology and the increasing confidence on the part of the museums to incorporate it in their setting has encouraged many institutions to use the high-end technological facilities, innovative environments, and equipment. As we can see, there are more and more museums and related exhibits that use interactive installations, simulation environments, and virtual reality.

Roussou (1999) is particularly interested in museums that make use of virtual reality technologies displays, and indicated that offering interactive experiences such as virtual reality technologies can allow visitors to travel through space and time without stepping out of the museum building. Moreover, by allowing museums to step outside the physical location of the built environment and thus increase their educative function, online museums which utilized multimedia embedded virtual reality technologies as a component has enhanced visitors' experience in collecting information to the exhibits, Helsinki City Museum[75] for example. The development of systems has matured enough to find their way out of the research realm and into public settings.

Zoos are a form of museums, but a zoo's exhibits are living creatures (Alexander, 1979; Mason, 2000). Zoos have discovered the outstanding interactive function of virtual reality, which can enhance virtual visitors experience and collect the zoological related knowledge in the online virtual ecological environment, such as an online virtual zoo for a butterfly exhibition[76] (Tarng and Liou, 2004) example (see Figure. 5.1).

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[75]Helsinki City Museum, Source: http://www.hel2.fi/kaumuseo/
[76] Online virtual zoo, Source: http://vr.nhcue.edu.tw/butterfly/


Figure 5.1: An Internet Virtual Butterfly Museum example

**5.7 Efforts in virtual zoological information delivery**

Multimedia technologies, which integrate texts, images, videos, and sound, are broadly used in creating zoos' websites, Lincoln Park Zoo (see Figure 5.2) for example. The zoo's website has a dual role in relation to zoos, providing sites either for introducing the institute's information, such as opening hours, buying tickets, zoo events, and so on (see Figure 5.3), or for providing animal and animal-related data resources (see Figure 5.4).

Although the Internet cannot deliver some of the experiences that many zoo visitors enjoy, the zoological information websites on the Internet are nonetheless likely to form a part of many zoos. The web-based zoological information site provides users with a complementary approach to obtain animal-related information and is an important aspect of making good benefits to animals (Richard, 2004). The web contents are used to enhance understanding about animals and to promote ecological protection, and is important for public and zoologists (Lobanov et al., 2000 ; Tarng and Liou, 2005; Wallis, 2008).

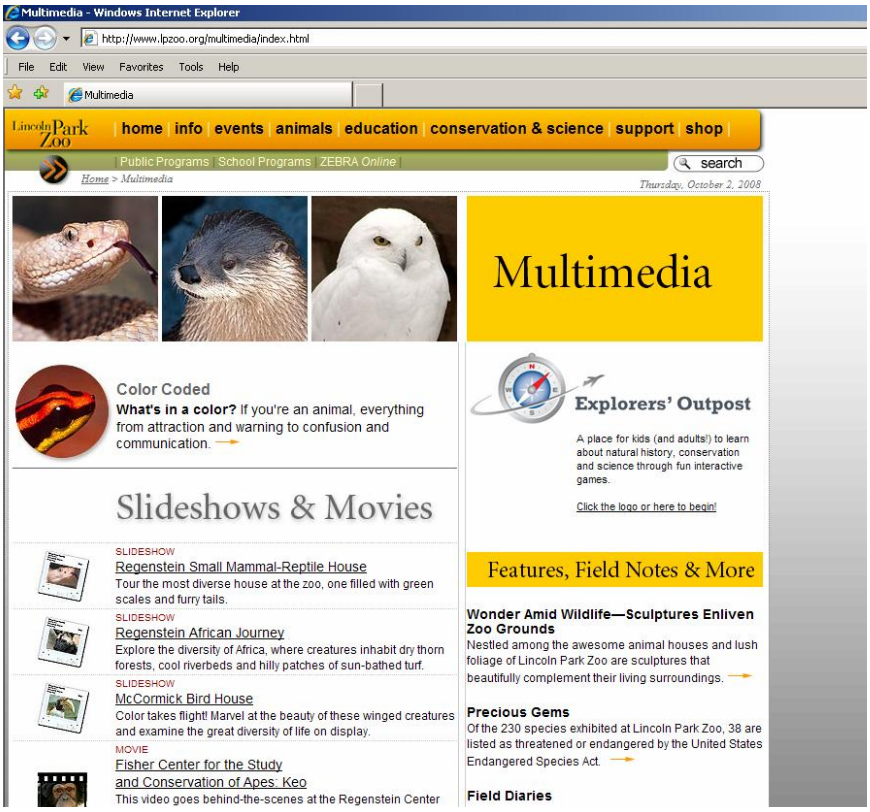


Figure 5.2: Lincoln Park Zoo (2007) – a Multimedia website

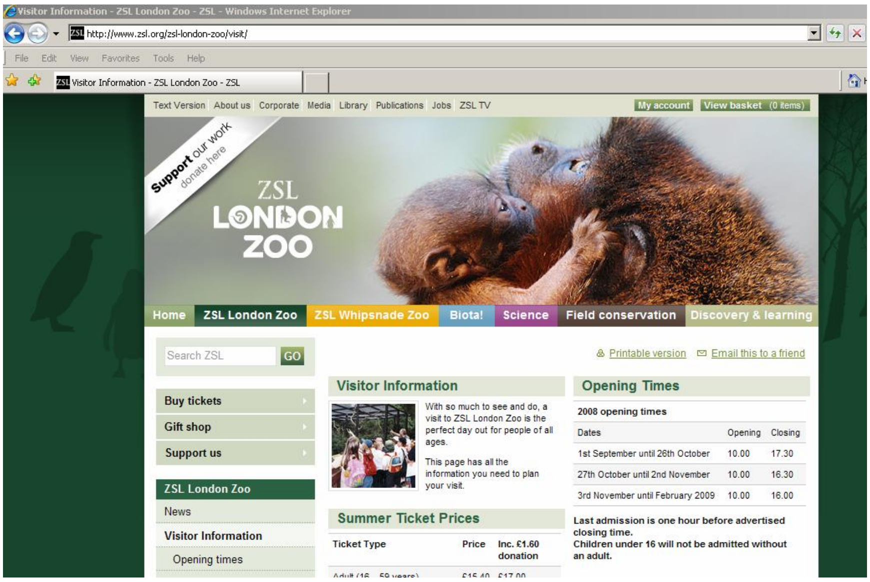


Figure 5.3: Zoo’s introduction on the London zoo website (2007)

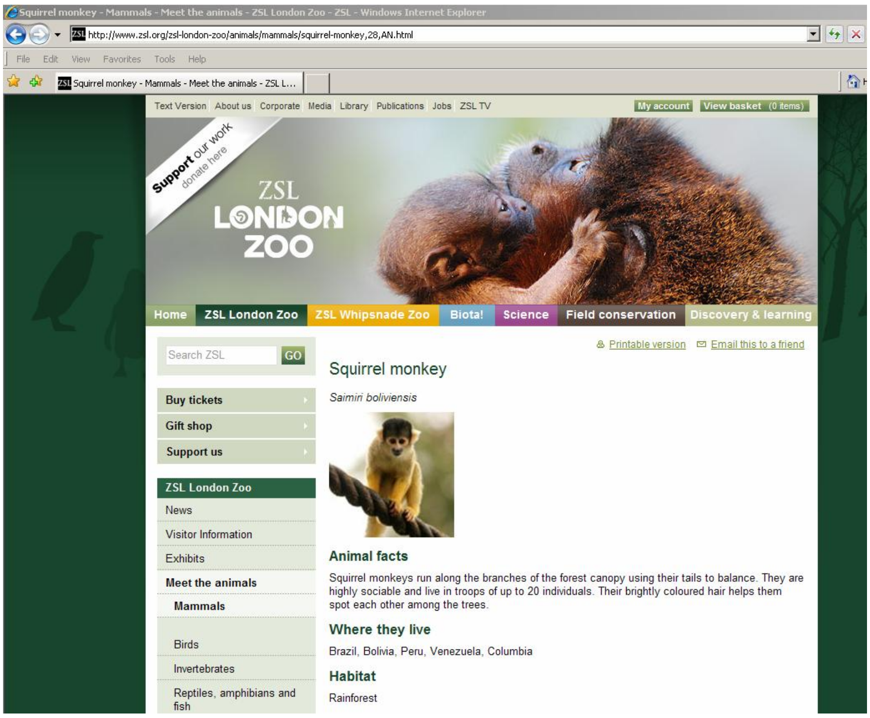


Figure 5.4: Animal and animal related data displayed on London Zoo website (2007)

Zoos have their conservation animals, which come from a wide range of wild species, and a number of domestic breeds. The size of the collections of the zoos ranges from a few to more than 1500 species. The information on the size of the collections can be found online, on WAZA's website[77] in the Zoos & Aquariums of the World Section. Although zoos have to rely on gate fees and other income to maintain them, most of the zoos in the world are not intend to be profit-oriented. Online zoological websites mainly have the following purposes, as do Zoological parks (WAZA, 2008):

- To allow people living far from nature to enjoy the beauty of, and have a close look at, animals to motivate the visitors to care about animals and the conservation of biodiversity.
- To provide knowledge of animals for people to understand about the biology, behaviour, ecology and conservation needs of animals.
- To offer animal-related data for reintroduction purposes.

[77] WAZA website, Source: http://www.waza.org/home/index.php?main=home

Online zoological information sites are mainly an information centre to provide animal-related information. The web is an effective tool to aid the learning of the animal's information in zoos. The main purpose of online zoological information web pages is to spread knowledge of animals and their ecological situation, and not attempt to replace the zoo as a whole. However, as the rapid expansion and increasing demand for access to the Internet has shown, the websites, like zoos, also have value in human entertainment and animal conservation. The increasing use of the Internet by the public for entertainment is also likely to affect the demands made on zoos and similar institutions for activities within their traditional boundaries.

However, it is still an increasing concern to attempt to match the animals at zoos and their needs to the climatic and environmental resources available. Even in 1974, the director of the Bronx Zoo, Conway, had begun to establish special collections of animals in appropriate conditions across the USA. He commented that "with all these far-flung installations, the Bronx Zoo would, in effect, become a kind of national zoo", and also envisaged that "the zoo of the future will tend to be more national, even international, with 'annexes' often located far beyond their city fences" (Livingston, 1974). World Wide Web sites today provide the opportunity to maintain linkages between these annexes, as well as other zoos. Therefore, the Internet may break down the traditional boundaries of the zoo, but will also extend the domain of a local zoo not only to other zoos, but also to animals in the wild.

The demands of the public for more information to be delivered in challenging ways will continue to be affected by the scientific and cultural influences of the day. The Internet is acting as a new influence, and will probably affect zoos in the future. Zoos provide close-up, even direct, interaction between the visitor and the animals, which is obviously lost in the traditional sense by the use of the Internet. The use of the Internet by zoos will provide a continuation of this process of distancing the public from the animals and their habitats. However, although zoos will continue to develop and change, they will not become obsolete (Thornberg, 1995 and Twycross Zoo, 2009) and as a result, they will continue to represent a synthesis of influences derived from the zoo objectives of the past.

5.7.1 Definition of virtual audiences

Online zoological information sites are designed to bring anyone, regardless of their location in the world, knowledge about animals and related information (Richard, 2004). VRWAY [78] (2007) revealed that people may visit places they have never seen by traveling through space and time, enhancing people's knowledge without moving from their desktop. The online zoological information site is a powerful information tool which serves to raise the general public's awareness of animals all over the world, and inform people accessing the website about the fearful rate of human expansion into various animals' habitats (ThinkQuest team[79], 1994). The visitors to online zoological information sites can obtain knowledge about animals, and related information through the Internet.

5.7.2 Zoos' current use of Multimedia and VR

The zoological environment is a resourceful place for learning by experiencing (Ohashi et al., 2007). There are various technologies used for presenting zoological information. The study of the current usage of technologies will obviously benefit the development of better solution.

5.7.2.1 Online Webcam

The use of webcams at work and home has become an online revolution in the communication between people. The technologies of the webcam developed approximately, in 1996. The webcam, embedded in home personal computers or in laptop computers, has become a necessary accessory for users today. There are many large companies, corporations and businesses that have learnt how useful being able to communicate instantly via the Internet, in real environments, live and in real time can be. The zoologists, mostly in zoos, have noticed the usefulness and cost effectiveness of

[78] VRWAY Int., Source: http://www.fullscreenqtvr.com/
[79] ThinkQuest team : Source: http://library.thinkquest.org/11922/

these technologies. Allardice[80] (2003) indicated the benefits that the usage of webcam can have in providing zoological information. Allardice said:

“Trips to the zoo reign supreme when it comes to seeing animals live and up close. But there are times when the tigers are too pooped to romp around their man-made playground, or the black bears are hiding inside their caves because it’s a scorcher of a day outside.”

“And what if you don’t live near any zoos or animal parks? That’s where the Internet and live zoo webcams really shine.”

The posting of the live, real environment is attractive to people, and the notion of setting webcams in zoos and in the ecological environments of animals is of benefit to people. Zoos have noticed this, and used Multimedia technologies and integrated webcam skills to create online websites that allow users to observe animals and collect information about their living environment. The online webcam provides safe and free video for people to look at a fixed frame, or a panning angle view of the environment and a glimpse of the animals. Nowadays, it is easy to find a Multimedia website which has embedded this technology, supplied for gathering zoological information and observation purposes. Just type the key words “zoological webcam” into an online search engine, like Google, and there will pop up a lot of Zoological website (Toledo Zoo[81], Zoo Hellabrunn[82], and San Diego Zoo[83]) options for users to select. Figure 5.5 is a website example from the results from the Google search engine. The website (2008), Smithsonian National Zoological Park, gives more than 20 animal cams for online visitors to collect animal data/information and for observation purposes.

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[80] Allardice, L.C. is a freelance writer with 20 years experience. She is editor of Footnotes at Other Side of Creativity at www.oscweb.com. Source: http://www.infotoday.com/linkup/lud021503-allardice.shtml
[81] Toledo Zoo. Source: http://www.toledozoo.org/
[82] Zoo Hellabrunn. Source: http://www.tierpark-hellabrunn.de/?L=1
[83] San Diego Zoo. Source: http://www.sandiegozoo.org/

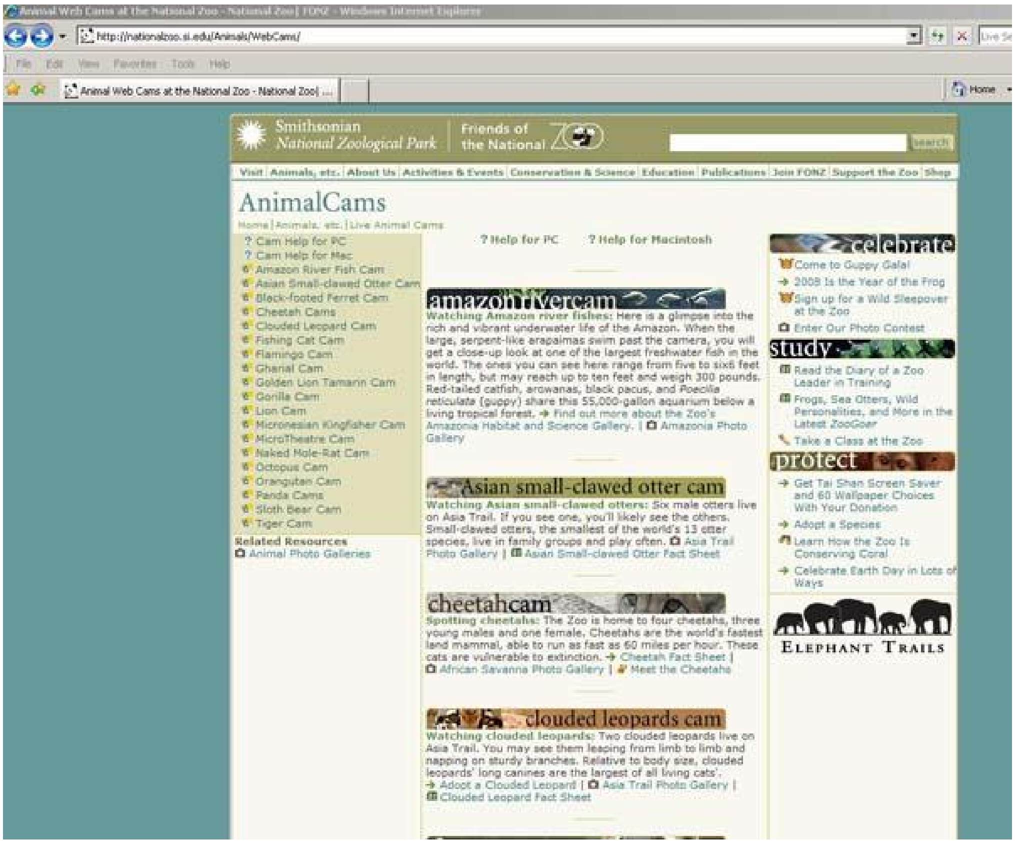


Figure 5.5: A screenshot of online Smithsonian National Zoological Park[84] (2008)

5.7.2.2 Second Life

Second Life was developed by Linden Lab of Linden Research, Inc. in 2003, and is a web-based three dimensional virtual world entirely created by its residents. Users can download a program called the Second Life Viewer to enable interaction with each other through motional avatars. Residents are the users of Second Life. The appearance of the residents is users' avatars. There are a variety human forms, with a wide range of physical attributes, such as gender. Users can own land or an island, and create the environment on it. Catteneo (2007) indicated that Second Life can be teaming with wildlife and almost all species of animals on earth have their virtual three dimensional representatives in Second Life. Figure 5.6 is a screenshot of a virtual zoo on Second Life for reference. Second Life has grown explosively and is expected to have more embedded zoological information in the future.

[84]Image Source: http://nationalzoo.si.edu/Animals/WebCams/

Figure 5.6: The image is adapted from the virtual zoo in Second Life created by Mizser[85] in 2007

5.7.2.3 Computer and Video games

It is evident that the computer and video games have come into people's daily life. ESA (2005) revealed that 75% of heads of households play computer or video games in the U.S.A. Peter D. Hart Research Associates[86] has further indicated that the average age of game playing Americans in 2005 was 30 years old. One of the famous games related to zoological information is Zoo Tycoon (see Figure 5.7). The 3D CG Zoo tycoon is a series of video games developed by Microsoft Game Studios. The players can run a zoo and make profits. Figure 5.8 is a basic Zoo in Zoo Tycoon for reference.

[85]Mizser, M. (2007), The Animals of Second Life Part 2, source: http://second-life-fresh-news.blogspot.com/2007/10/at-zoo.html

[86] Peter D. Hart research Associates is strategic research and is one of the leading analysts of public opinion in the United States. Source: http://www.hartresearch.com/

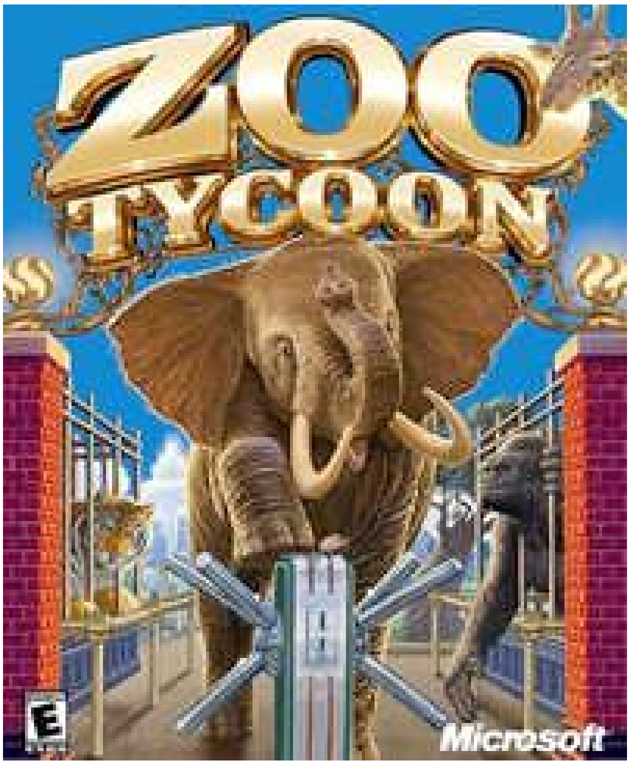


Figure 5.7: The cover image of Zoo Tycoon (version 1.0) video game (Microsoft, 2007)


Figure 5.8: A screen shot of Zoo Tycoon video game (Microsoft, 2007)

The objects of the game are to create a thriving zoo by building exhibits to accommodate animals and entertain the users. The users have to consider suitable environments for the animals' residence. Users will obtain monetary awards and steady income if they keep both animals and guests happy. The animal's environment consideration provided the sort of ecological information needed for users to realize the place in which the animals live. The latest version is Zoo Tycoon 2, which was released in 2004. More animals were introduced in the expansion packs.

5.7.2.4 Virtual Theatre – IMAX cinema and VR simulator

The Virtual Theatre was announced by Revolution Software Ltd. and is a computer game engine used to easily produce adventure games. IMAX[87] (2008), a film format, is a good application of Virtual Theatre. The standard IMAX screen is 22 meters wide and 16.1 meters high, and can be larger. The main goals of IMAX are to see more, hear more, and feel more. The dome environment of theatres using IMAX movies is intended to provide an immersive experience in terms of visual clarity and sound quality. Wild Safari 3D is a project created by nWave Picture[88] and announced in 2005 for IMAX theatres. It is a 3D adventure for all ages. Wild Safari 3D brings a safari in South Africa straight into the theater room. Figure 5.9 shows an IMAX Theater at Omaha's Henry Doorly Zoo[89] and screenshots of Wild Safari 3D movie.

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[87] IMAX Coporation Ltd. (2008), Source: http://www.imax.com/ImaxWeb/welcome.do
[88] nWave Picture (2008), Source: http://www.nwave.com/
[89] Omaha's Henry Doorly Zoo (2008), Source: http://www.omahazoo.com/


Figure 5.9: A web screenshot of Omaha's Henry Doorly Zoo and screenshots of Wild Safari 3D movie

Another good example is the 4-D Virtual Safari simulator in Lincoln Park Zoo[90]. The zoo, located in Chicago, is among the oldest zoological gardens in America (established in 1868) and is also among the most modern. Lincoln Park Zoo welcomes more than three million visitors each year, providing them with remarkable educational experiences, as well as fun and enjoyment. To reach this goal, the zoo cooperated with Technifex and developed an African Safari Ride, which provides visitors with an intense motion simulation through hyperspace on an intergalactic mission through the fiercest terrains of Africa. Visitors examine an assortment of species from across the continent in the virtual travel experience. A simulator is shown in Figure 5.10 for reference.

[90] Lincoln Park Zoo (2008), Source: http://www.lpzoo.com/


Figure 5.10: visitors exit the Safari simulator ride (Technifex[91], Inc., 2008)

5.7.2.5 QuickTime VR

QuickTime VR created by a series of still images being stitched together to form a still panorama view is a popular photo-based panorama technology (see 2.4.2). The technology has been integrated into a number of zoos' websites (see Figure 2.6). The use of the QuickTime VR in the zoos' website is mainly as a guide to their grounds and park space (Kansas City Zoo, 2008) rather than concentrating on animal habitats, Pana'ewa Rainforest Zoo (see Figure 5.11), Calgary Zoo (see Figure 5.12) and Twycross Zoo (see Figure 2.6) as examples.

[91] Technifex, Inc. (2008), Source: http://technifex.com/

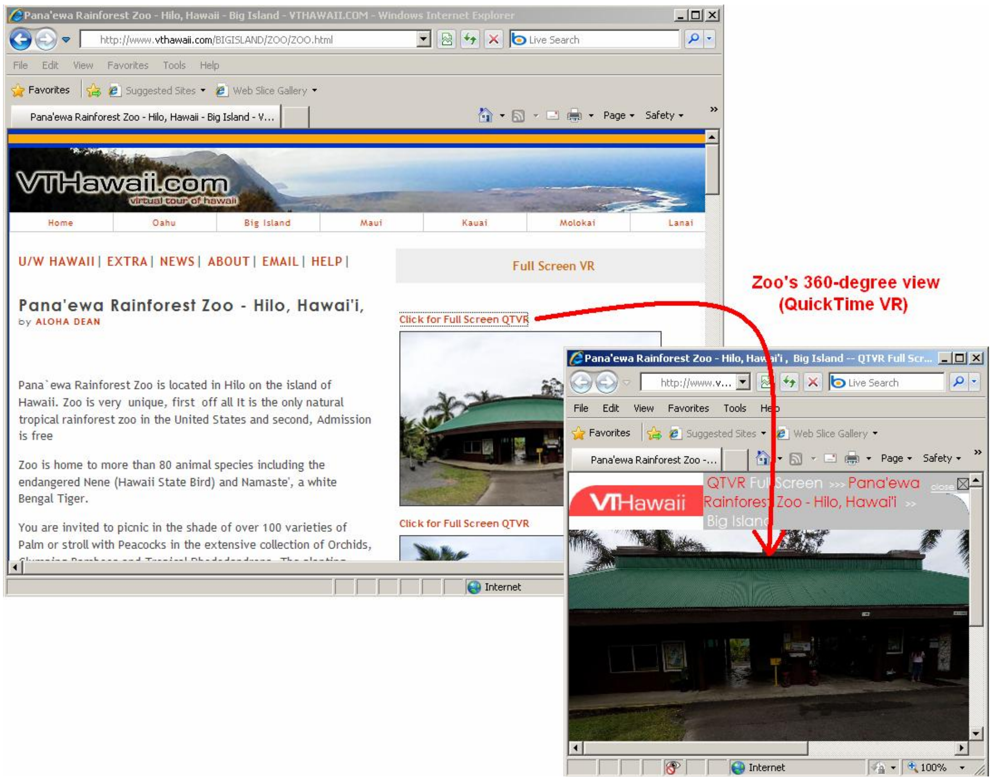


Figure 5.11: QuickTime VR used in the Pana’ewa Rainforest Zoo (VTHawaii, 2006)

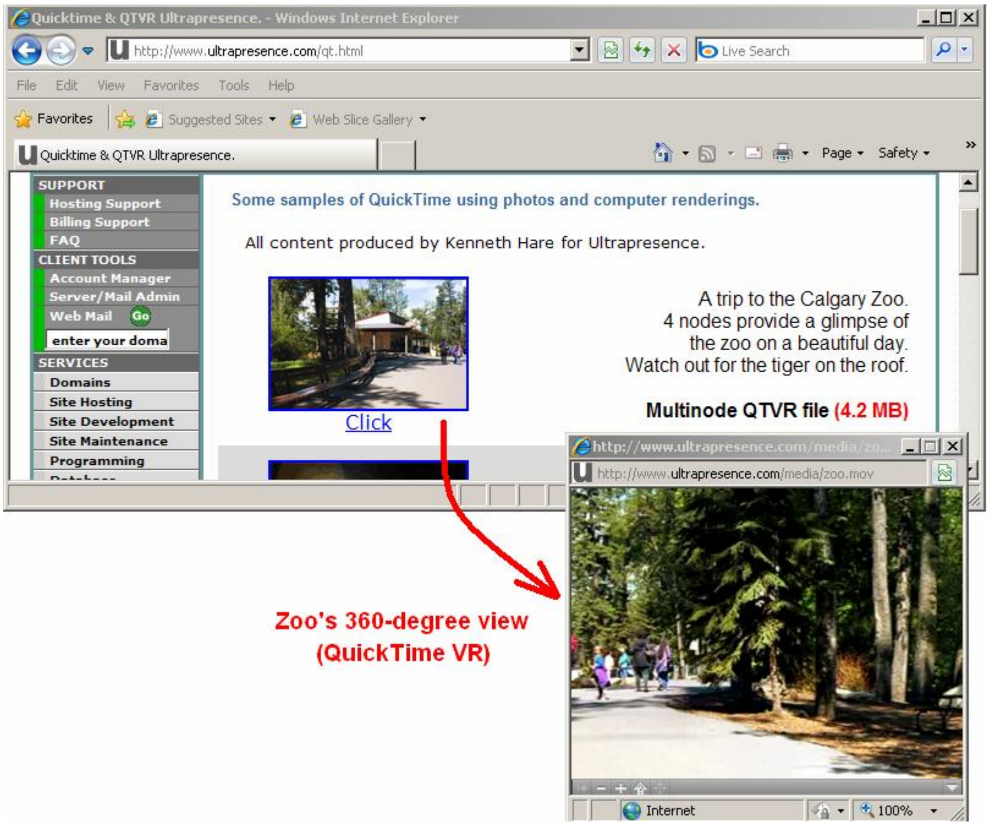


Figure 5.12: QuickTime VR used in the Calgary Zoo (Ultrapresence, 2004)

### 5.7.3 Summary

Table 5.1 shows the performance of current technologies analysis on communicating zoological information. It appears that a web-based integrated, interactive, and navigable dynamic real environments can fulfil human's curiosity about the natural environment in far away places, and are the essential features of communicating zoological information. This shows the significant advantages of using web-based integrated Panoramic Video in the delivery of zoological information. The research used pre-videoed, not real-time online video due to several practical experiences when visiting online webcam application websites (see 5.7.2.1). The online webcam, which is similar to online Panoramic Video, does not always allow the visitor to see the animal and the habitat due to time-difference, weather, and light issues.

| | 3D/Real | Online | Image | Interactive | Navigation | Issues |
|---|---|---|---|---|---|---|
| Webcam | Real | Yes | Dynamic Image | No | No | Online webcam proclaimed that it available in 24 hours. But according to author experience (several times in April 2008), there were over ½ webcams were offline or in dark display (because of time difference). Another issue is the most of the webcams faced in fixed direction. Visitors cannot move the frame freely to search the animals or observe the zoological environment. The weakness of interactive and navigation cause boring in look at. |
| Second Life | 3D | Yes | Virtual | Yes | Yes | The great benefits of Second Life are interactive, navigation, and post online. The frailties of Second Life are 3D computer graphic built animals and environments. According to Ohashi (2007) study, the real environment is a resourceful place, the zoological environment created by 3D computer graphic has the weakness in how details that can be design into for visitors' observation. |
| Computer and Video game | 3D | No | Virtual | Yes | Yes | The computer and Video game are attractive and mostly focus on entertainment. Computer and Video game are not online compared to Second Life and have the same issue created by 3D computer graphic. Another issue is users have to pay to have them. |
| Virtual Theatre | 3D | No | Virtual | No | No | Virtual Theatre is sort of big screen with quality sound and using 3D glasses to provide immersive experience. The issues to Virtual Theatre are non-interactive, non-navigation, not online, and created by 3D computer graphic mostly. Some visitors proclaimed that they feel uncomfortable when wearing the 3D glasses. The author had the same experience when visit space centre in Leicester in June 2007. |
| QuickTime VR | Real | Yes | Still Image | Yes | Yes | QuickTime VR format is a kind of Panorama VR which offering real environment surrounding image for users to experience. The still image caused an issue that it's differ to human daily life (see Chapter two for more discussion) it is a dynamic world. |

Table 5.1: The performance of current technologies analysis in providing zoological information

### 5.8 The advantage of a Virtual Zoo using dynamic panoramic video

The virtual zoo has been introduced as a new concept for presenting animals and their habitat-related information in a web format. A virtual zoo is basically a website that provides the opportunity to view exhibits about animals and their habitat (Wikipedia, 2009). Many zoos, such as London Zoo (see Figure 2.8) as well as education institutions, the Pioneer Middle School[92] project completed in 2008 for instance, have developed virtual zoos with articles and photos as exhibits.

The use of text and photo content in web format to communicate the animals and their habitat, the animal and animal related information displayed on London Zoo Website (see Figure 5.4) for instance, has limitations in that it does not allow visitors to the site to see dynamic animals in habitat, which is against one of zoos' aim on allowing people living far from nature to enjoy the beauty of and close encounters with animals (see 5.3) and noted as the primary purpose of visitors to zoos (see 5.5).

Section 5.7.3 summarized the effort of current methods in delivering zoological information concluded that an integrated web-based, interactive, and navigable dynamic real environments can fulfil human's curiosity about the natural environment in far away places, and are the essential features of communicating zoological information (see Table 5.1). This is emerging the potential employment and great advantage of the virtual zoo adopts proposed integrated application which created using a web-based integrated application of Panoramic Video with additional information provision in seeing the animal in natural habitat and educational purposes.

It is the research's view therefore, that the use of panoramic video in the development of the virtual zoo could have the advantage of giving the visitor an up close and personal encounter with the animals and their environments, while fulfilling or contributing to the aims of the zoo in terms of entertainment, education and conservation (the roles of zoos: Mason, 2007).

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[92] Pioneer Middle School is a learning community who recently (in 2008) implemented an online project, Pioneer Virtual Zoo - Kingdom Animalia which contain a large animals information in texts and photos based, Source: http://pioneerschooldistrict.org/education/staff/staff.php?sectionid=146

## 5.9 Conclusion

This chapter has presented a wide range of studies on the main and biggest online zoological information provider, which is zoos, of all institutes in order to collect knowledge of methods of information provision, and address the requirements of the proposed web-based integrated application of panoramic video, that virtual zoo.

Contemporary zoos have a significant role to play in offering people animal and animal-related data/information (knowledge in Education role), raising the awareness of people with regard to animal and habitat protection (preservation attention in Conservation role), and entertaining people safely (edutainment in Entertainment role) (see 5.2). A vital aspect is that visitors to zoos want to see the animals up close and in real habitats (see 5.5) but often fail to reach it (see 5.3). Zoos have tried hard to implement the dream to see live animals in habitats, as the zoological data supplied by zoos when seeing the animal can deliver one of the main purposes of zoos, educational knowledge.

The experience of seeing the animals alongside additional information including the species' name (both scientific and common), the species' natural habitat, its biological characteristics, and details of its conservation solutions (DEFRA, 2004) can not only communicate the educational information, but also raise awareness of animal and habitat protection issues (see 5.4). The efforts in virtual zoological information delivery study (see 5.7) summarized the best way of presenting animals, with related information, and reach the aims of zoos by multimedia and VR technologies, which are real animals in a dynamic, natural environment with additive information, and interactivity and navigability (see Table 5.1) in a web-based format. This is opposite to the virtual museum concept of museums, which adopted 3D CG of VR technologies (see 5.6) to demonstrate the exhibits, although a zoo is a kind of museum.

It is apparent that the virtual zoo created by the web-based integration of Panoramic Video has the ability to create the experience of being in, and navigating in, the habitat while seeing the animals, and has the great advantage to upgrade the current zoos' web page, as well as virtual zoos created by education institutions, the Pioneer Middle

School for example (see 5.1 and 5.8), which traditionally use text and photo content to communicate the exhibits' information (see 5.8).

The next chapter is going to visit to zoos to acquire the requirement as criteria and to build the production, of the proposed integrated application of the technology, that virtual zoo.

# Chapter Six: Production of integrated application - Virtual Zoo

## 6.1 Introduction

The last chapter revealed some of the potential adoption and requirement of the proposed integrated application of web-based panoramic video, by the study of the proposed application domain, the zoo. This Chapter is concerned with building the application. Relating to these likely uses and field visits to an actual zoo, the chapter will start by formulating a more detailed set of requirements. The advantage of these visits will be presented. The proposed production creation will be elucidated from the videos' acquirement of camera selection and set-up, filming synchronization testing, rig building, and system field-trials, and then production creation of the choice of animal and filming location, production design, and actual filming and the project creation. The advantage of using videos acquired in 3D CG simulation world will be made clear during the project creation process. An initial testing of the created project will then be presented to refinement of the production, before mass evaluation with an audience sample in the final section.

## 6.2 Practical opinions on the requirement of the proposed creation - zoos' visit

This section presents the purpose and the process of the zoos' visit. The obtained opinions have the benefit to the proposed application of being practically associated with the study of the application domain, zoos.

### 6.2.1 Purpose and process

The aim of the visits is to collect practical opinions on the employment and requirements of the proposed creation in the main application, the zoo. In addition, the visits are fundamental for supporting the notion of the research in developing the production, as this is the first time that Panoramic Video has been employed in such an application. There are seven zoos (five in UK and two in Taiwan) contacted through post and email, but only two, Twycross Zoo and Taipei Zoo, responded and accepted the idea of making a visit. The visits are then decided with the visit to Twycross Zoo first, then Taipei Zoo.

Meetings were arranged at each zoo with the attendees of the meeting being decided upon based on their background, namely zoologist and researcher, and zoos' web designer. Table 6.1 shows the background of the attendees of the meetings. The conservations typically lasted around 45 minutes with a brief introduction which would cover the technology of panoramic video, and the proposed integrated application idea on the zoo's website.

| Zoo | Attendance/ Position | Location |
|---|---|---|
| Twycross Zoo | Dr. Jackie Hooley/Researcher and education officer | Leicestershire, UK |
| | Mr. Matt Allen/ IT manager and Web designer | |
| Taipei Zoo | Dr. S.C. Chin/Researcher | Taipei, Taiwan |
| | Ms. C.L. Lin/Web designer | |

Table 6.1: The attendees of the meetings

### 6.2.2 Background of visited zoos

There are two zoos, Twycross Zoo and Taipei Zoo, who responded to requests for, and agreed to, the visit proposal. The background of the visited zoos is related to the selection of the animal to be filmed and location.

#### 6.2.2.1 Twycross Zoo

The first visit is to Twycross Zoo. The zoo is opened in 1963 in Leicestershire. The zoo has grown into one of the major British Zoos, and has over 450,000 visitors a year. The most famous collection is primates. There are a large variety of animals kept at Twycross Zoo, more than 1000, from approximately 250 species. Many are endangered in the wild and are kept for conservation purposes. In 1972, the zoo began concentrating on conservation and education, and now takes part in many captive breeding programmes for endangered animals. The zoo, like most British zoos, receives no government funds and relies entirely on money spent by visitors to continue its work. The research aim of Twycross Zoo is to facilitate undergraduate and postgraduate research studies, and encourage research into different disciplines related to conservation. Twycross Zoo has a professional Education Department whose task is to interpret the zoo for the public and supervise research. During the meeting, Twycross Zoo expressed a particular interest in interdisciplinary cooperation with the author, which they thought has a potentially great contribution to the field of zoology and their work.

#### 6.2.2.2 Taipei Zoo

The next visit was to Taipei Zoo. The zoo is well established in Yuan-Shan of Taipei City as a private zoological garden by the Japanese in 1914, when Taiwan was under Japanese sovereignty. The Japanese Government in Taiwan purchased the zoo in the next year, and turned it into a public park. Taipei Zoo is taken over by Taipei City Government after World War II. In 1986, the zoo moved to the Mu-Zha district of Taipei City and opened on New Year’s Day the next year. There are more than 4 million visitors to the zoo annually. Taipei Zoo hosts several international conferences on conservation related topics. There are seven exhibition areas including a Formosan animal area, an Asian tropical rainforests animal area, a desert animal area, an Australian animal area, an African animal area, Bird world, and a Temperate Zone animal area. They also have indoor display areas such as insectariums, and an amphibian and reptile house. Taipei Zoo has a professional Research and Education Department whose tasks are to interpret the roles of zoo for the public, and to undertake and supervise research in animals and habitats related topics.

### 6.2.3 Responses

The conversations started with a brief introduction to the research. The meetings in Twycross Zoo and Taipei Zoo are both in a very friendly and encouraging atmosphere, and revealed the integrated application idea is brand new and attractive to them. During the meetings, the author discovered that the participants appeared very interested in the proposed technologies for presenting animals and their habitats to website users, and in seeing the production. The participants indicated that the zoos have built Multimedia webpage for delivering the animal and related information but only used text and images currently.

“Our expectation is it could improve the website to demonstrate the animals and habitats. Multimedia/VR technologies are potentially very useful on interactivity function. Through the interactive function, we expect it could provide people close to animals and their habitats with fun. That will encourage people notice the animals' welfare and habitats protection,” (Dr. Chin and Ms. Lin of the Taipei Zoo)

Dr. Hooley and Mr. Allen of the Twycross Zoo have further indicated that,

“Our expectation is it could improve the website but it has to work. It has to be very efficient because people don't like finding the information to be hard” and, “We recommend that using the Multimedia/VR technologies on the website should encourage people to visit the zoo and provide more attractive to the care of animals”.

The conversation in the meetings presented great interest in employing the proposed idea of the integrated application of the technology to the zoos' website, and pointed out the requirements to the production, even though no working demonstration was available for presentation. This gives strong confidence that the proposed integrated production has potential investigation value, and that the research was advancing in the right direction.

To be part of the first application of the technology in the zoological field, the participants were all concerned that the production must take the knowledge, the conservation, and the joy of viewing animals and their habitats to the users, as this is the main purpose (simultaneous education, conservation, and entertainment) contained in any work of contemporary zoos (see 5.2). It is obvious, whether in the literature study, or in the practical opinions of the proposed integrated application domain, that communicating knowledge and conservation of animal and its habitat in a fun way is the essential requirement of the proposed creation.

The participants representing the web designers of the visited zoos, were further concerned with the quality of the image and the need for particular plug-ins to allow it to work. The reliance on the Flash plug-in was explained. The quality of the image and particular plug-ins for the proposed integrated application were considered, and provided solutions for the research (see 4.4 and 4.5).

#### 6.2.4 Collaboration certification

A certification letter of collaboration is sent by Twycross Zoo to embrace the study as part of the zoo's research, and this created the relationship between the application domain and the proposed technology. This gives a great benefit on the information collection and identification of animal and habitat, which will be used onto the production. The visits are not only elicited the potential employment and the requirements of the proposed integrated application from the zoo's domain, but also contributed to the expert interview, an essential step that would take place as part of the production evaluation later on. The collaboration certification of the research can be seen in **Appendix IV (2).**

### 6.3 Videos' acquirement

As stated previously the research is adopting the concept of multi camera system to obtain videos for creating panoramic video. The first step in developing panoramic video is to select suitable digital video cameras and properly design a video capturing system, the rig, to obtain videos for composition purposes.

#### 6.3.1 Camera selection and set-up

The digital video cameras used, Panasonic: Model AG-DVX100E (see Figure 6.1), were provided by the University and have many positive comments from users. The main setting of the camera had been simulated in 3D CG world (see Chapter Four), as reference. The main specifications of the camcorder are 480k pixels, a 3 CCD (Charge Coupled Device) imaging system with high F11 sensitivity and low smear and flare levels, and a wide 32.5mm – 325mm Leica Dicomar lens. Compared to most camcorders, which only come with one CCD, 3 CCD increases the colour and detail accuracy of the picture by recording the red, blue and green colours individually. The scene files and time code can be transferred over Firewire. The function of "What you see is what you get on LCD (Liquid-Crystal Display) and EVF (Electronic View Finder)" is superior for post-filming edit and stitch scrutiny. The camcorder is designed for professionals, with a large electronic viewfinder, audio XLR[93] input, and oversized audio controls. The IEEE 1394 terminal on the camcorder is for non-linear production and digital dubbing. An image stabilizer is installed in the camcorder in case there is any shaking. A remote control is one of the accessories, and can be used to turn on and off the video recording without touching the camcorder.


Figure 6.1: The video camera for capture, Panasonic: Model AG-DVX100E

[93] The XLR connector is an electrical connector design. Originally the "Cannon X" series, subsequent versions added a Latch ("Cannon XL") and then a Rubber compound surrounding the contacts, which led to the abbreviation XLR (Rane Corporation, 2009). Source: http://www.rane.com/par-c.html#XLR

6.3.2 Video synchronization testing

In considering video-capture in synchronization mentioned in section 4.3.1, the research undertakes a small experiment (see Figure 6.2), turning on and off the video-recording function of the selected camcorders. The frequency of the signals to control the filming action of the selected camcorders is at the same setting for all camcorders, meaning one remote control can control the video-capture process of all of the different camcorders at the same time when doing the experiment. Having this confirmation of synchronicity the camcorders, digital video camera is found to meet the requirements necessary for applying them to the multi-camera system. Figure 6.3 shows the full screenshots of the footage of the experiment in Leicester Castle Park, for reference. An alternative method to deal with the videos synchronization is using a clapperboard. The same video lengths can be obtained by clapping the board, if the provided camera is without a remote control function.

Figure 6.2: Levelling the tripods and shooting testing by remote control in Kingfisher Court dated 13th January, 2007

(a) Wide-angle image in 1st second frame

(b) Wide-angle image in 3rd second frame

(c) Wide-angle image in 13th second frame

(d) Wide-angle image in 23th second frame

(e) Wide-angle image in 36th second frame

Figure 6.3: Video-capturing in synchronicity experiment in Leicester Castle Park

### 6.3.3 Video capture rig making

The design of the virtual cameras system in Chapter Four gives the reference for the setup. The rig design for the research adopts the above concept and the virtual cameras practical experience gained in the 3D CG world, by designing a flexible slide to fasten different kinds of general digital video camera to increase the flexibility of the mounting and to decrease the cost. The detachable design of the rig (see Figure 6.4) provided an ‘easy to carry’ function. Due to the special purpose of the research, it is essential the video capturing system be suitable for rugged terrain and is stable on rough ground. This consideration is based on the land the animals normally inhabited, namely forest or jungle, which might have uneven terrain. The video capture rig is mounted on a tripod with adjustable legs (see Figure 6.5) to keep it level. A square of material connected the rig and tripod to expand the contact area of the linkage. This will make the video capture system have more stable centre of gravity. A horizontal level is fixed on the centre of the rig for obtaining the balance of the platform. Eight of the selected digital video cameras are positioned on the rig and faced different direction, (see Figure 6.6) to compose a 360-degree view. The number of cameras has been tested and determined from the 3D CG simulation in the Chapter Four. Figure 6.7 shows the constructed multi-camera system using eight of the provided digital video cameras.

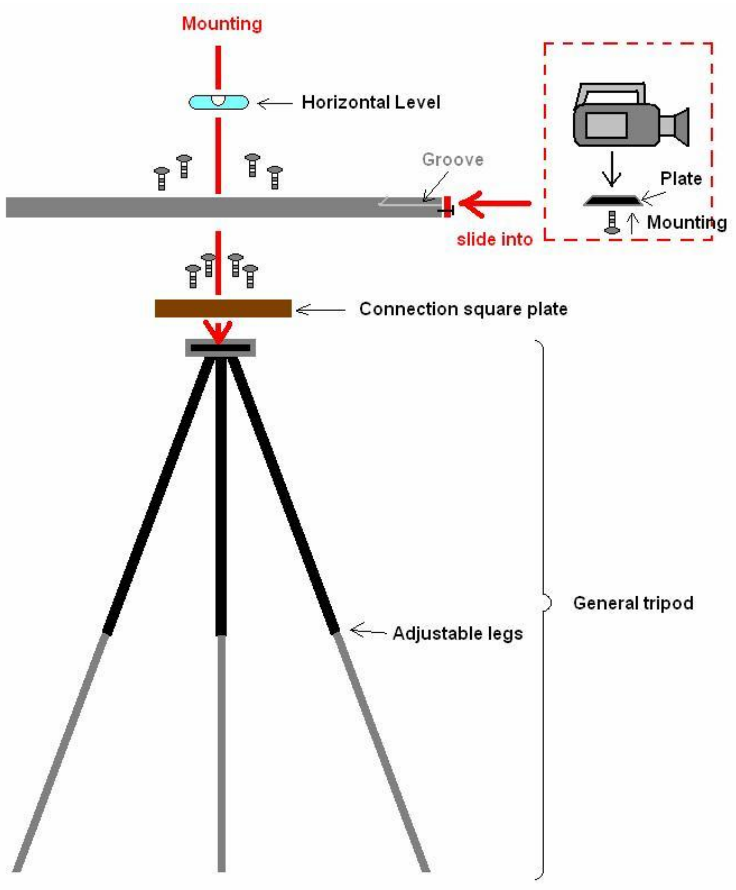


Figure 6.4: The detachable design of the rig meant it is easy to carry

Figure 6.5: Adjustable legs of tripod suited to different-surface ground

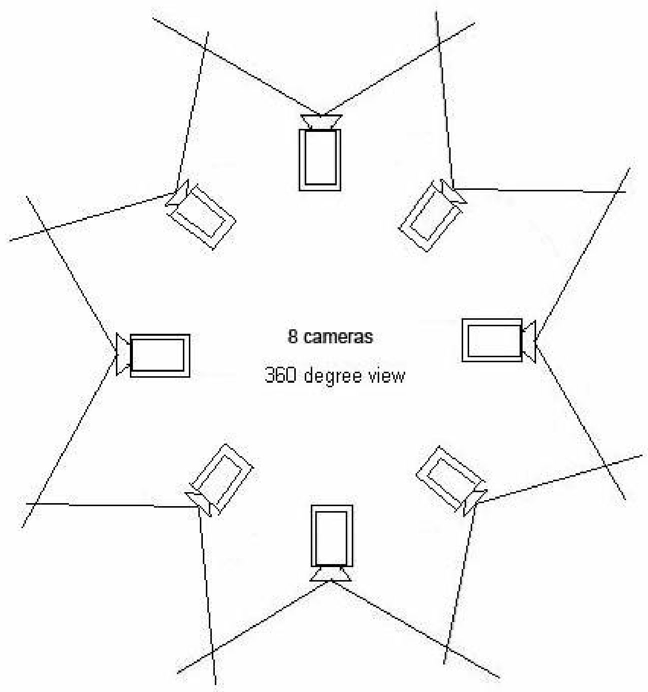


Figure 6.6: Eight digital video cameras’ array mounted on the rig

Figure 6.7: The apparatus of the created multi-camera system

6.3.4 Initial Fields-trials

Before travelling into the chosen habitat to film the animal, several initial exploratory field-tests examined the performance characteristics of the created panoramic video recordings under a variety of conditions. The following targeted test environments are chosen and allowed for assessment across a range of camera settings, lighting, and general dynamic scene conditions. In addition, a similar habitat environment, Castle Park, is taken. These scenarios are located in Leicester and listed in Table 6.2 for reference.

| Location | Environment |
| --- | --- |
| Kingfisher Court Parking Lot | An outdoor car parking area with multiple painted ground markings, on a sunny morning but surrounded by buildings, the rig in a static position in a shaded area |
| Gateway Building Street | The rig mounted in a static position in front of the glass-fronted IOCT laboratory, on an overcast day, with moderate human foot and car traffic, both close-up and at a distance |
| Goose Bar Lane | An open dynamic environment on a cloudy day, with the rig in a static position, with close background structures and busy car traffic, both close-up and at a distance |
| Castle Park | This environment was selected to simulate the considered habitat conditions. A park inhabited by highly active pigeons and squirrels, and having moderate human traffic. Moreover, the park is full of dynamic trees when windy, which is similar to the proposed habitat. The terrain is not exactly the same as the proposed habitat, but is similar enough to be beneficial as a test area for habitat filming. Three static rig positions were selected to film under different conditions, such as sunshine and cloudy weather, and with people and animals moving. |

Table 6.2: The test environments of field-trials

The trials give very important evidence that the capture and production proved easy to work on because the camera setting and the rig, the filming and the videos stitching have been simulated (see 4.3). This revealed the idea of 3D CG simulation (see Chapter Four) has great advantages, and is essential in the process of developing panoramic video and applications, particularly in the context of the discussed research. Although the trials of the Panoramic Videos created by the proposed design method works well in different environments, but further research is required to confirm this view.

## 6.4 Production creation - the proposed integrated application

The development of the proposed integrated application is started with the animal and habitat selection for filming, and then progressed to the real production building.

### 6.4.1 Choice of filming animal and area

There are many considerations in choosing the location and animal, including the access to the environment, consistency of weather, health and safety and getting regular access to the environment for repeat runs if needs be. Based on the issues above, and that the collaborator of the research, Twycross Zoo, is mainly targeting Primates, and the need for a place that the author of the research familiar with, the research eventually chose the Formosan Rock-Monkey, which has inhabited Taiwan for many years and is in an endangered condition.  The domain of this primate once stretched from the island's plains into the mountains, to an altitude of 3,000 meters. Owing to conflicts with humans, the habitat is compressing and this species is considered to be an endangered species (see Figure 6.8). These facts arose as the purpose of the research is to deal with information delivery and raise protection issues online.


Figure 6.8: The conservation status and scientific classification of the Formosan Rock-Monkey (Wikipedia[94], 2008)

6.4.1.1 Animal background

The Formosan Rock Monkey is a macaque living in Taiwan, and it has been introduced to Japan. This species is the first primate to set foot on Taiwan and classified by most zoologists as a unique species, Macaca cyclopsis. In view of the macaque's uniqueness as the only non-human primate in Taiwan living outside zoos, it has become a superstar of conservation efforts over the past decade. The international association, NGO (Non-Government Organization) for instance, the Government, and local associations

[94] Source: http://en.wikipedia.org/wiki/Formosan_Rock_Macaque

conducted many efforts to raise attention to the species and habitat protection issues (Hund, 2004).

The Formosan Rock-Monkey has a head and trunk ranging from 36-45cm in length and a tail that is 26-46cm in length. Each monkey weighs 5-12kg and has a flat round head, a hairless face, and two small ears. Their thick, soft coats of fur cover their entire body and are dark slate in colour in the winter and olive-green in the summer, with greyish-white bellies, reddish-brown buttocks, black lower limbs, and thick, long tails with black ends (see Figure 6.9)

Figure 6.9: The Formosan Rock-Monkey (taken by the author, 2008)

The Formosan Rock-Monkey is omnivorous; feeding primarily on fruits, tender leaves, and berries, depending on the season, but occasionally eating insects too. They are highly social animals and form colonies that generally comprise 10-30 monkeys. The monkey is active during the day. They are seen normally in the early morning and at sunset. The species lives most of their lives in trees located on exposed, rocky ground or near sources of water, and search for food in either the early morning hours or at dusk. When in danger, they will make short, loud noises or violently shake the trees they are in, to warn others in their group.

6.4.1.2 Habitat location

Formosan Rock-Monkeys are unique to Taiwan and are quite widespread in densely forested mountainous regions including the Central Mountain Range, National Parks, e.g. Taroco National Park and the Eastern coast (Lin, 2001). The research chose one of the animal's habitats, Shou-Shan, a mountain near Kao-Hsiung City in the south of Taiwan, to film and to obtain the videos to create the production because the area is familiar to the author of the research. Figure 6.10 shows the location of the habitat of the monkey. Figure 6.11 shows the images of the animal and habitat.

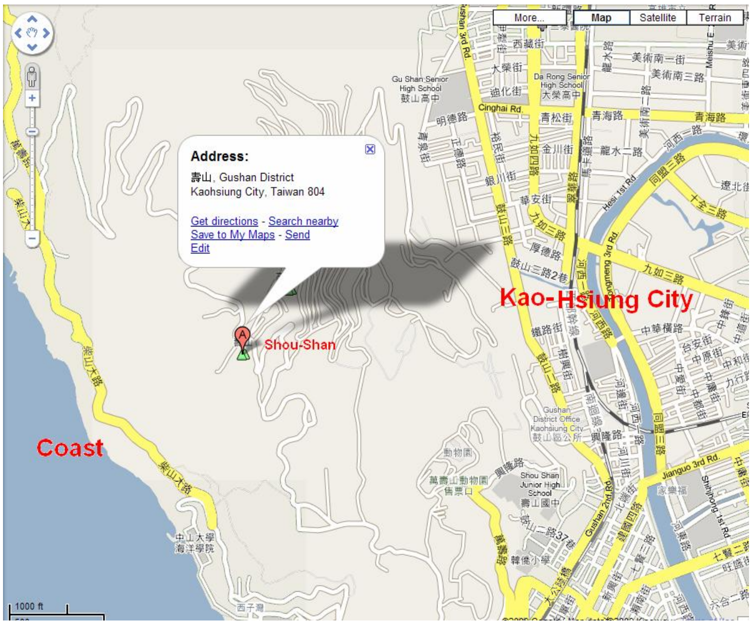


Figure 6.10: The location of the habitat of the Formosan Rock-Monkey in Shou-Shan (Google Map, 2009)

Figure 6.11: Composite image of the monkey and its habitat

6.4.2 General Product design

The adoption of an initial 3D CG generated video test gave a practical solution for developing and improving the technologies, the confirmation that an unlimited extendable scene is possible using Multimedia integration, and the provided the reference and guidance for interactive design of the web interface with identified elements which enlarges the amount of information obtainable through the proposed production (see 4.4 and 4.7). The production rig and method could be easily built relatively easily because the main framework of the web interface design had been established and tested in this way (see 4.7.6).

The theme of the panoramas was decided, namely to deliver the knowledge of the monkey (theme “Understanding Monkey”), to understand the problems caused to the animal and the habitat ecology by human behaviours (theme “Human Acts and Conservation”), and to obtain the information about current status of the animal (theme Habitat and Animal Status”), with reference to the conversation during the zoo visits (see 6.2) and current zoos' websites (see Figure 5.4 and Twycross Zoo). Moreover, the objects which are filmed in the panoramas are concerned with these themes, and provided contents consideration. Table 6.3 shows the theme category of the panoramic videos, with interactive information related to the animal and its habitat. Figure 6.12 illustrates the position arrangement of the three panoramic videos with embedded information.

| **Theme of Panorama** | **Tag** | **Annotation** |
|---|---|---|
| Understanding Monkey | | |
| | Vocal communication | Image, texts, and sound |
| | Social behaviour | Image and texts |
| | Animal facts | Image and texts |
| Human Acts and Conservation | | |
| | Human Influence and Harm | Image and texts |
| | Conservation Issues and Activities | Image and texts |
| Habitat and Animal Status | | |
| | Where they live | Image and texts |
| | What they eat | Animated images and texts |
| | IUCN status | Classification table and texts |
| | Habitat | Image and texts |

Table 6.3: The themes included in the production

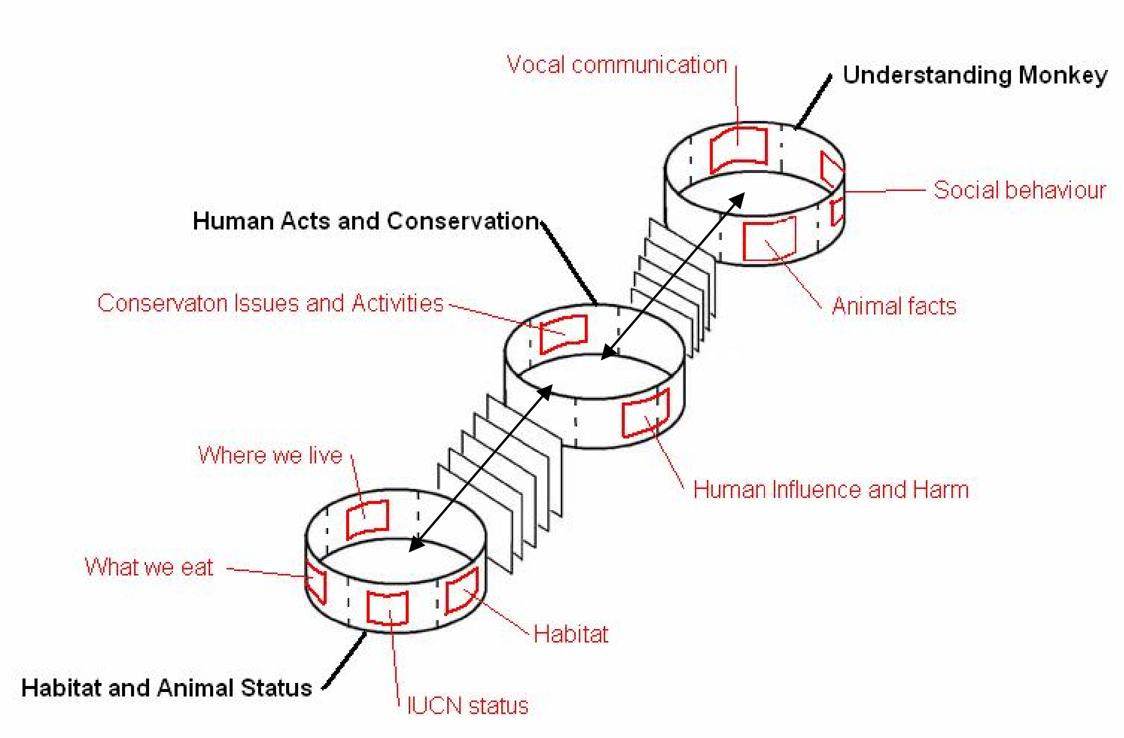


Figure 6.12: The construction of the production

### 6.4.3 Filming and production

This section outlines details of the created project.

#### 6.4.3.1 Panoramic videos

On account of the weather, the time, and the cost constrains, eventually three adjacent positions in the habitat, on a 15 degree slope trail about 90 – 100 meters in height, were filmed to create composite panoramic videos with two Image Channel bridges. The monkeys were unexpectedly wandering in two of the positions captured to make up the panoramas, providing a natural behaviour observation. Mountain climbers appear uninvited, showing some influence of humans on the animal and the habitat.

There are three panoramic videos created and named (see Table 6.3). The entrance of the scene is the panoramic video “Understanding Monkey”. There are three live monkeys in “Understanding Monkey”, eating, walking and looking around. A dynamic footprint icon (tag) is located on the ground path to give guidance to the next panorama.

Figure 6.13 shows the wide screen view of the panoramic video. Figure 6.14 shows the screenshot of the production in this panorama.


Figure 6.13: 360 degree view of the entrance to the scene


Figure 6.14: The screenshot of the production on Understanding Monkey panorama

The next connected panoramic video is "Human Acts and Conservation". There are human footprints on the path in this panoramic video, which have more relation to the theme of the panorama. Two dynamic footprint signs as tags are located on the inverse side of the path, according to natural geography. One footprint sign, after clicking, will return to the entrance panorama. The other will lead to the third panorama. Figure 6.15 shows the wide screen view of the panoramic video. Figure 6.16 shows the screenshot of the production on this panorama.

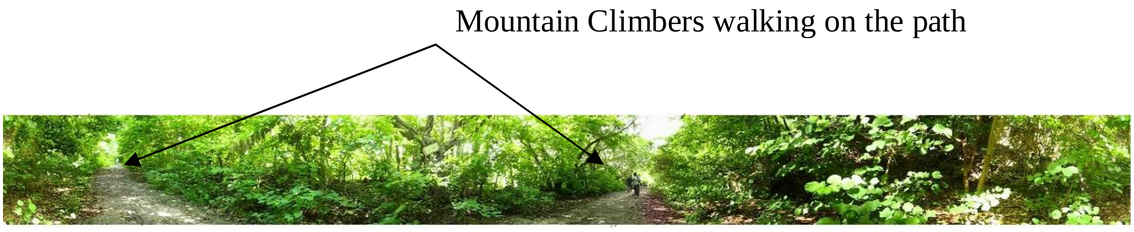


Figure 6.15: 360 degree view of the panoramic video of “Human Acts and Conservation”

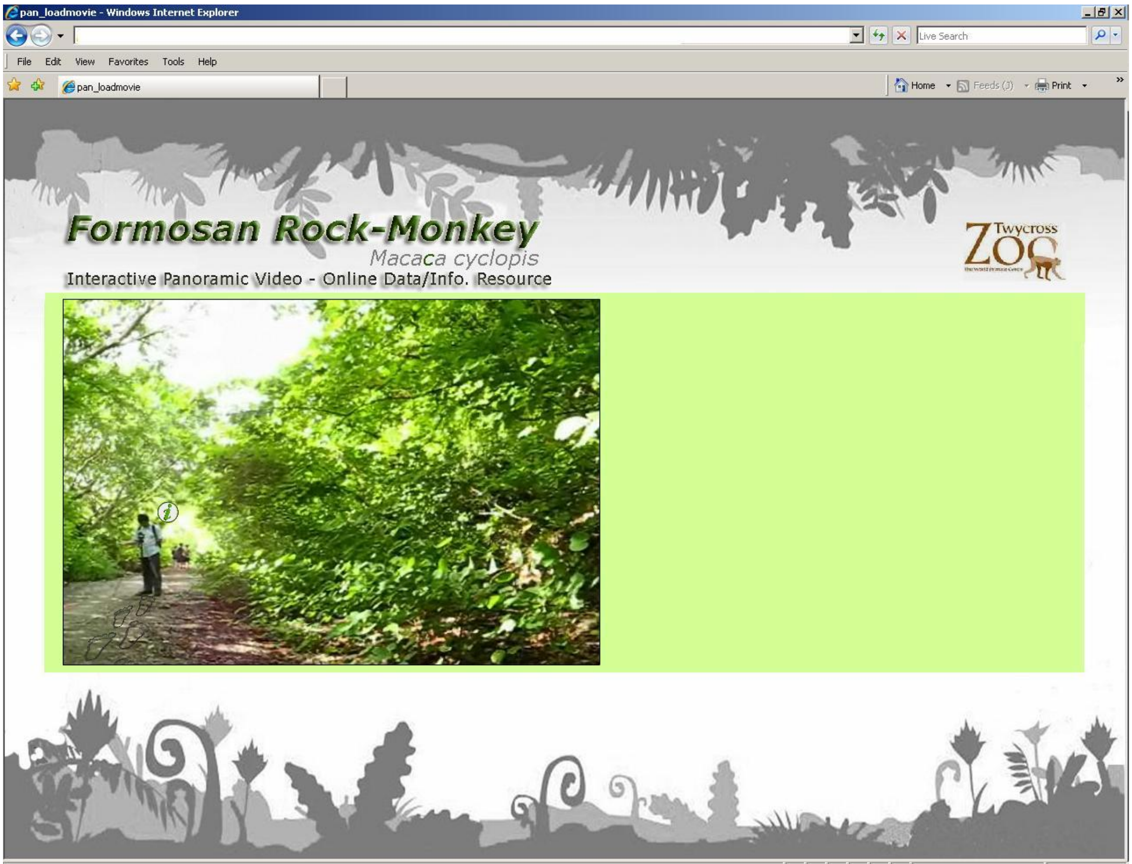


Figure 6.16: The screenshot of the production on Human Acts and Conservation panorama

The last panoramic video is “Habitat and Animal Status”. This panoramic video has humans and live monkeys together, to represent the current habitat circumstance. A dynamic footprint sign as tag is located on the ground path, bringing the user back to the last panorama after clicking on it. Figure 6.17 shows the wide screen view of the panoramic video. Figure 6.18 shows the screenshot of the production on this panorama.


Figure 6.17: 360 degree view of the panoramic video of “Habitat and Animal Status”

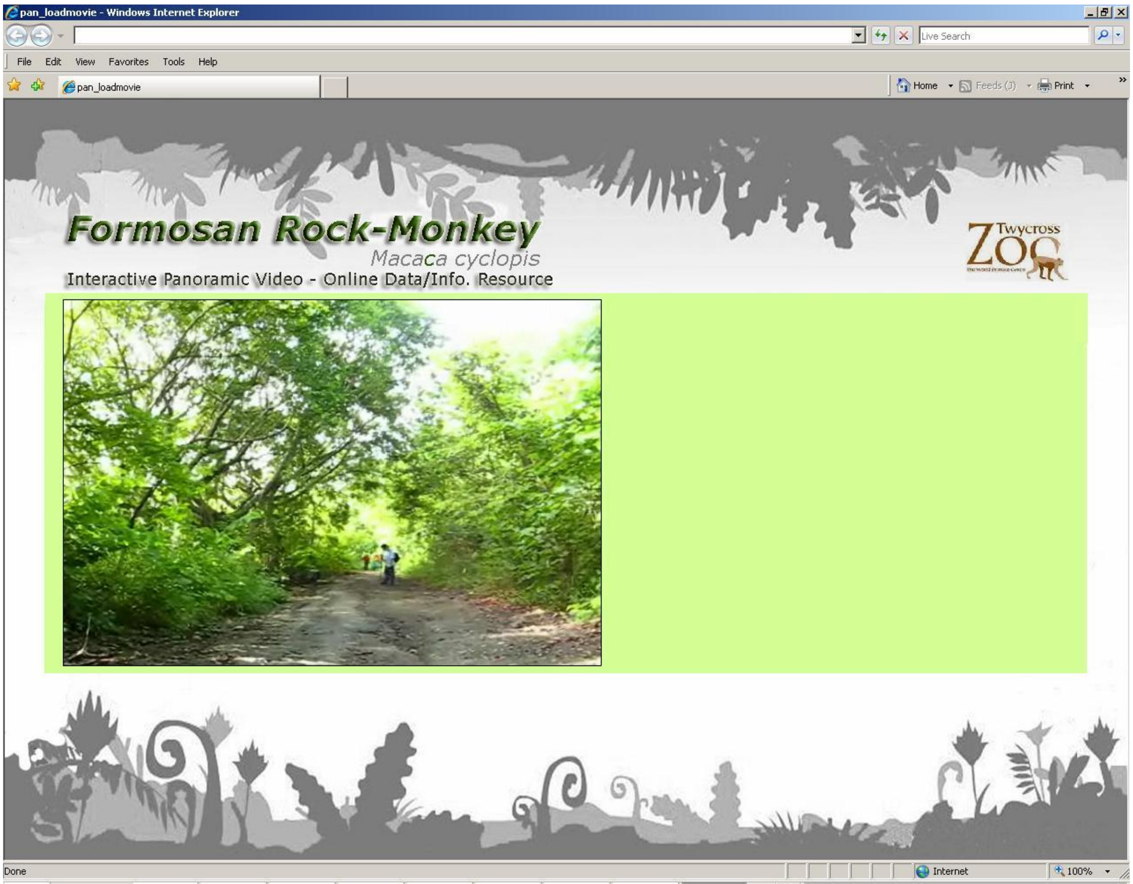


Figure 6.18: The screenshot of the production on “Habitat and Animal Status” panorama

### 6.4.3.2 Image Channels

There are two pairs of Image Channels used for travelling within the two panoramic videos. The first pair is for traversing between the panoramic videos of “Understanding Monkey” and “Human Acts and Conservation”. The other is for navigating with the panoramic videos of “Human Acts and Conservation” and “Habitat and Animal Status”.

The duration of the Image Channels is different depending on the distance between the two connected panoramas. During recording the playing speed of the Image Channel was set by the walking speed of the photographer. The digital video camera was carried by the photographer for practical filming. This speed was set in response to the users' comments on portraying a natural walking condition to perceive presence at the CG stage (see 4.4.7). In addition, the practical filming of the terrain for the Image Channel should increase the realism when navigating afterwards. Figure 6.19 shows the sequences of Image Channel traversed between "Understanding Monkey" and "Human Acts and Conservation". Figure 6.20 shows the Image Channel traversed between the panoramic videos of "Human Acts and Conservation" and "Habitat and Animal Status".


Figure 6.19: Image Channel for traversing between "Understanding Monkey" and "Human Acts and Conservation"

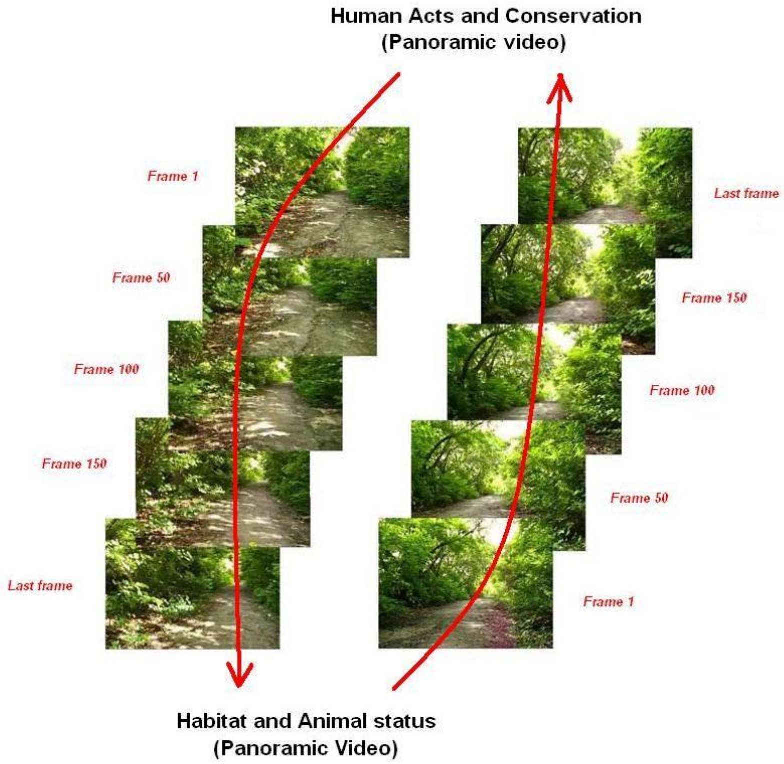


Figure 6.20: Image Channel for traversing between "Human Acts and Conservation" and "Habitat and Animal Status"

6.4.3.3 Tags and annotations

There are two kinds of tag attached on the panoramic videos, movement icons and information provision icons. The movement icon is for understanding where the user is going to, e.g. the next panorama. Figure 6.21 shows the dynamic footprint icon design used as a guidance of movement. The information icons are attached to the assigned objects of panoramas and, when clicked, offer related information (see Figure 6.22). Figure 6.23 shows the interactive information icons with annotations displayed on the information display area of the web page layout (see Figure 4.12). The program for the interactive design is tested and referred to in Chapter Four.

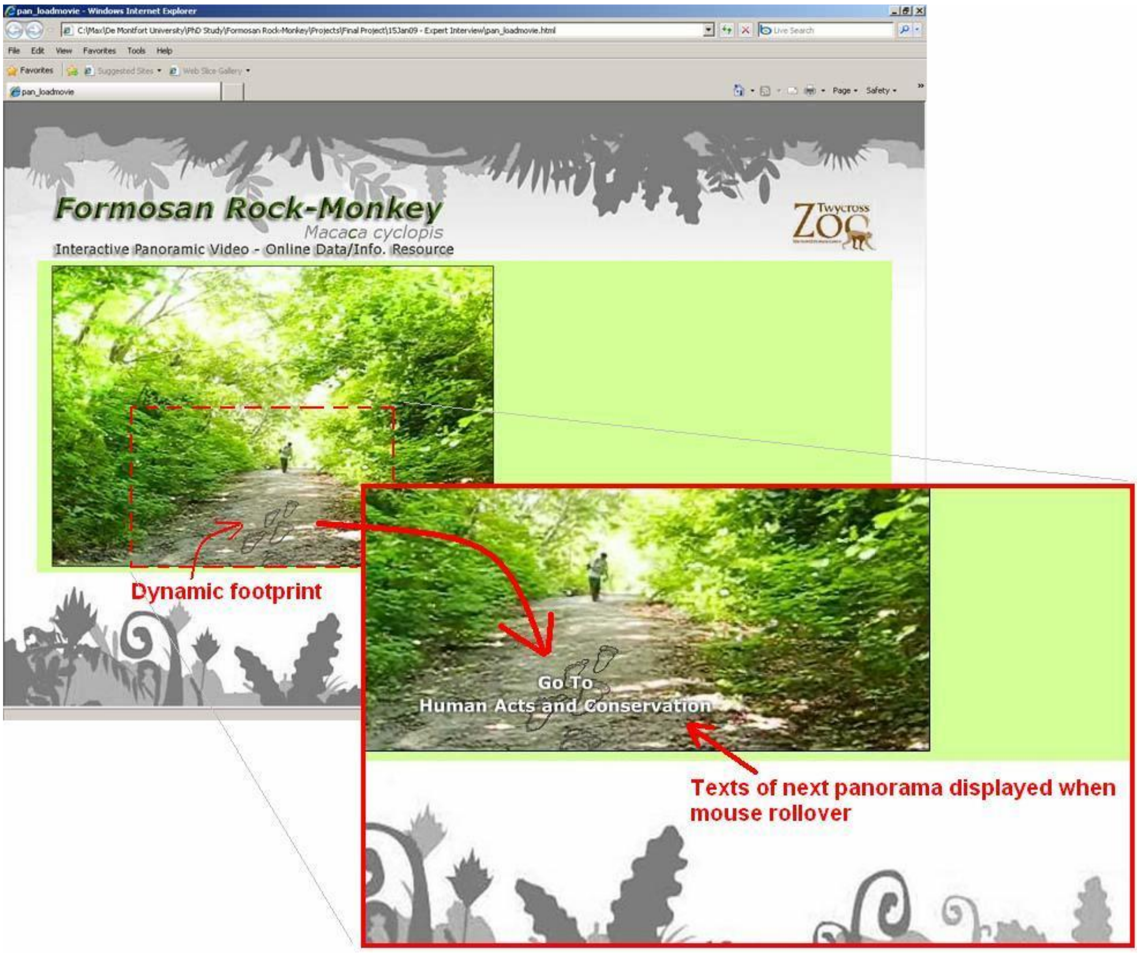


Figure 6.21: The icon and attached texts for indicating the way to next panorama


Figure 6.22: Icons for providing information

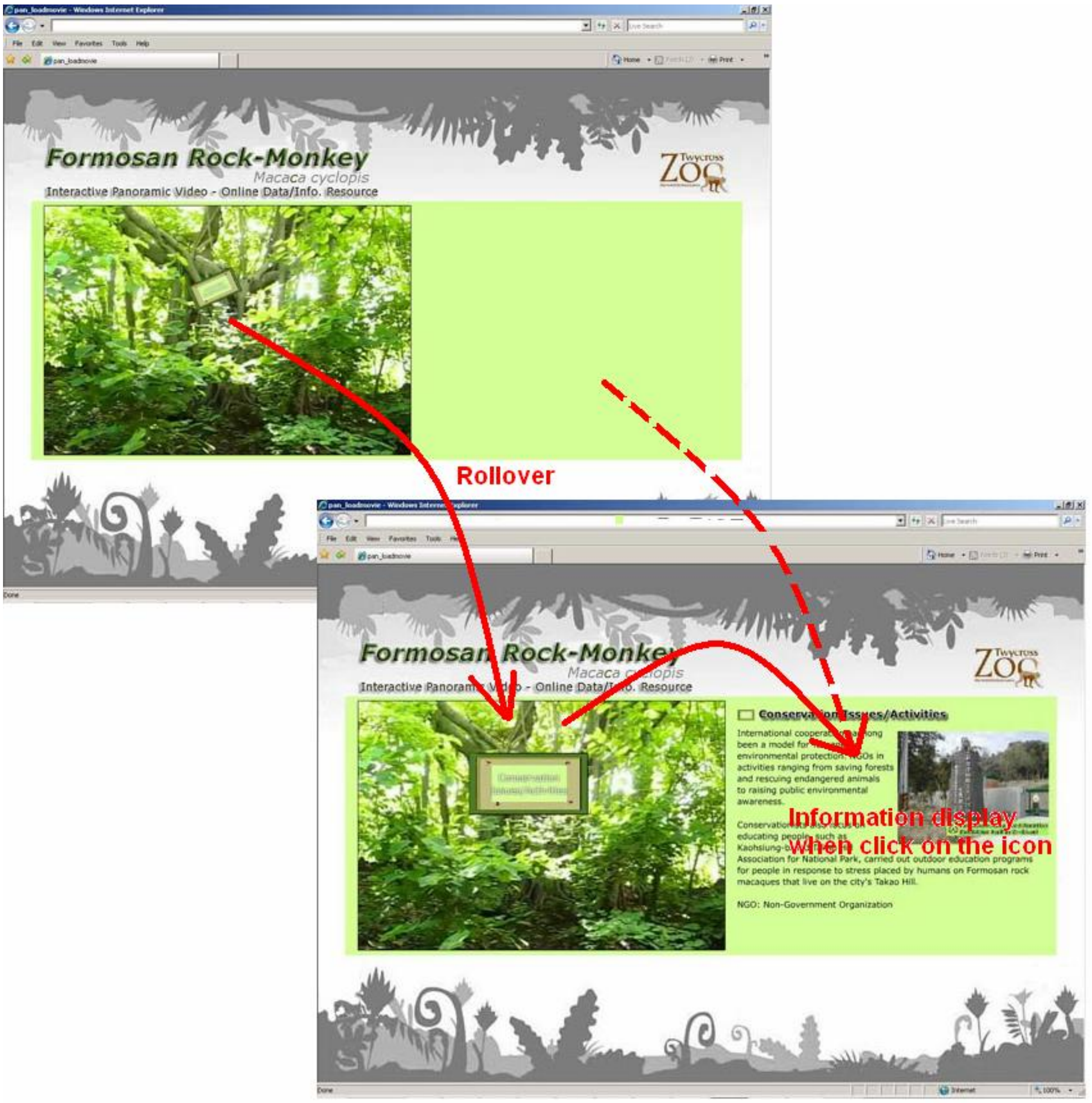


Figure 6.23: The point-and-click design of the tag and its annotation

Figure 6.24 shows the screenshots of three located interactive tags, with annotations displayed on the panoramic video of "Understanding Monkey" after mouse clicking.

Figure 6.25 is the screenshots of two located interactive tags with annotations, on the panoramic video of the "Human Acts and Conservation". Figure 6.26 is the screenshot of four located interactive tags with annotations, on the panoramic video of "Habitat and Animal Status".

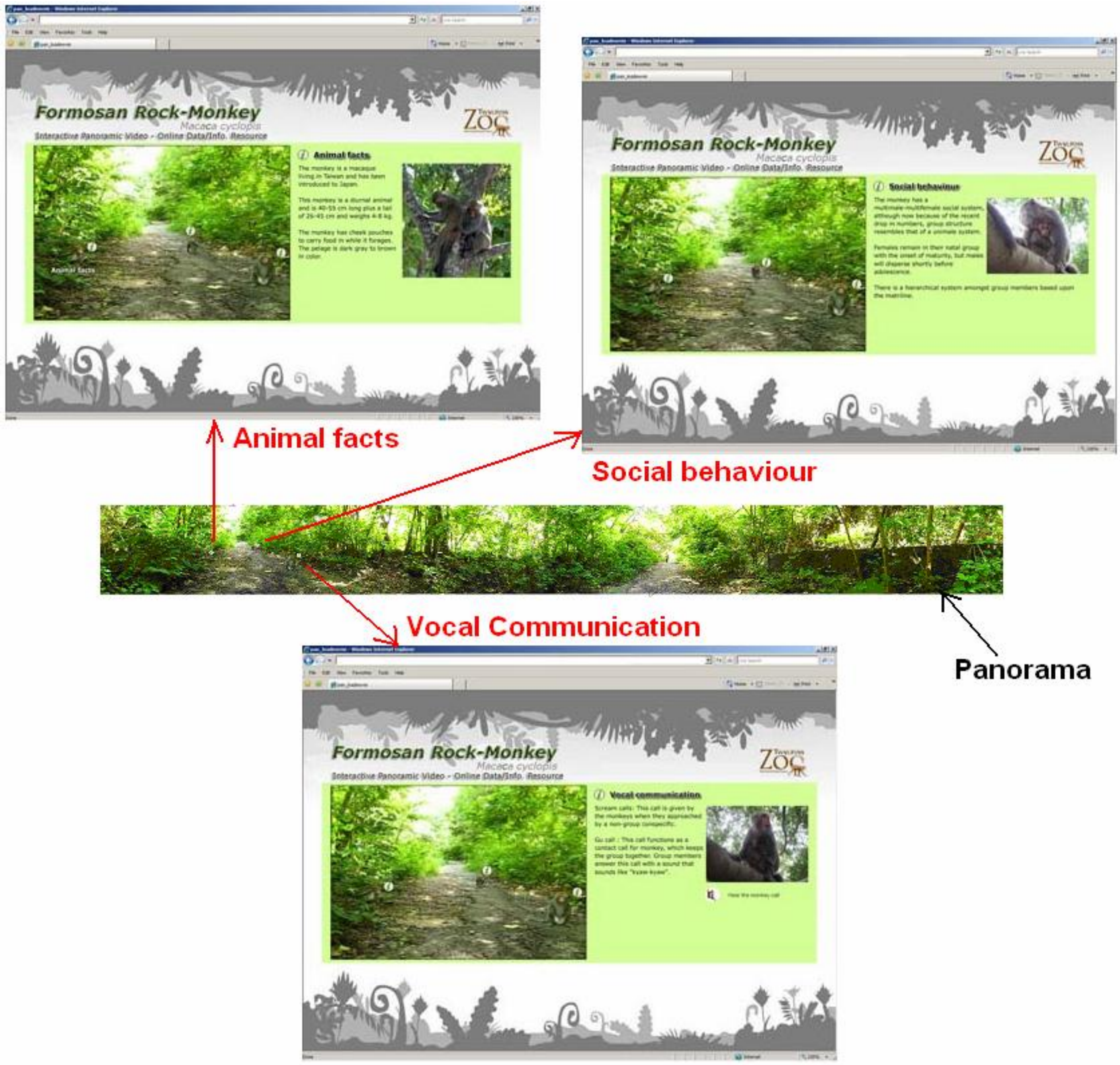


Figure 6.24: Screenshots of tags and annotations in the panoramic video of Understanding Monkey

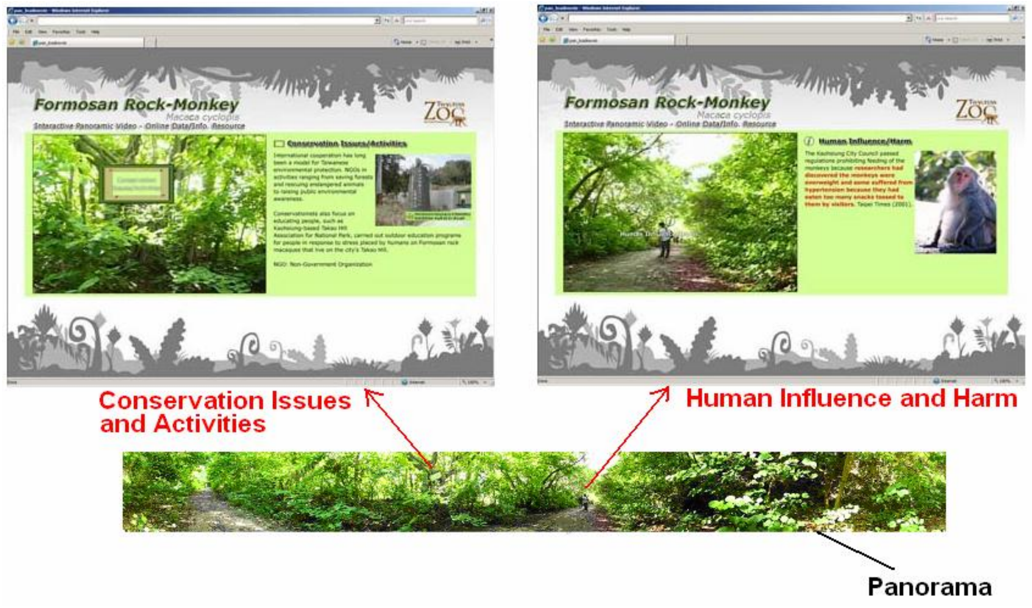


Figure 6.25: Screenshots of tags and annotations of the panoramic video (Human Acts and Conservation)

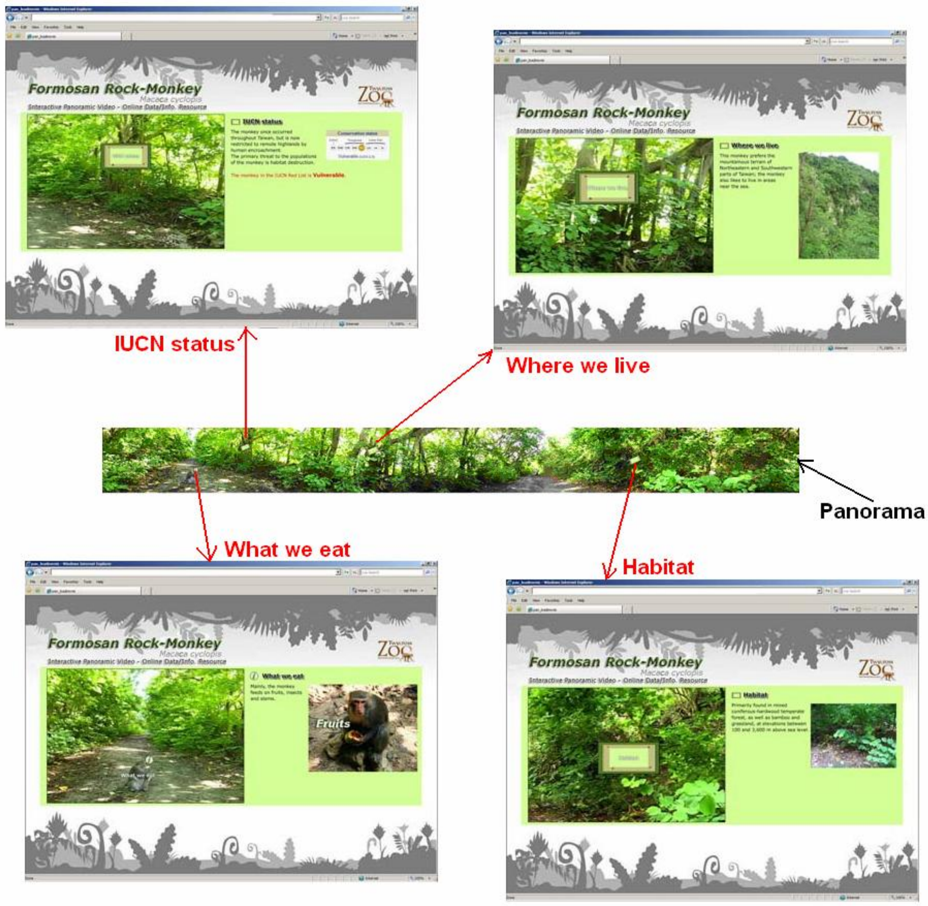


Figure 6.26: Screenshots of tags and annotations on the panoramic video (Habitat and Animal Status)

6.4.3.4 Sound

Two sounds were recorded for the production: habitat environmental sound, and monkeys' noise and screaming. The environmental sound was synchronized when filming the panoramic videos and Image Channels. This is in response to the users' comment on the artificial sound in the 3D CG project (see 4.7.6.3), and hopefully would increase presence perception of the real environment. The monkeys' sound is recorded when the monkeys approached the locations of filming. In the interests of ethics and safety, the recorder was well hidden. The habitat environmental sound was embedded in the layer of the selected Multimedia software, Adobe Flash (see 4.4 and Figure 4.5). The natural "talk" (monkey's screaming) of the monkey is expected to be a good resource for zoologists, and also increase attraction to users of the production. A speaker shaped icon is designed and located on the annotation (see Figure 6.31) of Vocal Communication, to enable the sound to be played. The user of the production can turn on and off the monkey's talk.

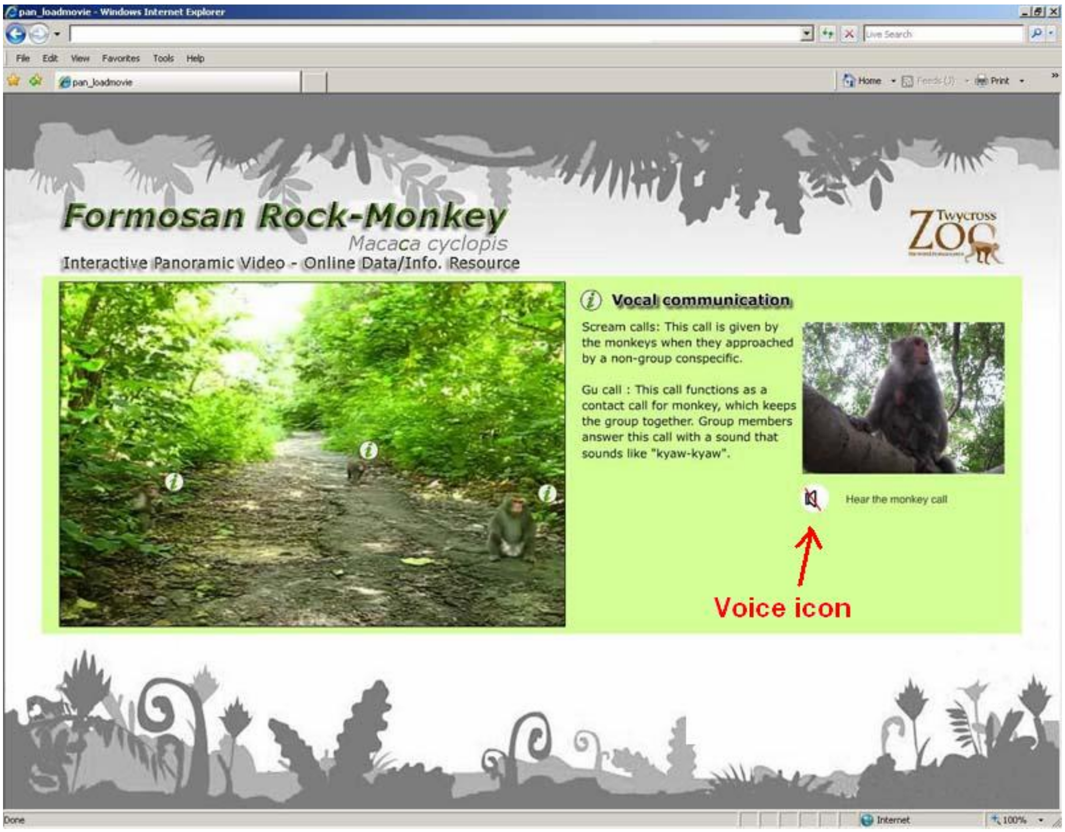


Figure 6.27: The voice icon for playing natural talk of the monkey

## 6.5 Pilot testing before mass evaluation

The research has taken four subjects as the pilot experiment sample (see 3.3.4), to test and to refine the production before delivering the final evaluation. The results will not include in the production evaluation, and were eliminated after the testing for reasons of confidentiality.

The important discovery of the pilot tests is on the contents of the first frame of the scene displayed to users. The subjects indicated that the first image should be monkeys, as this is the theme and attraction of the project. Without this cue, users could be perplexed about the purpose of the production. In the research's opinion, the panorama VR researchers and developers have not noticed this important issue, perhaps because panorama VR provides 360 degree view control. The finding, which was that the first frame of image of panoramic video should meet the project's theme, was adopted in order to refine the production, meaning that the monkeys are in the first frame displayed to the user.

## 6.6 Conclusion

This chapter has been concerned with obtaining practical opinions on the potential employment and detail requirements of the proposed integrated application, that virtual zoo, from zoo visits, and the selection of animal and environment that would enable full testing of the provisional findings gained from videos obtained in the 3D CG simulation world method.

The initial zoo visits before doing the production had a great advantage: They provided affirmative practical evidence to the potential employment and the requirement of the production. In addition, the participants in the meeting indicated the research is worthwhile and is connected with the cross disciplinary approach.

By taking account of the major roles of the zoos and their options on the direction in which this application should go, a test-bed application was constructed that embedded one animal type, a typical environment in which users could navigate and interact with different forms of embedded information.

The tested approach of videos obtained by the 3D CG simulation method was then employed in filming the real environment, which is the Formosan Rock-Monkey in Taiwan. The innovation of the idea of using the 3D CG simulation method is proved by the real filming practices (see 6.3) and the development of the production (see 6.4), in that time and costs are saved because the camera settings, the filming rig design, videos editing and stitching, panning control, proposed web interface design, and overall programming have been previously and initially tested (see Chapter Four).

A small group of users (see 6.5) was taken for a pilot test before delivering the final evaluation of the created project. A finding that the first frame of the first displayed panoramic video should contain monkeys to look at will meet the theme of the project and will attract the users. This was adopted in order to refine the production.

In addition, the collaboration obtained with Twycross Zoo, also provides an invaluable opportunity for expert interviews in the production evaluation phase by not only determining the requirement, e.g. level of performance in communicating knowledge and conservation of animal and habitat, and fun when experiencing the production, but also will elicit more potential employments for the created technologies in the proposed application domain. In this way it would be possible to test that the application met the needs of the end user but also met the needs of the zoo “client” in effectively communicating what they do.

The next Chapter is going to elucidate the final stage of the research, which is the built production evaluation by end user testing and expert interview.

# Chapter Seven: Product Evaluation

## 7.1 **Introduction**

This chapter is concerned with the evaluation of the proposed integrated application developed in chapter 6 from both an end-user perspective and from the perspective of the expert audience and potential client (zoo owner). The evaluation will use end-user testing (quantitative method) and expert interview (qualitative method).

The chapter starts by discussing the evaluation criteria and hypotheses, and then each test set. More importantly, the evaluation has an additional intention, to not only find evidence to support the generated hypotheses, but also elicit more potential uses of the developed technology. The adopted web page layout with interactive design will be tested, which is the final process (see Table 4.4) of the adopted Multimedia Design Model in developing the web interface, and be interpreted. An overall discussion section will be given for summarizing the results.

## 7.2 **Evaluation design and the hypotheses**

The traditional method to determine the application of panoramic video is field-trials and the developers' self-evaluation. Another informal method appears to be testing the created project by informal evaluation during shows or exhibitions. These methods are facing bias due to a shortage of specialist's points of view in the specific application domain, and distrusted results due to an improperly designed user testing method (see 3.2 for more detail). The opinions of experts in the application domain have the potential advantage in not only obtaining the specialists' viewpoints of requirement performance of the created project, but also importantly, exploring more employments of the created technology in different applications to the specific area. In terms of the informal evaluation event, practical evidence is given by the author of the research, who exhibited one of the projects created in the 3D CG simulation phase (see 4.7) of the research at London CREATE 2008, where evaluation took place. It is decided to abandon the collected data because the testing is in an uncontrolled and complex environment. The evaluation of the project is then designed into formal end-user testing in a controlled environment, and expert interviews of the application domain. The advantage of the adopted project test method has been previously detailed in section 3.2.2.

The end-user testing and expert interview are designed mainly to determine the performance of the integrated application on the requirement of the created production, which is called application's performance later on. In addition, the end-user testing also included evaluating the design method which tested in 3D CG environment (see 4.5) to the production. The test is referred to the technology's performance later on. An open comment section will be provided during the end-user testing for production refinement and obtaining more potential application employments of the created technology. Topics of the expert interview events are also designed to elicit additional applications in the specific domain and to the interface design.

Based on the study of literature (see Chapter Five) and practical viewpoints of the application domain from zoo visits (see 6.2), the hypothesis is produced directly relating to the production requirements, e.g. communicating knowledge, conservation and entertainment when experiencing the project. The hypothesis is generated as follow:

**Hypothesis Five:** When the environment is implemented in the virtual zoo, the interface and interactive design are judged by the users to make an effective contribution as an educational tool in communicating aspects of conservation and animal knowledge in an entertaining way

## 7.3 **End-user testing - Quantitative method**

### 7.3.1 Sample size and population

Previous researchers appear to test panoramic video's application is generally by field-trials of developers' self-evaluation (Pintaric et al, 2000), or informal demonstrations conducted with unknown focus group in the laboratory and exhibitions (Rizzo et al, 2001). This presents bias of a single standpoint (the developer’s) and unreliable data (due to the complexity of the users testing environment, see 3.2). The research had practical experience of exhibiting one of the research projects in CREATE 2008 LONDON also demonstrated that this form of testing should be excluded from the data collection process. Based on the sample size and population estimation study in section 4.7.1 and discussion of the obtained data analysis (see 4.8), the research eventually adopted 38 subjects as a sample size, and calculated means and 95% confidence intervals for estimating the population statistic. The samples were randomly recruited students studying in different subject areas in the University, and from workers outside the University. All participants had at least a basic knowledge of IT meaning that the population would be representative of those likely to visit and use a web-site.

### 7.3.2 Hardware setting and testing progress

The hardware settings for the user testing are same as the 3D CG simulation testing, and used a desktop computer (an Intel Core 2 Duo CPU with 150GB hard drive and 2GB RAM) with a 1280 X 1024 pixel window on a 19-inch TFT LCD screen (see 4.7.2). The process started with a short oral introduction to the testing, with participants given the opportunity to ask questions. Ten minutes’ practice was given to familiarise the user with the technology. The duration of the practice could be extended or shortened depending on participants’ need.

The participants were asked to discover information of why the monkey is overweight? related to the animals, as the information-searching idea was used (see 4.7.6) and suitable, being associated with one of the purposes of the research, namely information communication. The task typically took 10 minutes. The participant was asked to fill in the questionnaire after completing the task, and to give comments freely. The overall length of the testing was around 30 minutes. The end-user testing followed the above steps as SOP (Standard Operation Procedure) ensuring the participants had the same progress, and trustable data could be obtained.

### 7.3.3 Survey questionnaire design

The questionnaire was divided into two portions: the technology's performance, which was related to proposed design method in developing and improving the panoramic video and interactive design, and the application's performance in determining the performance level of the production requirement. Table 7.1 shows the questions related to the technology's performance, and table 7.2 lists the questions related to the application's performance. The questions to determine the technology's performance are basically acquired from the experiments in the phase of testing the proposed methods of developing and improving the technology (see 4.7). Participants undertaking the user testing were asked to grade their assessments of each question on a 5 level Likert scale, where 5 denoted strongly agree and 1 denoted strongly disagree. The rating method was recommended and used in evaluating research aims of panorama VR studies (see 3.4.1).

| Sequence | Question | Aim (determining) |
|---|---|---|
| Q1 | The perspective looked natural | Editing and stitching |
| Q2 | The stitching of videos was generally acceptable | Editing and stitching |
| Q3 | Manipulating the movement of the view was easy | Panning control |
| Q4 | It was easy to find the object | Interactive design |
| Q5 | It is easy to recognize my position | Orientation |
| Q6 | It is easy to understand my orientation (the way I am facing) | Orientation |

Table 7.1: The questions and aims of determining the technology's performance

| Sequence | Question | Aim (determining) |
|---|---|---|
| Q1 | The knowledge provision method in this technology enriched my understanding of the animal and its habitat | Level of communicating the knowledge of animal and habitat |
| Q2 | This technology increased my awareness of the animal and its habitat protection | Level of communicating the conservation of animal and habitat |
| Q3 | The experience was fun | Level of entertainment when experiencing the project |
| Q4 | The overall design of this application was good | Web page layout and interactive design |
| Q5 | This technology would encourage me to visit this site again | Product reuse |
| Q6 | The sound made me feel I was in the environment | Component update |

Table 7.2: The questions and aims of determining the application's performance

7.3.4 Results and comments

7.3.4.1 Technology's performance

The results as calculated by Microsoft Excel, are displayed in table 7.3. Figure 7.1 shows the means and 95% confidence interval of the response to each question.

| Question | Average | std dev | count | std error | conf lower | conf upper | conf range |
|---|---|---|---|---|---|---|---|
| 1 | 4.84 | 0.37 | 38 | 0.06 | 4.72 | 4.96 | 0.12 |
| 2 | 5.00 | 0 | 38 | 0 | 5 | 5 | 0 |
| 3 | 4.87 | 0.34 | 38 | 0.06 | 4.76 | 4.98 | 0.11 |
| 4 | 4.84 | 0.37 | 38 | 0.06 | 4.72 | 4.96 | 0.12 |
| 5 | 4.95 | 0.23 | 38 | 0.04 | 4.88 | 5.02 | 0.07 |
| 6 | 5.00 | 0 | 38 | 0 | 5 | 5 | 0 |

Table 7.3: The mean and standard error calculations in technology's performance

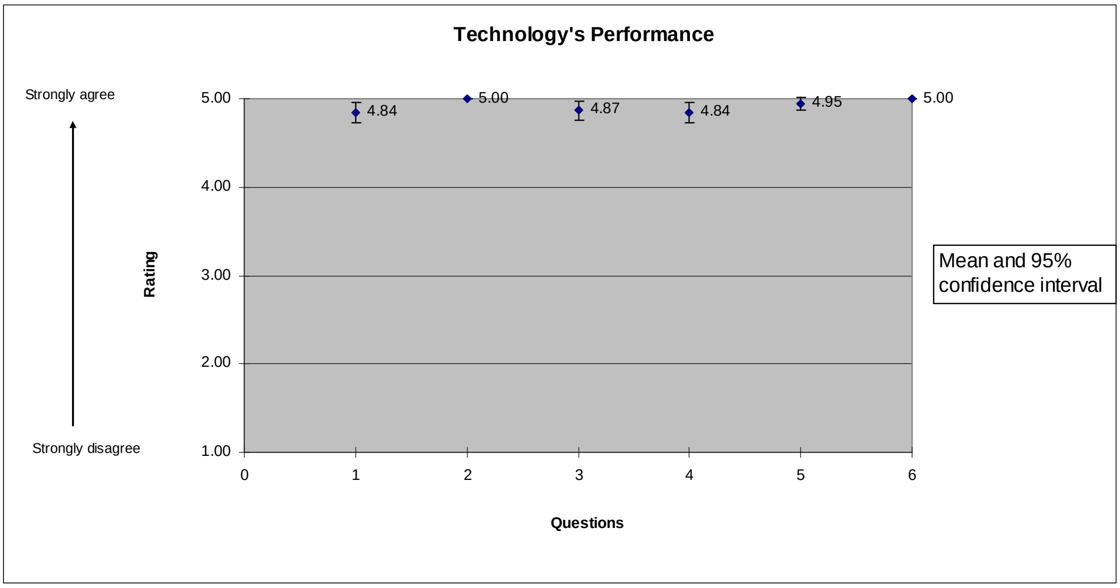


Figure 7.1: Mean and 95% confidence interval of the technology's performance

The technology's performance in terms of videos composition (Q1 and Q2) and panoramic video manipulation (Q3) are very clear, as the results obtained show very strong agreement within the group. From a practical standpoint, the perspective obtained looked natural to a level very close to "strongly agree" and an extremely high level of rating and agreement (5 out of 5) for the stitching quality is obtained. This was a good result.

Participant's responses to the overlap areas indicated that the technology applied to this specific area make the overlap invisible and seamless. There was wide agreement about the ease of panning manipulation, which again obtained a high rating.

Discovering that the way-finding (Image Channel) design (Q5 and Q6) and the interactive icon design for displaying annotations make it easy to find the object and received a high rating (Q4), can be seen in Chart 7.1. The Chart also indicates there is great agreement that the spatial recognition of the production make it very easy to "recognize my position" and to understand users' orientation.

7.3.4.2 Application's performance

Table 7.4 shows the statistical data of each question after calculation by Microsoft Excel, and Figure 7.2 shows mean and 95% confidence interval of each question.

| Question | Average | std dev | count | std error | conf lower | conf upper | conf range |
|---|---|---|---|---|---|---|---|
| 1 | 4.87 | 0.34 | 38 | 0.06 | 4.76 | 4.98 | 0.11 |
| 2 | 4.87 | 0.34 | 38 | 0.06 | 4.76 | 4.98 | 0.11 |
| 3 | 4.95 | 0.23 | 38 | 0.04 | 4.88 | 5.02 | 0.07 |
| 4 | 4.87 | 0.34 | 38 | 0.06 | 4.76 | 4.98 | 0.11 |
| 5 | 4.92 | 0.27 | 38 | 0.04 | 4.83 | 5.01 | 0.09 |
| 6 | 4.97 | 0.16 | 38 | 0.03 | 4.92 | 5.03 | 0.05 |

Table 7.4: The mean and standard error calculations in application's performance

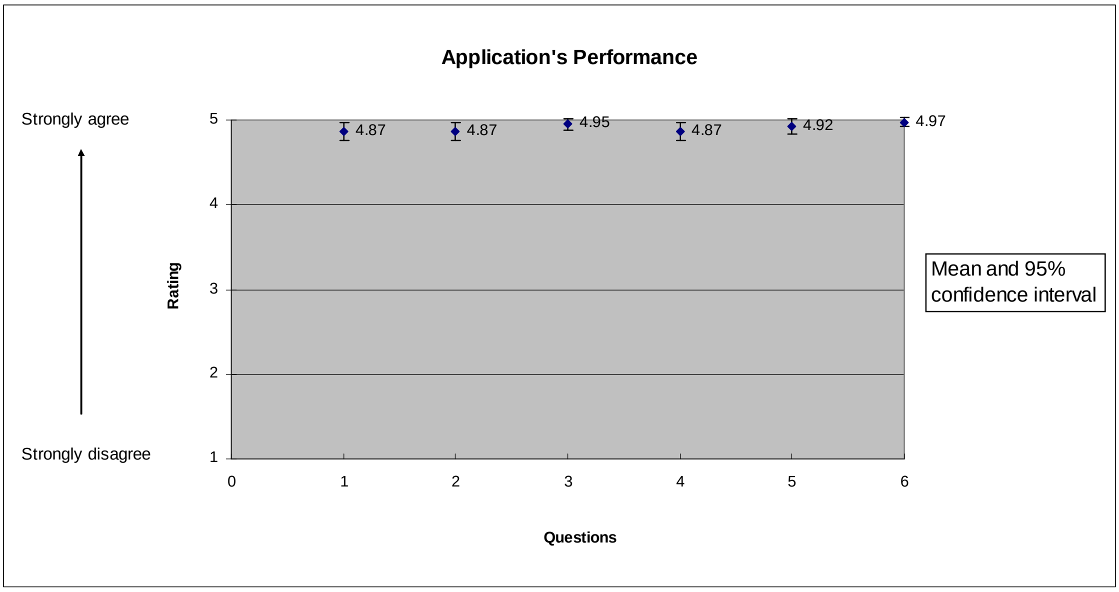


Figure 7.2: Mean and 95% confidence interval of the application's performance

The application's performance clearly has high statistical and practical ranking within the group that knowledge delivery enriched understanding of the animal and its habitat is rated very close to "strongly agree" (Q1), and the awareness of conservation of the animal and its habitat achieved a high level of ranking and agreement (Q2). In addition, the experience of using this product received almost the same rank of strong agreement in terms of entertainment (Q3), as the experience is fun.

The overall design of this application, including layout and interactive design, received very high ranking, and shows that the group agreed it is an acceptable design (Q4). This can be seen in Chart 7.2. The graphic also indicates the users have very high willingness to re-visit the production, as the rank is almost the same as strong agreement (Q5). The perception that the sound recorded in the habitat together with videos filming makes the user feel they were in the environment, obtained a very high level close to strong agreement (Q6).

#### 7.3.4.3 Comments of the subjects

Over 70% of the participants showed their strong willingness to comment on the experience of the creation. The comments were varied, and included praising the production in terms of creative design, in communicating the knowledge, conservation, and providing fun and joy. Moreover, several suggestions were on potential applications and future development. Some specific suggestions for improving and updating the production are also mentioned in the comment section. For easy understanding and analysis, the comments are sorted by technology's performance (see Table 7.5), application's performance (see Table 7.6), and recommendations on potential applications and investigations (see Table 7.7).

| Subject | Comments | Indicator of Performance in |
|---|---|---|
| 4 | 1. This is a creative inspiration technology<br>2. Enjoy the project because of its interactivity and fun | 1. Creative<br>2. Interactive Design |
| 5 | The connections are a bit similar to recognize the position and orientation | Spatial perception |
| 6 | The design is good. It made me feel I was in the environment. | Spatial perception |
| 10 | This is the first webpage I think let me experience a real environment. | Creative |
| 11 | I am very impressed with the site's layout and how the videos seamlessly work together. | Composition design and layout |
| 12 | This project makes the information so obvious and easy to access | Interactive Design and layout |
| 14 | The interaction is good. | Interactive Design |
| 15 | Really enjoy it. It's just like walking in that environment. | Spatial perception |
| 34 | It was very easy to navigate | Operation and spatial perception |
| 35 | The technology used is very new and provides the experience, a real-time environment | Creative |
| 38 | The project overall looked very innovative and natural | Creative and composition |

Table 7.5: The comments on technology's performance

| Subject | Comments | Performance |
|---|---|---|
| 4 | 1. Enjoy the project because of its interactivity and fun<br>2. Will definitely visit the site again | 1. Entertainment<br>2. Re-visit |
| 6 | 1. I learnt a lot about the monkey by this project<br>2. This project raised my attention to the conservation to the animal and environment | 1. Education<br>2. Conservation |
| 10 | The way of finding the information related to the monkey is fantastic, good. | Education and entertainment |
| 13 | The site is interesting and makes gaining knowledge more fun! | Education and entertainment |
| 23 | The sound is an excellent feature and makes the experience more "real" | Immersive |
| 25 | This project can be used in children's education to understand the animals | Education and conservation |
| 27 | Background voice made me feel more immersive | Immersive |
| 30 | I will introduce to my friends if this website existed | Re-visit |
| 31 | It is good technology. It will help to understand animal life closely and it also fun to have live forest experience | Education, conservation, and entertainment |
| 32 | The sounds from the environment sounded relax. Good! | Immersive |
| 33 | Very educational, having the visual effects | Education |
| 34 | It is a very useful program to find out information of the monkey | Education |
| 38 | The sound in the application sounded natural | Immersive |

Table 7.6: The comments on the requirement of the product

| Subject | Comments | Recommendation |
|---|---|---|
| 1 | Suggest adopting in tourism project | Application |
| 2 | Suggest adopting in interior design | Application |
| 3 | Recommended using high definition camera system | Investigation |
| 10 | 1. This project is good for people who cannot experience, such as the disabled and the patient who cannot go outside.<br>2. I would like to suggest using the technology in museums. | Application |
| 12 | This technology can have a good impact even on other areas such as economy, time, etc. | Application |
| 15 | I was thinking the interface can be designed fitted to variety application easily. | Investigation |
| 17 | I was really impressed with the technology. I think it can be used in advertising, the fun people have in roller coaster and could make memorable videos to take home. | Application |
| 22 | For the people who need the alive experience, such as online shopping, wedding and party. It is extremely important to apply this technology into the application. | Application |
| 23 | 1. To make the experience more immersive it would be good to have full-screen video display<br>2. 3D projection would be a good next step in development maybe even virtual reality | Applications and Investigations |
| 28 | 1. Video can be improved by resolution & lighting improvement<br>2. Widescreen can provided more surround experience<br>3. Information embedded on the main screen<br>4. This technology can be used to offer other kind of atmosphere e.g. shopping mall, concert hall, hotel ballrooms, tourist place<br>5. Advantage on improving customer experience and lower sales cost | Applications and Investigations |
| 33 | It can target all ages. | Investigations |
| 37 | Very interesting project with handy commercial applications. | Application |
| 14 | I would like to see more filming related to the information title | Investigation |

Table 7.7: The suggestion in future applications and investigations

### 7.3.5 Discussion

The results and comments give significant evidence to the Hypothesis that the production approached the requirement from end-users' points of view. The evidence comes from the very high and consistent ranking of the system on both technological issues and application related questions. Moreover, the 3D CG method is considered as important and necessity to the Panoramic Video and its application in development and refinement.

The method of filming the videos synchronized with recording the environmental sound led to the sound quality being given much praise, answering any concerns expressed in during testing of the 3D CG method (see 4.7.6 and Table 4.8). The comments of "The sound is an excellent feature and makes the experience more real" and "Background voice made me feel more immersive" provide the improvement evidences.

The concern of movement design between panoramas in the 3D CG method (see 4.8) was resolved by the use of pre-filmed video following the path. The comments of, "Really enjoy it. It's just like walking in that environment" gives the refinement evidence of success. In addition, the web interface with identified embedded elements and interactive design started from analysis and design with tests in the 3D CG method (see 4.5.3), leading to the success of the final design of the proposed production. This was also evidenced by the comments of, "Enjoy the project because of its interactivity and fun" and, "This project makes the information so obvious and easy to access". The important and necessity of adopting the 3D CG method (see Chapter Four) is apparent from the practical and statistical results (see 7.3.4), and the advantages to the filming and product creation (see 6.6).

The further refinement suggestion from the user during the pilot test (see 6.5) recommending the monkeys are displayed in the first frame is considered as one of the successful designs of the created production. The participants were excited at seeing the animals when the production is opened, and have a lot of queries about the animals and wanted to know more information. This revealed that the displayed first view frame of the application using panoramic video, which normally can be ignored as panoramic video can be operated in any viewing direction should in fact be noticed and will influence the interest and success of any application.

Besides the statistical and practical results which indicated the technology is effective and the application meets the requirements to a high level, a noticeable comment direct stated that, “It is good technology. It will help to understand animal life closely and it also fun to have live forest experience,” (see Table 7.6) gives the evidence that adopting Panoramic Video, as kind of VR, is a suitable selection to the production in this application domain.

The suggestion of further applications and investigations from the end users will be elucidated alongside the suggestions from the participants of the expert interviews in the concluding chapter.

### 7.4 **Expert interview - Qualitative methods**

Interviewing the experts who are working in the application domain has the advantages in not only ensure the credibility of content and therefore making findings stronger, but also for both parties to fully explore  the applications and use of the created technology. (see 3.2.2 for discussion of this method).

The strategy for visiting the zoo was formulated in production creating stage (see 6.2). It helped not only in consulting the contents of the proposed production (from both visited zoos, the Taipei Zoo and the Twycross Zoo), but also in establishing the research collaboration with the Twycross Zoo. It resulted in full co-operation which led to the event of the expert interview successfully taking place at Twycross Zoo. It also minimized the practical problems with the timing issues of zoos’ staffs in taking care of animals and enclosures as learnt from the seven contacted zoos (see Table 7.8).

| Zoo | Location | Distance | Website | Remark |
|---|---|---|---|---|
| Dudley Zoological Gardens | Dudley Zoo<br>2 The Broadway<br>Dudley, DY1 4QB | 53.9 mi – about 1 hour 4 mins | http://www.dudleyzoo.org.uk/home.htm | Email & Post |
| Hamerton Zoological Park | Hamerton Zoo Park<br>Hamerton<br>Nr Sawtry Cambs, PE28 5RE | 59.6 mi – about 1 hour 13 mins | http://www.hamertonzoopark.com/index.htm | Email & Post |
| Twycross Zoo | Burton Road<br>Atherstone, Warwickshire, CV9 3PX | 21.3 mi – about 47 mins | http://www.twycrosszoo.com/ | Email & Call |
| Woburn Safari Park | Woburn Safari Park<br>Woburn Park<br>Bedfordshire, MK 17 9QN | 57.9 mi – about 1 hour 9 mins | http://www.woburnsafari.co.uk/ | Email & Post |
| London Zoo | London Zoo<br>Regent's Park<br>NW1 4RY, London | 99.6 mi – about 1 hour 56 mins | http://www.zsl.org/zsl-london-zoo/ | Email & Post |
| Shoushan Zoo / Taiwan | Shoushan Zoo<br>No. 350, Wansou Road<br>Kusan district, Kaohsiung, Taiwan | Intercontinental | http://ksscenic.kcg.gov.tw/zoohtm/<br><br>Contact:<br>http://ksscenic.kcg.gov.tw/zoohtm/home30.htm | Email & Post |
| Taipei Zoo / Taiwan | Taipei Zoo<br>No. 30, Sec. 2, Xinguang Road<br>Taipei City, Taiwan | Intercontinental | http://english.taipei.gov.tw/zoo/index.jsp | Email & Call |

Table 7.8: Zoos of asking interview

### 7.4.1 The venue and experts recruitment

In case of any potential disturbance, the venue for the interview was arranged in a quiet conference room of Twycross Zoo. The interviewees from the zoo were specifically recruited from different backgrounds to ensure the widest range of points of view as to the application’s performance. The interviewees were recruited from three departments of the zoo: Education (researcher and lecturer), Information Technology (zoo’s web designer), and customer service management.

The zoologists’ points of view (researcher and lecturer) are potentially contributing to the determination of the performance level of the requirement of the application, which answer the contemporary roles of zoos, thus understanding the employment of the developed production on the zoo’s website. The viewpoint of the IT technicians working on the zoo’s website may donate more to technical parts of the production, and also increase the possibility of employing the production as part of the zoo’s website. The customer management department may offer the zoo visitors’ point of view of the production, and may indicate potential applications for the developed technologies. There were seven interviewees in total, including three zoologists (researcher and lecturer), two IT experts, and two customer service members of staff. The job position of the expert interviewees is listed in table 7.9. The interviewees listed on the table are numbered for confidentiality purposes. The procedure for interviewing the participants was done on a one-by-one basis. The sequence was arranged at the convenience of the zoo. It was requested that there be no discussion between the interviewees who attended the interview regarding the interview process, to prevent any sharing of opinion and potential bias.

| Subject and interview sequence | Job position in the zoo | Role in the zoo |
|---|---|---|
| 1 | Head of Research | Research and education |
| 2 | Head of education department | Education |
| 3 | Head of IT department | Web design |
| 4 | IT officer | Web design |
| 5 | Customer experience manager | Customer service |
| 6 | Director of communication | Customer service |
| 7 | Lecturer and researcher | Research and education |

Table 7.9: The background of the interviewees

### 7.4.2 Topics and progress

The main scope of the interview event was to provide affirmative evidence to Hypothesis Five (see 7.2) from experts working in the zoo. Topics related to the Hypothesis will be included. The web page layout with interactive design is important and will influence the intention of employment so is included in the topics. In addition, the interview also has the intention of unveiling more potential applications for adopting the created technology, and this too is included. The interview progressed in two parts, after giving an initial introduction to the purposes and process of the interview to each interviewee. The first part involved giving a presentation of the technology being operated and then letting the interviewee play with, and experience the production. The second part started with general questions and become more specific to the main purpose of determining the requirement performance, the application's performance, of the created project, and ended with eliciting more potential applications of the created technology. Table 7.10 shows the aims of the topics.

| Topic | Purposes |
|---|---|
| 1 | Understanding the reflection of the web page layout and interactive design |
| 2 | Knowing the benefits of adopting the project as part of zoo |
| 3 | Realizing the thinking of the way in communicating the knowledge of animal and its habitat |
| 4 | Realizing the though of the way in communicating the conservation message of animal and its habitat |
| 5 | Realizing the idea of the way in providing fun and joy when using the project |
| 6 | Understanding the issues of adopting the project |
| 7 | Extending more applications of the created technology in the domain |

Table 7.10: The purposes of the interview topics

The interview of each interviewee is conducted in 20-30 minutes and is recorded by digital recorder for analysis purposes. Each data set was kept safe and under protection, and was deleted after the analysis for reasons of confidentiality. Table 7.11 shows the interview process, with the intentions of each topic.

| Topic | Interview process | Probe or prompt |
| --- | --- | --- |
| 1. What's your impression of the project after the demonstration? | General questions | layout, interactive design, and animal related information presentation |
| 2. Thinking about the zoo website, what do you feel that this technology can offer? | | 1. What is good about having this as part of zoo's website? What is not good? 2. Advantages and disadvantages |
| 3. Do you think this medium is good at educating the public about animal habitats? | Thoughts on the three roles of zoo | 1. What potential do you think the project has in an education role? 2. The way to provide animal related information |
| 4. Do you think this medium is good at communicating conservation issues and the zoo's role in conservation? | | 1. What potential do you think the project has in a conservation role? 2. Will the observation of an animal and its habitat help people to understand the important of the protection? |
| 5. Do you think the application presented would entertain a visitor on your website? | | 1. What potential do you think the project has in an entertainment role? 2. Will it attract visitors? |
| 6. What would be your main consideration in adopting this project as part of the zoo website? | Comments on future development | What are the issues? Cost, time, or something else? |
| 7. Would you like to make any further comments about the project? | | 1. Can this technology help in the other interpretation applications in the zoo? 2. Any recommendations for other applications related to zoo and for the design, content etc. |

Table 7.11: The interview process and the contents

### 7.4.3 Results

The responses of the interviewees are sorted by each topic and can be seen in the tables below. The topics one to five, have posited a positive ("☺") or negative ("☹") mark to represent the opinion, and to ease tallying (see Table 7.12 to 7.16). Topics one and two are mainly for starting the interviews gently and acquiring the opinions of the web interface design after the interviewees have gained an impression of, and experienced using, the project. Topics from three to five (see Table 7.14 to 7. 16) are given for obtaining the opinions of the requirement performance of the production from the interviewees, which are related to Hypothesis Five. Topics six and seven are listed in table 7.17 and table 7.18 for understanding the concerns of adopting the proposed integrated application and acquiring more potential applications for adopting the created technology in this area.

| Subject | Response | Performance mark |
|---|---|---|
| 1 | 1. Beautiful and potentially very useful<br>2. Gives the impression of actually being there and gives control over what you do/where you go<br>3. Not like a video game, but allows exploration in sense of being there, I particular like walking to the next section. It really feels you are engaging in it<br>4. Very easy to use, very interactive<br>5. Lovely, absolutely lovely | ☺ |
| 2 | 1. Looks very useful for the organization<br>2. Lots of information<br>3. Very interactive, very nice and user -friendly | ☺ |
| 3 | 1. Fantastic, very good<br>2. Very impressive technology<br>3. Panning movie is new<br>4. The sound effect and visual effect are good | ☺ |
| 4 | 1. Really good idea<br>2. Like a game – makes you want to keep exploring | ☺ |
| 5 | 1. It's very good – like the real-life, moving footage of the environment that you can explore<br>2. Very interactive<br>3. The layout and interactive design looks good intuitive, natural understand to move around<br>4. Intuitive/natural operation | ☺ |
| 6 | 1. I like it very much<br>2. Like the sound, it feels as though you're there – you can hear what they sound like when they call<br>3. Interactivity is good<br>4. I think it's very interesting<br>5. I like the way you can find out more information | ☺ |
| 7 | 1. It is a very interesting idea<br>2. Nice information presentation and being able to see the animals is an interesting feature | ☺ |
| | | Result: Full positive (7 marks) |

Table 7.12: The interviewees response to topic one – the impression of the production

| Subject no. | Response | Performance mark |
|---|---|---|
| 1 | Two aspects would be useful:<br>One: for the zoo itself – visitors, especially schools, can plan days. It can offer a preview of attractions, the site and answer health and safety questions. It is a fun site, and would give publicity and advertise the zoo to attract visitors | ☺ |
| 2 | More useful and friendly to the users, especially for children and students, and anyone | ☺ |
| 3 | It will be very good to have this in our website. It's a great website for visitors before they come. Offers a "taster" of the zoo – will entice visitors and let they know what they will get here. They will look forward to visiting here. | ☺ |
| 4 | Would bring traffic to the site and offer a "teaser" of the zoo. They can see what they'll see when they come | ☺ |
| 5 | Useful to give a preview and as a "day planner" – builds anticipation | ☺ |
| 6 | Three aspects would be useful: one, Conservation – to show animals in their natural habitat and show good balance with captive animals and in their native country, two, this could also allow a virtual tour of the zoo, also can be used in learning the knowledge of animal and its habitat, and three: Education | ☺ |
| 7 | Very nice as it is not static, normally we have photograph of the animal only, this is not exciting for people to see, and attract people to see. This shows animals in their environment, and natural behaviours | ☺ |
| | | Result: Full positive (7 marks) |

Table 7.13: The interviewees' response to topic two – the offers of the technology to the zoo's website

| Subject no. | Response | Performance mark |
|---|---|---|
| 1 | Yes, very useful in educating particularly for wild/real-world conservation. It highlights why the zoo exists. It is NOT just a tourist attraction but for conservation | ☺ |
| 2 | Yes, it's good to look for things and find information. People absorb information better if they look for it then if you just put it there for them. "It is the kind of thing we should be doing". | ☺ |
| 3 | Definitely, you can see how they live, how they move around. The interactivity is good and especially will interest the children. They can see the animal and the interactive data involved. | ☺ |
| 4 | Yes, a lot of opportunities in the movie and the information to provide education purpose, also it is addictive | ☺ |
| 5 | Yes, fun to use and combines play with written information | ☺ |
| 6 | Yes, people are not aware of where all the animals come from so it would be good for them to understand the difficulties endangered species face and show damage of the environments, and equally to show projects in the wild | ☺ |
| 7 | Yes, potentially it can get people more interested and engaged, and look around the environment to get the information | ☺ |
| | | Result: Full positive (7 marks) |

Table 7.14: The interviewees reply to topic three – knowledge performance to the production

| Subject no. | Response | Performance mark |
|---|---|---|
| 1 | This media is good at communicating conservation issue. Also, children would particularly like it. People don't always appreciate why we have animals in zoos and this would explain it | ☺ |
| 2 | Yes, links the zoo with the real environment | ☺ |
| 3 | Obviously, the answer is yes. The interactivity is good – makes people want to read the information. Natural environment observation is attractive and raises the attention to the conservation issues. People can see what the zoo is trying to do | ☺ |
| 4 | Links the zoo with conservation – a "before and after". Yes, I do really like it. It provided a lot of opportunity to go back to see the conservation, go back and go back to see the natural habitat and know what we are doing. It's full of opportunities. | ☺ |
| 5 | Yes, real-life images/footage shows good and bad aspects that will help people to understand the issues and pay attention to the protection of animal and habitat. It has good way putting things in the front of people. | ☺ |
| 6 | People like to watch animal in nature habitat, the observation will raise people notice the animal and habitat protection | ☺ |
| 7 | It could be – animals in their own environment may stimulate interest in conservation issues overall. The view of watching animal in habitat will raise people's attention to animal and habitat protection | ☺ |
| | | Result: Full positive (7 marks) |

Table 7.15: The interviewees reply to topic four – conservation performance of the production

| Subject no. | Response | Performance mark |
|---|---|---|
| 1 | Entertaining, particularly for children, very engaging | ☺ |
| 2 | Oh yeah, it's the kind of thing that keeps people on the site as it is interactive | ☺ |
| 3 | Definitely, this provide a taster to come | ☺ |
| 4 | Yes, definitely entertain really, it has to be on the front page on the website | ☺ |
| 5 | Yes, it's fun and it's different from traditional websites. I believe it will keep people on the website for a quite long time to explore, and come back to visit. | ☺ |
| 6 | Yes, if it was on the website people would definitely use it. It would encourage visitors to the zoo, and encourage people to get more actively involved in conservation | ☺ |
| 7 | Yes, exactly, it's more fun/interesting than a photo and make a lot of prompts to visitors to visit | ☺ |
| | | Result: Full positive (7 marks) |

Table 7.16: The responses of interviewees to topic five – entertainment performance of the production

| Subject no. | Response | Issue |
|---|---|---|
| 1 | Download speed, compatibility with users' computers | Facilities |
| 2 | Who's going do it? Who's going to carry it out? Who's going to put the information together? | Project developer |
| 3 | Do not show too much, otherwise visitors may not come. It should be like a teaser | Contents design |
| 4 | It's great. It's fantastic but content should be limited to make sure visitors will still come | Contents design |
| 5 | Quality of the footage and easy to update as new animals arrive, also must offer full coverage of the zoo the exhibits | Contents design |
| 6 | Cost as Twycross is a charity. We have a very tight budget and website work is all done internally. The relevance of the information is vital. It should show the animals the zoo has and show the conservation projects e.g. the DR Congo bonobo sanctuary project. | Cost and contents design |
| 7 | The film contents and information you want to convey | Contents design |

Table 7.17: The replies of interviewees to topic six – main consideration in adopting this project as part of the zoo website

| Subject no. | Response | Future works |
|---|---|---|
| 1 | 1. Possible additional to it, higher levels of detail in the information and three levels of ability: Primary 4-8 years old, Secondary 11+ years old and Undergraduate.<br>2. There could be links to references and research projects.<br>3. Different levels of information in pop-up. In the same button, same set up but simply maybe three different level information buttons, which would be really useful. | Application and investigation |
| 2 | 1. Touch-screen in the front of enclosure, not just the website<br>2. Environment and conservation links. Links website and zoo. | Application and investigation |
| 3 | 1. Could be used for touch-screens next to the animal enclosures that people can see it beside, and instant know what it is and what they can do.<br>2. Day planner where the website allows visitors to make a custom map for their visit  an automatic route-planner | Application and investigation |
| 4 | Generated of enclosure map for day planner | Application |
| 5 | 1. Could be used for marketing term, to show the board room and conference facilities.<br>2. The walks between scenes are too long. Shorten these, or have a commentary to fill the time to keep the peoples' interest. | Application |
| 6 | 1. Larger "window" to display video<br>2. Re-design icons to make them relevant to the subject not just an **i** icon<br>**3.** More information, with a choice of knowledge level<br>4. More information regarding the zoo's role in conservation – introduce what zoo is doing to this animal. The message needs to be more explicit<br>5. Ability to do a "Virtual Tour" of the zoo so visitors could plan their day<br>6. Suggest, if possible, a text message to introduce the animal and its habitat before enter the panoramic video. This will enhance the performance of the project in the roles of education and conservation | Application and investigation |
| 7 | 1. The icons need to be more clear, not similar to the background, users will need to pan slow done to find the icons<br>2. Speed up the walking-through<br>3. Suggest adding a quick access menu to find information for people who just want to get the information and don't need to wait or spend time to find it<br>4. A mini-movie of each animal's behaviour when "social behaviour" icon is clicked<br>5. Include research links to the animal | Investigation |

Table 7.18: The responses of interviewees to topic seven - recommendations

The marks collected from the interviewees are entirely positive (seven positive marks) for the topics one to five, shows the web page interface design is practicable and highly acceptable (see Table 7.12), and reveal a strong intention to adopt the project as part of zoo's website (see Table 7.13). The subject who is the head of the IT department gives further evidence, indicating that, "It will be very good to have this in our website". In addition, the result of the main determination, which is the requirement performance of the project (see Table 7.14, 7.15, and 7.16) gives confirmative evidence to Hypothesis Five. The subject who is the head of education revealed that, "It is the kind of thing we should be doing", the subject who is the head of research indicated that, "very useful in educating particularly for wild/real-world conservation", and the customer experience manager and the director of communication demonstrated that, "Yes, it's fun and it's different from traditional website" and, "Yes, if it was on the website people would definitely use it", thus offering the evidence of the entertainment performance. The determination of the entertainment performance of the project (see topic five) also elicited the intention to use in the zoo's web page, which currently uses texts and photos, e.g. one subject stated, "Yes, exactly, it's more fun/interesting than a photo and make a lot of prompts to visitors to visit".

There are many responses regarding the recommendations and the future work towards the topics six and seven (see Table 7.17 and 7.18), which are related to the recommendation and future works of the research, and these will be discussed and interpreted together with suggestions from end-users, in detail in Chapter Eight.

### 7.4.3 Discussion

The interviews fully achieved the purpose and expectation of not only providing evidence to confirm Hypothesis Five through experts' opinions, but also extending the future studies in the proposed application domain.

During the event, the interviewees presented a lot of interest in the developed technology for use by the zoo, and to the adoption of the production to the zoo's website, which currently uses photos and texts for delivering animal and animal-related information. Interviewees who represented researchers and educators of the zoo invited the author to publish papers in a zoological journal to reveal the developed technology and the production, which demonstrates the cross-disciplinary value of the research between the technology and zoological domains. Expert interviews not only give evidence that the production meets the intended requirements, but they also reveal other potential employments for the technology (see 3.2). This confirms that it is important and necessary to have expert interviews in the evaluation stage.

## 7.5 **Summary of results**

Table 7.19 shows the combination of the requirement performance determination results of the production, for the two sets of evaluation methods, indicating that both are in very high agreement to Hypothesis Five: The project, the virtual zoo, communicates the knowledge, conservation, and entertainment to the user well. It does this in relation to the general roles of the zoo for consistency with previous discussion.

| | Knowledge delivery | Conservation conveyance | Entertainment |
|---|---|---|---|
| End-User Testing | Highly agree (Chart 7.2: Question 1) | Highly agree (Chart 7.2: Question 2) | Highly agree (Chart 7.2: Question 3) |
| Expert Interview | Strongly agree (Table 7.14: Topic 3) | Strongly agree (Table 7.15: Topic 4) | Strongly agree(Table 7.16: Topic 5) |
| Result | Very high agreement | | |

Table 7.19: Performance in communicating knowledge, conservation, and entertainment

Comments and responses from end-users and interviewees give many recommendations for further and future investigations on the technology and the application. Table 7.20 shows the areas for obtaining the feedback in the two sets of evaluation methods. The feedback will be categorized in the concluding chapter.

| | User Testing | Expert Interview |
|---|---|---|
| Recommendation and future works | Comments (Table 7.7) | Topic 2 (Table 7.13) |
| | | Topic 6 (Table 7.17) |
| | | Topic 7 (Table 7.18) |

Table 7.20: The areas of obtaining further investigations on the two sets of evaluation method

The web interface generated from the Multimedia Design Model (see 4.5.3) is approved by the high acceptance of the production from both the end-users and the experts, and the zoo has a strong willingness to adopt the project as part of the zoo's website (see Table 7.12 and 7.13). Table 7.21 shows the combination of the two sets of evaluation methods on the web interface design received very agreement that it is well designed.

| | Web page layout with interactive design is well designed |
|---|---|
| End-User Testing | Highly agree to "It was easy to find the object" (Question 4: Chart 7.1) |
| | Highly agree to "the overall design of this application was good" (Question 4: Chart 7.2) |
| | Strongly agree (Comments: Table 7.5 and 7.6) |
| Expert Interview | Strongly agree (Table 7.12: Topic 1) |
| Result | Very agree |

Table 7.21: The web interface design is very well designed, as agreed by both end-users and experts

Besides the above combination results of the two sets of evaluation, the end-user testing also included evaluating the proposed design method, which was tested and proved to be highly effective when using the 3D CG method (see 4.7) to create Panoramic Video. The results obtained show the design method was also successful in obtaining optimal videos' editing and stitching, acceptable panning control, and effective spatial recognition, such as position and orientation, when navigating in scenes of the created Panoramic Video of the production (see 7.3.4.1).

### 7.6 Conclusion

This chapter has been concerned with the acquisition of practical and statistical results on determining the application's performance level of the requirement. In addition, the importance and necessity of testing the design method using videos obtained by the 3D CG simulation method prior to videos filmed in the real environment, which is the animal's habitat, and adopting expert interview along with end-user testing to the final production evaluation has been confirmed.

Findings from the preceding analysis of conditions from the two sets of evaluation methods can respond to the purposes of this production evaluation, and can be concluded as follows:

Firstly, the production of the proposed integrated application achieved the production requirement that the project is communicating knowledge, conservation, and entertainment well to the end-users and experts of the application domain (see Table 7.19). This reveals the research has successfully approached a practicable integrated application of the created Panoramic Video, that virtual zoo.

Secondly, the interface design received highly agreement that it is well designed from both end-users and experts (see Table 7.21), and this erases the bias of the adopted web page layout with interactive design, developed and determined by the author only (see 4.5.3.2). The results reveal the research has successfully approached a practicable interface design of a web-based integrated application, that virtual zoo. Many comments and opinions on this can be seen in sections 7.3.4.3 and 7.4.3, and emphasise the implementation.

Thirdly, the proposed design methods, e.g. the DO, the panning control, and the Image Channel (see 4.5), tested using videos obtained by the 3D CG simulation method and later adopted in filming the real environment, which is the animal's habitat, both have the same approach for achieving optimal resolution in editing and stitching with acceptable panning control of Panoramic Video, and good orientation perception and recognition in navigating in scenes, as evidenced during user testing (see 7.3.4.1). This reveals the research has successfully identified new methods to create optimal Panoramic Video with acceptable panning control and obtained good orientation when navigating in scenes of the proposed production, the virtual zoo.

The results of the evaluation indicate the 3D CG idea is not only effective in terms of cost and time to create the panoramic video (see Chapter Six), but also successful in terms of guidance to develop the proposed integrated production, that virtual zoo (7.3.5). This reveals affirmative evidence that videos obtained by the 3D CG method to deal with proposed design method prior the real production creation, have the great advantage in developing panoramic video and applications.

The results of the evaluation also indicate the two mixed sets of evaluation methods have great advantages of not only obtaining wider and deeper understanding of the production to the requirements, but also in extending the research in the proposed application domain and others (see 7.3.5 and 7.4.2). This reveals the importance and necessity of adopting end-users testing and expert interviews in the proposed production evaluation.

Finally, the author was pleased to receive two unexpected e-mails after the interview event, one directly from the zoo, the other forwarded by the supervisors of the research, confirming the success of using this production, the integrated application of web-based panoramic video VR, in the application domain (see **Appendix IV (3)**). The e-mails expressed a high willingness to continue the research and adopt the production in the zoo's website.

The next chapter is going to summarise the overall studies of the research, including the aims, achievements and contributions to knowledge. In addition, the recommendations and future works will be provided.

# Chapter Eight: Conclusions and Recommendations

## 8.1 Conclusions

People have always been curious about nature. There have been many attempts to recreate the experience of being in a particular place, by having a panoramic view. The Panoramic Video, as a dynamic panorama VR, has been interpreted as a kind of Virtual Reality technology to create virtual environments which provide users with the ability to look around and pick the direction of view in a dynamic retrieved real scene, potentially fulfilling the human interest and curiosity about nature (see 1.1).

A web-based Panoramic Video VR is an idea for upgrading the functionality of the recreated scenes of Panoramic Video which can be delivered to anywhere in the world, through the World Wide Web. Web-based Panoramic Video VR, which is an integrated application of Panoramic Video posted on the web was found, after an initial study into the technology and application development, to be facing several major concerns, e.g. resolution defects caused by the video/s composition method and panning control influencing the operation of the Panoramic Video, disorientation issues when navigating in scene with web interface design, and requirement acquirement, with the performance level of the application applied to it. Section 1.2 outlined the motivation for carrying out the research and forming the aims of the research.

The aims of the research (see 1.3) are:

**Aim one**: To investigate innovative methods to create panoramic video with regard to optimal resolution in editing and stitching, and acceptable panning control.

**Aim two**: To investigate creative techniques to improve the disorientation issue when navigating in scene of panoramic video, with practicable interface design of a web-based integrated application.

**Aim three**: To develop and examine an emerging and potential web-based integrated application, virtual zoo, of panoramic video to the production requirement.

To achieve these aims, the study started with a wide literature review of the technology (chapter 2) and characterised the issues in detail and identified some limitations of previous work. It was noticed that many former researchers faced practical problems when dealing with these issues, such as bias and distrusted data collection, cost and time constraints, lighting and weather issues, and video/s capture system design and construction (see 3.2.1).

A modified method for developing panoramic video VR and application was proposed, namely Twin Cycle, adopting video/s generated in a 3D CG simulation world method, to test the proposed design method, and expert interview together with end user testing into the process of developing panoramic video and applications. Section 3.2 detailed the adopted methodology of the research, and section 3.3 outlined the five phases of the framework based on the process of the Twin Cycle of the research. The phases were designed to deal with the aims of the research in a logical order from technology first, then through to the application.

Table 8.1 categorises the phases of the research framework, linking the chapters of the thesis and objectives of the research (see 1.4) to the aims of the research, to enable clear interpretation of the process of the study, and the key outcomes.

| The research framework | Chapter | The research objectives | The research aims | | |
|---|---|---|---|---|---|
| | | | One | Two | Three |
| Phase One: documentary research on the technologies and problems to be addressed | Two | 1. To undertake a literature review of the technologies which focus on panorama evolvement, and address the issues of the current technologies of panoramic video | ⦿ | ⦿ | ⦿ |
| Phase Two: experiments to test the proposed methods to deal with the issues by using videos obtained in 3D CG simulation environments | Four | 2. To investigate a design model for developing the integration of web interfaces | | ⦿ | ⦿ |
| | Four | 3. To investigate and test innovative methods for creating panoramic video with optimal resolution and panning control by using videos obtained in 3D CG world method | ⦿ | | |
| | Four | 4. To investigate and test creative technology of in-scene navigation by using videos obtained in 3D CG world idea | | ⦿ | |
| | Four | 5. To determine the necessity of recommended embedded elements, which enhance information and spatial recognition by videos obtained in 3D CG world idea | | ⦿ | ⦿ |
| Phase Three: studying the interest and the emergent application domain to obtain the production requirement | Five | 6. To review the relevant literature on the application domain, that is the zoo, with particular focus on emergence and requirement of the proposed production | | | ⦿ |
| Phase Four: developing the production | Six | 7. To identify the practical requirement of the proposed production through zoo visits | | | ⦿ |
| | Six | 8. To create the proposed integrated application, virtual zoo, using video/s obtained in the selected animal's habitat (natural environment) based on the tested design method for creating and improving the panoramic video with web-based interface design developed in the 3D CG world idea | ⦿ | ⦿ | ⦿ |
| Phase Five: evaluating the created production and giving recommendations and identifying future investigations | Seven | 9. To evaluate the created virtual zoo in terms of the requirement performance through end user testing and expert interview, and also evaluate the design method with web-based interface design in the created panoramic video through the same participants of the user testing (Qualitative and Quantitative methods) | ⦿ | ⦿ | ⦿ |
| | Seven | 10. To identify more potential employments of the created technologies both in zoos and other fields | | | ⦿ |

Table 8.1: The relationship of phases, chapters, objectives, and aims of the research

The implementation of aim one (see Table 8.1) started by understanding the issues of the possible technologies for image capturing and composition.

The study on the possible technologies for image capture found that single camera systems were not appropriate for reasons of resolution and artefacts caused by warping the image to suit the view port (see 2.4.3.1 and 2.10.1). However, multi camera systems are revealed as better resolution after videos composition, but introduced their own problems relating to video composition method (see 2.10.1 and Table 2.3), and the author went on to find a way of reducing stitch artefacts and edge of the frame distortion. A video stitching method, namely the Direct Overlap (DO), was proposed, which has no treatment through transforming and reconstructing, and involves the overlapping and pasting of the double filming fields of adjacent videos (see 4.5.1). A virtual mesh was used for alignment and stitching analysis of the DO method (see 4.6). The system was proven by user testing, using video acquired in the 3D CG environment (see 4.7.3), and in the real environment (see 7.3), to have successfully achieved the aim of providing optimal resolution. The perspective looked natural and the stitching of videos was generally acceptable through the creation of a new composition method, the DO, resolving the highlighted resolution and stitching problems.

The technology study also indicated that panoramic video was not always easy to pan around (redirect point of view), and this is a frequently noticed problem (see 2.10.2). The panning operation is the basic feature (see 2.6.1) of panoramic video, and will latently influence the usability of any integrated applications using an improperly designed panning speed. However, previous researchers have failed to test it practically and the author went on to design an easy panning manipulation system and then demonstrate its validity. A code was written for the panoramic video created by the DO method, to solve the identified panning control issues, and a Ball Tracking (BT) method for testing it developed (see 4.7.4). The system have successfully achieved the aim of creating an effective panning control operation allowing easy manipulation of the movement of the view, This was confirmed by user testing, using video acquired in the 3D CG environment by the BT method (see 4.7.4) and in the real environment operation (see 7.3.4.1).

To achieve aim two (see Table 8.1), the study started with a wide literature review (see chapter Two) of the technology in order to understand the issues, and then proposed new methods (see Chapter Four) for better orientation and generating a feasible web interface by investigating a design model (see 4.5.3 and Chapter Six). These were then tested (see Chapter Four and Seven) to assess their validity.

The literature study indicated that the Hotspot design (see 2.6.3) is the common method used to navigate in scenes of panoramic video, but has spatial recognition issues (see 2.10.3), making it more difficult for users to find their way around, and their position in, the virtual environment. This motivated the author to investigate a new navigation method, titled Image Channel, for the orientation solution. The Image Channel concept was then proposed and created to solve the identified disorientation issues. Image Channel uses two sequences of pre-videoed images (back and forth) that show the path between scenes, and positions them between two panoramic videos for traversing (see 4.5.2). The Image Channel proved to have successfully achieved the aim of creating an effective navigation in scenes method, having first been tested in comparison with the Hotspot method using videos acquired in the CG environment, (4.7.5), and then by itself utilizing videos obtained in the real environment (see 7.3). During testing, the method received a high level of agreement that the orientation issue had been improved through the Image Channel method, in respect that it was easy for a user to recognize their position and to understand their orientation within the group (see 4.7.5.3 and 7.3.4.1).

The literature review also has the great benefit for understanding the web interface design for the application of the web-based panorama VR (see 2.8) by showing that the web page layouts are varied, and that elements embedded into the web-based integration such as annotations, maps with direction guides, tags, and audio are recommended by former researchers (see 2.9) for presenting additional information and spatial recognition. The web interface design with these elements needed to be tested for their practicability and usability (see 2.10.4) before being put into the application. However, there are no direct web interface design references for the proposed integrated application, and the author went on to provide the solution by analysing the current panorama VR applications using four phases of the Multimedia Design Model process: analysis, design, production and evaluation, to test the necessity of embedded interactive elements.

The initial designed web interface with recommended embedded elements was tested with videos acquired in the 3D CG environment, using both the Hotspot and the Image Channel navigation styles of panoramic video (see 4.7.6). This test looked at how recommended additional elements could be embedded, but not what they should be, and revealed that no map or orientation guidance is needed for the Image Channel style. The key objective findings of the web interface development is that the very high rating value and degree of agreement with the testing group for orientation of Image Channel without the map being equal to map based systems (see 4.8.1). This tested result guided the final web interface design in adopting an integrated Image Channel navigation style of panoramic video, preventing the complex programme design of embedding maps and orientation guidance. The website was created (see 6.4), and prove to have successfully achieved the aim of creating a practicable web interface design, having been tested using videos acquired in the real environment, which is the selected animal's habitat, with end users and expert interviews, revealed the web page layout with interactive design is well designed and easy to find information (see Table 7.21).

Aim three was concerned with developing the virtual zoo. The research was concerned initially in reviewing the current application of web-based panorama VR and in collecting knowledge by studying the proposed application domain, the zoo, emerged as the potential employment of the proposed web-based integrated application.

The study of zoos (see Chapter Five) indicated they are trying to provide the most realistic habitat with animals to exhibit and visitors are interesting in learning about the animals, their habitat, behaviour, and conservation status. Enabling visitors to see real animals in habitat closer emerged as the proposed integrated application for production which had the capability for displaying the natural environment with additional information (see 2.8). Moreover, the analysis of the efforts of current projects (see 5.7), included zoos' website in virtual zoological information delivery by Multimedia and VR emphasised the requirement for adopting an integrated web-based, interactive, and navigable dynamic natural environments (see Table 3.1) with information embedded (see 5.5).

Virtual information resources as proposed above can satisfy the intention of zoos and the requirement of people, and has great advantage for improving the zoos' website (see 5.8). In addition, the study of zoo (see 5.3) and the practical opinions obtained by zoo visits (see 6.2) also indicated the roles of zoos were mostly in communicating the knowledge and conservation of animals and their habitats, and entertaining the visitors (see 5.3): all these key roles of a zoo, formed a useful framework to evaluate the performance of the proposed production in the areas of education, entertainment and conservation. Direct collaboration between the author and Twycross Zoo was achieved and this framework was agreed to be appropriate (see 6.2 and **Appendix IV (2**)).

A virtual zoo production using video acquired in the selected animal's habitat environment was created, which adopted the approached design method (see 6.4). This was then tested against the generated hypotheses of production requirements (see 7.2). Having been tested with end users and expert interviews, the production confirmed (see 7.5) to have successfully achieved the aim of developing and examining a practicable web-base integrated application, virtual zoo, of panoramic video by communicating knowledge and conservation information, with fun and enjoyment for users, as shown by the evidence listed in the test results (see Table 7.19). Further studies were obtained and categorized in the tables of section 8.4 for reference. Two emails sent by the interviewed zoos emphasised the achievement of the aim and confirmed the employment to the created production (see **Appendix IV (3)**).

The proposed Twin-Cycle method was found to be a useful technique to test and implement an effective design for the technology of a Panoramic Video and the production of a virtual zoo. The advantages that it offered were the ability to test camera configurations and the production method away from the real environment where experimentation would have been costly and more time consuming, and to erase bias of the product-evaluation without expending more potential investigations. Using the 3D CG environment, (see 4.7) the author was able to experiment and come up with the Direct Overlap (DO) method for stitching the video and also to evaluate a technique for controlling panning in the environment. In addition, the proposed Image Channel method for orientation solution and the generated web interface were able to be experimented with and tested prior to the final production and creation process. The real filming practices provided the evidence for saving time and reducing costs as the digital video cameras and the video-capturing rig were easy to setup up and build because of they were simulated by the 3D CG method. The product evaluation included expert interview and end user testing (see 7.2) which enabled the author to erase bias of the product-evaluation which is generally assessed by developers' self-determination and informal user testing, and receiving more future studies to the proposed domain and others of using the developed technology emphasised the advantage and necessity of adopting the mix assessment method. The above statements give affirmative evidence that the refined and adopted Twin-Cycle method properly fit the needs of the research.

The achievements and the contributions to knowledge (see 8.2) of the research, the limitation of the current works (see 8.3), and the recommendations (see 8.4) for further study are elucidated in the following sections of the chapter.

## 8.2 Achievements of the research and outcomes contributing to knowledge

The three aims of the research were met and listed in 1 to 5 below, further contributions to knowledge not specified in the original aims are listed in 6 to 8 below, and table 8.2 shows the achievements/outcomes and their relationship to the objectives:

1. A new proposed method, namely the Direct Overlap (DO), to compose the panoramic video (see 4.5.1).

2. A tested practical method, namely a ball tracking (BT) calibration routine, to determine the manipulation of the panning control of panoramic video (see 4.7.4).

3. An innovative approved navigation in-scene method, titled "Image Channel", to increase the spatial recognition such as way-finding method through panoramic video (see 4.5.2).

4. A new and practicable interface design used in the application domain (see 4.5.3).

5. An approved novel and useful production to communicate knowledge of, and to raise concerns about, the conservation of animals and habitat, while also being fun to use (see 7.5).

6. Evidence that no on-screen map is required in the production of panoramic video if using the Image Channel navigation style, as a result maximising the screen space that can be devoted to being immersed in the environment, and improving presence (see 4.6.3 and 4.6.4).

7. Establishment of a cross-disciplinary link between the domains of Multimedia integrated panoramic video VR technology and zoology (see 7.5).

8. A new tested, practicable and modified methodology for developing panoramic video and applications (see 3.2).

| The achievements/ outcomes | Objectives of the research (see Table 8.1 and 1.4) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | ⦿ | | ⦿ | | | | | ⦿ | ⦿ |
| 2 | ⦿ | | ⦿ | | | | | ⦿ | ⦿ |
| 3 | ⦿ | ⦿ | | ⦿ | | | | ⦿ | ⦿ |
| 4 | ⦿ | ⦿ | | | ⦿ | | | ⦿ | ⦿ |
| 5 | ⦿ | ⦿ | | | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ |
| 6 | ⦿ | ⦿ | | | ⦿ | | | ⦿ | ⦿ |
| 7 | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ |
| 8 | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ | ⦿ |

Table 8.2: The achievements and outcomes were obtained by the objectives of the research

Further evidence that the aims of the research have been achieved is evidenced by the refereed papers published within the process of the research period, listed in table 8.3. In particular, the Image Channel project and the virtual zoo production were accepted for exhibition in the CREATE showcase in London in 2008, and the TELDAP exhibition in Taiwan in 2009. A lecturer job in a national university of Taiwan in order to continue the study has been offered to the author after attending the TELDAP exhibition, which can be treated as the main achievement of the research to the author personally. Moreover, the collaboration received by Twycross Zoo can be looked upon as the one of the successful achievements in cross-disciplinary co-operation. Two unexpected e-mails sent by the zoo after the interview event to the author and to the supervisors of the research, expressed a high willingness to continue research and adopt the production in the zoo’s website (see **Appendix IV (3)**).

| Item | Paper title / venue | Relation to the aim |
|---|---|---|
| 1 | “Online Panoramic Video approach by Multimedia Design” / IPVC conference, USA , 2008 | Aim One |
| 2 | “Online Navigation in Environments Using Panoramic Video” / ZA-WWW conference, S.A./2008 | Aim One |
| 3 | "Image Channel" in Panoramic Video: a method to improve presence in virtual environments”/ CREATE showcase and conference, London, 2008 | Aim Two |
| 4 | “An Investigation into Web-based Panoramic Video VR Environments Applied to Zoological Information” / TELDAP exhibition and conference, Taiwan, 2009 | Aim Three |

Table 8.3: The achievements (see **Appendix III**) related to the aims of the research

### 8.3 Limitations of current work

There are certain issues which emerged during the research process:

1. The interface and icon design of the production could be improved and expanded even more for specific target customers as the user testing and expert interviews showed that, although the production met the requirements, some people prefer different styles of interface text/graphics (Table 7.7 and 7.18), but only one style was tested for the research.

2. During the design method tested in 3D CG (see 4.7) and real environment (see 6.4), the 3D CG idea is approved as being very useful in developing panoramic video and application, but it takes a lot of time to create virtual environment. A suggestion for a solution is that researchers may use off-the-shelf virtual environments to test their design methods, reducing costs and time when testing and making a real rig for the real world, but more evidences are needed to validate the method.

3. In the events of user testing study (see 4.7 and 7.3), the limited opportunities for personal social interaction and the students' busy term-time schedule at the time the testing took place, were the two main issues when trying to recruit subjects.

4. The ball tracking (BT) method, (see 4.7.4) is satisfactory to determine the panning control in the context of the research, but needs more evidence to determine whether it is suitable for other applications. This method will be carried on in the future studies.

5. The questions in the questionnaires are limited and could be extended more to other areas of the research, e.g. sound quality determination, and to different investigation purposes (Chapter Four and Seven).

6. Although the research knew Flash could stream video, the download speed needs to be determined as this will increase the availability of the product online, according to the responses of an interviewee (see Table 7.17). A solution of cutting down the file size by reducing the video rate in terms of the number of images in one single second while retaining acceptable video playing quality could be possible, but the exact details of caching scenes for this to take place was not considered. Whether this may be good for increasing download speeds should be investigated.

7. Sound is an important element (Chapter Four and Seven) for providing an immersive presence, and the production needs more specialists in this field to refine this aspect.

8. The created panoramic video is not perfect because all camera lenses have some distortion, but from a practical point of view, and the statistical results, it is thought to be good (see 7.3.4.1).

9. The adopted Twin Cycle method in developing the panoramic video and application has been tested as practicable to the proposed application domain compared to general methods (see 8.1), but needs to be tested in different panoramic video creation and application areas, in an effort to develop a widely applicable method.

10. Whether new features for increasing engagement of the senses such as smell and visual 3D would increase presence performance could be investigated, but need extra specialists.

11. The research is sponsored by the Taiwan Government for three years. This was a constraint on the research in terms of time.

12. Video quality can be upgraded if the digital video camera selection is not constrained (Chapter Five).

13. Arranging the visit to, and subsequent expert interviews at, zoos (see 6.2) is time-consuming to the research and often frustrating to undertake, as the zoos' staff are always busy because the exhibits are live and need to be looked after. This problem could probably have been reduced if the collaboration relationship had been built at an earlier stage of the research.

14. The making of the video capturing rig (see 6.3.3) took a long time, and can be made more portable and commercialized if the research involved a team investigating the hardware and the firmware.

15. The fields-trials testing the design method in different natural scenes (see 6.3.4) uses self-determination by the author, thus has bias and therefore needed more evaluation evidence.

Although there were limitations of the investigation, the author had overcome these above factors to achieve the aims of the research (see 8.2). The limitations stated above mainly raise more potential investigations to researchers and developers who are interested in, or working on, the technology and its application, and serve as good points of reference.

## 8.4 Recommendations for future work

The recommendations for future work are mainly directly suggested by participants in the end-user testing and interviewees in the expert interviews (Chapter Seven). These are distributed into two sections including studies on technologies and on applications, which could take the current research further.

### 8.4.1 The technologies

The suggestions for further investigation into the developed technology are categorized by the application product, which is the created virtual zoo, (see table 8.3) and improving and developing the technologies (see table 8.4).

| No. | Content | Recommender |
|---|---|---|
| 1 | Three levels of detail in the information and three levels of ability: Primary 4-8 years old, Secondary 11+ years old, and Undergraduate | Interviewee |
| 2 | Include research links to each animal | Interviewee |
| 3 | Different levels of information pop up in the same button. Same set up but maybe three different level information buttons, which would be really useful. | Interviewee |
| 4 | Investigate the cost | Interviewee |
| 5 | Link the website and the zoo | Interviewee |
| 6. | Shorten the walk distance or have a commentary to fill the time to keep the visitors' interest | Interviewee |
| 7 | More information regarding the zoo's roles in conservation – introduce what the zoo is doing for this animal. | Interviewee |
| 8 | A text message to introduce the animal and its habitat before entering the panoramic video. This will enhance the performance of the project in the roles of education and conservation | Interviewee |
| 9 | Adding a quick access menu to find information for people who just want to get the information and do not want to wait or spend time finding it | Interviewee |
| 10 | A mini-movie of the animal's behaviour not just an image of the animal displayed in the information area when "social behaviour" icon is clicked | Interviewee |
| 11 | The icons need to be more clear, not similar to the background, and the design should fit to the contents of the display information | Interviewee |
| 12 | Full screen or large, wide video display | User and interviewee |

Table 8.3: Recommendations in refining the production, virtual zoo

| No | Content | Recommender |
|---|---|---|
| 1 | Investigate more effect of sound quality according to difference scenes | User |
| 2 | 3D projection | User |

Table 8.4: Recommendations in developing and improving the technologies

### 8.4.2 The applications

The suggestions for more potential employments of the created technology of panoramic video are listed in the application domain of zoo (see 8.5), and in other areas (see Table 8.6).

| Item | Content | Recommender |
|---|---|---|
| 1 | Projects that focus on children's education to help them understand the animals | User and interviewee |
| 2 | Touch-screen system in the front of enclosure, not just the website to provide additional information to zoo visitors | Interviewee |
| 3 | A Virtual Tour project of the zoo so visitors could plan their day. This may generate a visitor map after using it | Interviewee |
| 4 | A project for use as a marketing strategy, to show the board room and conference facilities the zoo has to offer | Interviewee |

Table 8.5: The potential employment projects of the created technology for zoos

| Item | Content | Recommender |
|---|---|---|
| 1 | Tourism | User and interviewee |
| 2 | Interior Design | User |
| 3 | Museum | User |
| 4 | Roller coaster | User |
| 5 | Shopping mall | User |
| 6 | Wedding | User |
| 7 | Party | User |
| 8 | Concert hall | User |
| 9 | Hotel ballroom | User |
| 10 | Any application that needs visual effects | User |

Table 8.6: The suggested projects for using the technologies in other domains

The author plans to start investigating the application of the created Panoramic Video production in the context of a museum application as this has a close relationship to the research - a zoo is a kind of museum. The author also plans to investigate adopting the video acquired in 3D CG world to test single camera systems of panoramic video, to compose spherical panoramic video, to integrate Head Mount Display (HMD) as display hardware, and to develop stereo panoramic video in the very near future. In addition, full screen and large-scale panoramic video will be developed soon as well.

## 8.5 Final summary

This chapter reports the overall conclusions of the research and the major results of the research findings. The achievements and outcomes of the research related to the research aims and objectives are described. The achievements include published papers and exhibited projects that relate to the aims of the research, and the outcomes that contribute to the knowledge are listed.

Although there are some limitations, the research has accomplished the intended aims of creating an optimal panoramic video with an easy to manipulate panning control. The created panoramic video also completes the requirement of improving the repeatedly reported issue of disorientation, by proposing a new navigation method. Moreover, the practicable production, the virtual zoo, completes the final task, namely the production of a valuable application meeting high level performance requirements.

The volume of recommendations received from the participants of the product evaluation and the very positive responses to the work overall have been an inspiration to the author to complete further study in the field. The cross-disciplinary collaboration between design, zoology and technology has been established, and there are expected to be more contributions in this area in the future.

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## APPENDICES

**APPENDIX I - QUESTIONNAIRES**

# APPENDIX I (1)

## 3D CG testing (Chapter Four) - Questionnaire

# Orientation Script

Dear participant,

I, Wu-Hsiung Chen, am a PhD student in the Faculty of Art and Design at De Montfort University. I am doing research which involves improving the Internet technologies which let people look at the environment in which an animal lives with a particular focus on information provision. I need your help to answer the following questions: how effective is the technology; how can people best use it and interact with it; and will the virtual environment be engaging and interesting.

I will be working with you today throughout the test. This process may take 40 minutes. There are two parts in each task:

I. Part one – to become familiar with the technologies
You will have the opportunity to play with the technologies that I want you to look at.

II. Part two – a task will be given to you
You will complete a series of tasks and fill in a questionnaire about your experience with the technologies.

All replies will be confidential and kept anonymous. If you are uncomfortable or stressed during the test, you can quit at any time.

The test is going to proceed. Do you have any questions before we start?

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A Survey investigating online Panoramic Video to improve online Zoological Data access

Name (optional): ______________________________ Gender: M / F _______

Occupation:__________________ Age: ☐ 18 to 25 ☐26 to 33 ☐34 to 40 ☐over 40

Average online hours per week: ☐ 0 to 5 ☐6 to 10 ☐11 to 15☐16 and up

Experienced in Panorama VR: ☐ Yes ☐ No

**Task 1**: How the panoramas are made

Task description: look at the display on the screen and try to find the stitched or connecting area; afterward please answer the questionnaire attached. Your comments on the task are welcome.

Please Rate the task using the following rating code:
5=strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1= strongly disagree

| Ques. | criteria | Rating |
|---|---|---|
| 1 | The perspective looked natural | ☺ 5 4 3 2 1 ☹ |
| 2 | The stitching of videos was generally acceptable | ☺ 5 4 3 2 1 ☹ |

Comments: ______________________________

______________________________

______________________________

**Task 2**: How you control movement within the scene

Task description: you will be shown a shape of a ball and asked to control the movement of the scene to keep this ball within an area of the screen. Your comments on the task are welcome.

Please Rate the task using the following rating code:
5=strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1= strongly disagree

| Ques. | criteria | Rating |
|---|---|---|
| 1 | I can keep the ball in the area | ☺ 5 4 3 2 1 ☹ |
| 2 | Manipulating the movement of the ball was easy | ☺ 5 4 3 2 1 ☹ |
| 3 | Tracing the running ball provided fun and engagement in the scene | ☺ 5 4 3 2 1 ☹ |

Comments: ______________________________

______________________________

______________________________

**Task 3**: The preferred style of moving within scenes

Task description: you will be asked to look at two different styles of navigation: Image Channel and hotspot, and answer the questions after each style. Your comments on the tasks are welcome.

Please Rate the task using the following rating code:
5=strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1= strongly disagree

Style: Image Channel

| Ques. | criteria | Rating |
|---|---|---|
| 1 | This style gives me a good feeling of my position | ☺ 5 4 3 2 1 ☹ |
| 2 | This style made me feel I was walking through the scenes | ☺ 5 4 3 2 1 ☹ |
| 3 | This style gives me a good feeling of my orientation (the way I am facing) | ☺ 5 4 3 2 1 ☹ |

Style: Hotspot

| Ques. | criteria | Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | This style gives me a good feeling of my position | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 2 | This style made me feel I was walking through the scenes | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 3 | This style gives me a good feeling of my orientation (the way I am facing) | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |

Comments: ________________________________________________________________

________________________________________________________________

________________________________________________________________

## **Task 4**: The feeling of "being there"

Task description: This task will be like treasure hunting. You will be provided with a target/information to find using the two navigation styles, Image Channel and Hotspot, and answer the questions after each style. Your comments on the tasks are welcome.

Please Rate the task using the following rating code:
5=strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1= strongly disagree

Style: Image Channel

| Ques. | criteria | Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | This style, with the map helped me to recognize my position | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 2 | This style, with the map helped me understand my orientation (the way I am facing) | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 3 | It was easy to find the object. | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 4 | I enjoyed the experience of being in this environment | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 5 | The sound made me feel I was in the environment | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 6 | Please rate your overall experience of using this style out of 5, 5 is good | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |

Style: Hotspot

| Ques. | criteria | Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | This style, with the map helped me to recognize my position | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 2 | This style, with the map helped me understand my orientation (the way I am facing) | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 3 | It was easy to find the object. | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 4 | I enjoyed the experience of being in this environment | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 5 | The sound made me feel I was in the environment | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |
| 6 | Please rate your overall experience of using this style out of 5, 5 is good | ☺ | 5 | 4 | 3 | 2 | 1 | ☹ |

Comments: ________________________________________________________________

________________________________________________________________

________________________________________________________________

**APPENDIX I (2)**

**Natural environment testing (Chapter Seven) - Questionnaire**

# Orientation Script

Dear participant,

I, Wu-Hsiung Chen, am a PhD student in the Faculty of Art and Design at De Montfort University. I am doing research which is related to Web based zoological information. I need your help to answer the following questions: the experience of the website in information provision, in raising the awareness of zoological protection, in terms of user enjoyment, and performance.

I will be working with you today throughout the test. This process will take around 30 minutes. There are two parts in the task:

I. Part one – to experience the web site provided
You will have the opportunity to explore with the web site that I want you to look at.

II. Part two – a task will be given to you
You will complete a task and fill in a questionnaire about your experience with the web site in the areas of technology and performance.

All replies will be confidential and kept anonymous. If you are uncomfortable or stressed during the test, you can quit at any time. If you require any explanation of the questions during the session please feel free to ask at any time.

The test is going to proceed. Do you have any questions before we start?

dmu.ac.uk
DE MONTFORT UNIVERSITY
LEICESTER

A Survey investigating online Panoramic Video in providing zoological information

Name (optional): ______________________________ Gender: M / F _______

Occupation:__________________ Age: ☐ 18 to 25 ☐26 to 33 ☐34 to 40 ☐over 40

**Task Description**:

This task will be like treasure hunting. You will be provided with a target or information to find, and answer the questions after completing the mission. Your comments on the task are very welcome.

Please Rate the task using the following rating code:
5=strongly agree, 4=agree, 3=neither agree nor disagree, 2= disagree, 1= strongly disagree

Section 1: Technology

| Qs. | Criteria | Rating |
|---|---|---|
| 1 | The perspective looked natural | ☺ 5 4 3 2 1 ☹ |
| 2 | The stitching of videos was generally acceptable | ☺ 5 4 3 2 1 ☹ |
| 3 | Manipulating the movement of the view was easy | ☺ 5 4 3 2 1 ☹ |
| 4 | It was easy to find the object | ☺ 5 4 3 2 1 ☹ |
| 5 | It is easy to recognize my position | ☺ 5 4 3 2 1 ☹ |
| 6 | It is easy to understand my orientation (the way I am facing) | ☺ 5 4 3 2 1 ☹ |

Section 2: Performance

| Qs. | Criteria | Rating |
|---|---|---|
| 1 | The knowledge provision method in this technology enriched my understanding of the animal and its habitat | ☺ 5 4 3 2 1 ☹ |
| 2 | This technology increased my awareness of the animal and its habitat protection | ☺ 5 4 3 2 1 ☹ |
| 3 | The experience was fun | ☺ 5 4 3 2 1 ☹ |
| 4 | The overall design of this application was good | ☺ 5 4 3 2 1 ☹ |
| 5 | This technology would encourage me to visit this site again | ☺ 5 4 3 2 1 ☹ |
| 6 | The sound made me feel I was in the environment | |

Comments: ____________________________________________

____________________________________________

____________________________________________

____________________________________________

**Thank you!!**

**APPENDIX II - SOURCE CODES**

**APPENDIX II (1)**

**Stitching and panning project (Chapter Four: Experiment 1 and 2)**

```
nowstop="null"
nowpoint="A"
srotation=90
canmove=true
yy=Movie.movies._y
side._x=this[nowpoint]._x
side._y=this[nowpoint]._y
side._rotation=srotation
mapx=0
function movieload(file:String){
	Movie.movies.loadMovie(file);
	Movie.createEmptyMovieClip("copyMovies",10)
	Movie.copyMovies.loadMovie(file);
	Movie.movies._y=yy
	Movie.copyMovies._y=yy
	Movie.copyMovies._x=Movie.movies._x
}
function movetoline(xpoint){
	Movie.copyMovies._x=0
	Movie.movies._x=0
	Movie.copyMovies._x-=xpoint
	Movie.movies._x-=xpoint
}
movieload("movie1.swf")
movieset=2
this.onEnterFrame=function(){
	if(Movie.movies.getBytesLoaded()>1000){
		delete this.onEnterFrame
		movieScale = 110;
		speed = 30;
		moveing = false;
		updown=false
		Movie._xscale = movieScale;
		Movie._yscale = movieScale;
		moveLimit = _root.Movie.movies._x-320;
		moviewidth = _root.Movie.movies._width;
	}
}
var tempmovie = this.createEmptyMovieClip("tempmv", 998);
var mousemovie = this.createEmptyMovieClip("mousemv", 999);
var keyListener:Object = new Object();
///////////////
//zoom in and zoom out Botton's AS START
///////////////
function zoomMovie(boo, scales) {
	tempmovie.onEnterFrame = function() { if(scales<0){
				if(Movie.hitTest(HT_top)&&Movie.hitTest(HT_down)){
						if (boo) {
						movieScale += scales;
```

```
                                        Movie._xscale = movieScale;
                              Movie._yscale = movieScale;
}else {
                                        boo = false;
                                        delete tempmovie.onEnterFrame;
                    }
                              }else{
                                   boo = false;
                                   delete tempmovie.onEnterFrame;                    }
                    }else{
                              movieScale += scales;
                              if (boo) {
                                   if (movieScale>150) {
                                             movieScale = 150;
                                             boo = false;
                                   }
                                   Movie._xscale = movieScale;
                                   Movie._yscale = movieScale;
                              }else{

                                   delete tempmovie.onEnterFrame;
                              }

                    }
          }
}
////////////////
//zoom in and zoom out Botton's AS End
////////////////



////////////////
//move Botton's AS START
////////////////

function movie_move(about) {
          if (moveing && canmove) {

          ////////////
          //
          ////////////start///////////
                    if (_root.Movie.movies._x>=moveLimit &&
_root.Movie.movies._x<=320) {
                              _root.Movie.copyMovies._x = _root.Movie.movies._x-
moviewidth+movieset;
                              //trace(_root.Movie.copyMovies._x)
                              siderotation(Movie.movies._x/Movie.movies._width)
                    } else if (_root.Movie.movies._x+moviewidth<=320 &&
_root.Movie.movies._x+moviewidth>=moveLimit) {
```

```
				_root.Movie.copyMovies._x = 
_root.Movie.movies._x+moviewidth-movieset;
				//trace(_root.Movie.copyMovies._x)
			} else if (_root.Movie.copyMovies._x>=moveLimit) {
				_root.Movie.movies._x = _root.Movie.copyMovies._x-
moviewidth+movieset;
				//trace(_root.Movie.movies._x)

			} else if (_root.Movie.copyMovies._x+moviewidth<=320) {
				_root.Movie.movies._x = 
_root.Movie.copyMovies._x+moviewidth-movieset;
				//trace(_root.Movie.movies._x)
			}

			_root.Movie.movies._x += about*speed;
			_root.Movie.copyMovies._x += about*speed;
			mapx+=about*speed
			siderotation((mapx)/(-1*moviewidth)*360)
		////////////end////////////

		} else {
			delete tempmovie.onEnterFrame;
		}

}
function movie_udmove(about){
if(updown && canmove){
			if(about>0){
				if(Movie.copyMovies.hitTest(HT_top) || 
Movie.movies.hitTest(HT_top)){
					Movie.copyMovies._y += about*speed;
//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
					Movie.movies._y += about*speed;
		//Movie.movies._y=Movie.movies._y+about*speed
				}
			}else{
				if(Movie.copyMovies.hitTest(HT_down) || 
Movie.movies.hitTest(HT_down)){
					Movie.copyMovies._y += about*speed;
		//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
					Movie.movies._y += about*speed;
		//Movie.movies._y=Movie.movies._y+about*speed
				}
			}

		}else{
			delete tempmovie.onEnterFrame;
		}
}
////////////////
```

```
//move Botton's AS START
////////////////

onMouseDown=function(){
	mousex=_root._xmouse
	mousey=_root._ymouse
	mousemovie.onEnterFrame=function(){
		moveing = true
		updown=true
		movesx=(mousex-_root._xmouse)/200
		movesy=(mousey-_root._ymouse)/200
		movie_move(movesx)
		movie_udmove(movesy)
	}
}
onMouseUp=function(){
	moveing = false
	updown=false
	delete mousemovie.onEnterFrame
}

keyListener.onKeyDown = function () {
	if(Key.getCode()==17){
		zoomMovie(true,-1);
	}else if(Key.getCode()==16){
		zoomMovie(true,1);
	}
}
keyListener.onKeyUp = function () {
	zoomMovie(false,0);

}
Key.addListener(keyListener);
```

## APPENDIX II (2)

## Image Channel project (Chapter Four: Experiment 3)

```
movieset=2
nowstop="null"
nowpoint="A"
srotation=30
canmove=true
showtxt=false
yy=Movie.movies._y
side._x=this[nowpoint]._x
side._y=this[nowpoint]._y
side._rotation=srotation
mapx=0
//ss=_root.Movie.movies._x
function showtext(value){
	textmovie.gotoAndStop(value)
	trace(value)
}
function movieload(file:String){
	Movie.movies.loadMovie(file);
	Movie.createEmptyMovieClip("copyMovies",10)
	Movie.copyMovies.loadMovie(file);
	Movie.movies._y=yy
	Movie.copyMovies._y=yy
	Movie.copyMovies._x=0
	Movie.movies._x=0
	movieScale = 100;
	speed = 30;
	moveing = false;
	updown=false
	Movie._xscale = movieScale;
	Movie._yscale = movieScale;
	moveLeftLimit = _root.masks._x;
	moveRightLimit=_root.masks._x+_root.masks._width
}
function movetoline(xpoint){
	moviewidth = _root.Movie.movies._width;
	Movie.copyMovies._x=0
	Movie.movies._x=0
	Movie.copyMovies._x-=xpoint-_root.masks._width/2
	Movie.movies._x-=xpoint-_root.masks._width/2
	moveing=true
	movie_move(0)
	moveing=false
}
movieload("movie1.swf")
var tempmovie = this.createEmptyMovieClip("tempmv", 998);
var mousemovie = this.createEmptyMovieClip("mousemv", 999);
var keyListener:Object = new Object();
///////////////
//zoom in and zoom out Botton's AS START
///////////////
```

```
function zoomMovie(boo, scales) {
	tempmovie.onEnterFrame = function() {
		if(scales<0){
			if(Movie.hitTest(HT_top)&&Movie.hitTest(HT_down)){
				if (boo) {
					movieScale += scales;
	//moviescale=scales+moviescale
					Movie._xscale = movieScale;
					Movie._yscale = movieScale;
				}else {
					boo = false;
					delete tempmovie.onEnterFrame;
				}
			}else{
				boo = false;
				delete tempmovie.onEnterFrame;
			}
		}else{
			movieScale += scales;
			if (boo) {
				if (movieScale>150) {
						movieScale = 150;
						boo = false;
				}
				Movie._xscale = movieScale;
				Movie._yscale = movieScale;
			}else{
				delete tempmovie.onEnterFrame;
			}

		}
	}
}
///////////////
//zoom in and zoom out Botton's AS End
///////////////


///////////////
//move Botton's AS START
///////////////

function movie_move(about) {
	if (moveing && canmove) {

	////////////
	//
	///////////start///////////
	//trace()
	moviesX=_root.Movie._x+_root.Movie.movies._x
```

```
	copyMoviesX=_root.Movie._x+_root.Movie.copyMovies._x
	//trace(moveLeftLimit+"==moveRightLimit")
		if (moviesX>=moveLeftLimit && moviesX<=moveRightLimit) {
			_root.Movie.copyMovies._x = _root.Movie.movies._x-
moviewidth+movieset;

		} else if (moviesX+moviewidth<=moveRightLimit &&
moviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.copyMovies._x =
_root.Movie.movies._x+moviewidth-movieset;

		} else if (copyMoviesX>=moveLeftLimit &&
copyMoviesX<=moveRightLimit) {
			_root.Movie.movies._x = _root.Movie.copyMovies._x-
moviewidth+movieset;

		} else if (copyMoviesX+moviewidth<=moveRightLimit &&
copyMoviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.movies._x =
_root.Movie.copyMovies._x+moviewidth-movieset;
		}

		_root.Movie.movies._x += about*speed;
		_root.Movie.copyMovies._x += about*speed;
		mapx+=about*speed
		siderotation((mapx)/(-1*moviewidth)*360)
	////////////end////////////

	} else {
		delete tempmovie.onEnterFrame;
	}
}
function movie_udmove(about){
if(updown && canmove){
		if(about>0){
			if(Movie.copyMovies.hitTest(HT_top) ||
Movie.movies.hitTest(HT_top)){
				Movie.copyMovies._y += about*speed;
//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
				Movie.movies._y += about*speed;
	//Movie.movies._y=Movie.movies._y+about*speed
			}
		}else{
			if(Movie.copyMovies.hitTest(HT_down) ||
Movie.movies.hitTest(HT_down)){
				Movie.copyMovies._y += about*speed;
	//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
				Movie.movies._y += about*speed;
	//Movie.movies._y=Movie.movies._y+about*speed
			}
```

```
			}

		}else{
			delete tempmovie.onEnterFrame;
		}
}
////////////////
//move Botton's AS START
////////////////

onMouseDown=function(){
		mousex=_root._xmouse
		mousey=_root._ymouse
		mousemovie.onEnterFrame=function(){
			moveing = true
			updown=true
			movesx=(mousex-_root._xmouse)/200
			movesy=(mousey-_root._ymouse)/200
			movie_move(movesx)
			movie_udmove(movesy)

		}
}
onMouseUp=function(){
		moveing = false
		updown=false
		delete mousemovie.onEnterFrame
}

keyListener.onKeyDown = function () {
		if(Key.getCode()==17){
			zoomMovie(true,-1);
		}else if(Key.getCode()==16){
			zoomMovie(true,1);
		}
}
keyListener.onKeyUp = function () {
		zoomMovie(false,0);

}
Key.addListener(keyListener);
```

## APPENDIX II (3)

**Web interface with testing recommended elements project (Chapter Four: Experiment 4)**

```
movieset=2
nowstop="null"
nowpoint="A"
srotation=30
canmove=true
showtxt=false
yy=Movie.movies._y
side._x=this[nowpoint]._x
side._y=this[nowpoint]._y
side._rotation=srotation
mapx=0
//ss=_root.Movie.movies._x
function showtext(value){
	textmovie.gotoAndStop(value)
	trace(value)
}
function movieload(file:String){
	Movie.movies.loadMovie(file);
	Movie.createEmptyMovieClip("copyMovies",10)
	Movie.copyMovies.loadMovie(file);
	Movie.movies._y=yy
	Movie.copyMovies._y=yy
	Movie.copyMovies._x=0
	Movie.movies._x=0
	movieScale = 100;
	speed = 30;
	moveing = false;
	updown=false
	Movie._xscale = movieScale;
	Movie._yscale = movieScale;
	moveLeftLimit = _root.masks._x;
	moveRightLimit=_root.masks._x+_root.masks._width
}
function movetoline(xpoint){
	moviewidth = _root.Movie.movies._width;
	Movie.copyMovies._x=0
	Movie.movies._x=0
	Movie.copyMovies._x-=xpoint-_root.masks._width/2
	Movie.movies._x-=xpoint-_root.masks._width/2
	moveing=true
	movie_move(0)
	moveing=false
}
movieload("movie1.swf")
var tempmovie = this.createEmptyMovieClip("tempmv", 998);
var mousemovie = this.createEmptyMovieClip("mousemv", 999);
var keyListener:Object = new Object();
///////////////
//zoom in and zoom out Botton's AS START
///////////////
```

```
function zoomMovie(boo, scales) {
	tempmovie.onEnterFrame = function() {
		if(scales<0){
			if(Movie.hitTest(HT_top)&&Movie.hitTest(HT_down)){
				if (boo) {
					movieScale += scales;
	//moviescale=scales+moviescale
					Movie._xscale = movieScale;
					Movie._yscale = movieScale;
				}else {
					boo = false;
					delete tempmovie.onEnterFrame;
				}
			}else{
				boo = false;
				delete tempmovie.onEnterFrame;
			}
		}else{
			movieScale += scales;
			if (boo) {
				if (movieScale>150) {
						movieScale = 150;
						boo = false;
				}
				Movie._xscale = movieScale;
				Movie._yscale = movieScale;
			}else{
				delete tempmovie.onEnterFrame;
			}

		}
	}
}
///////////////
//zoom in and zoom out Botton's AS End
///////////////


///////////////
//move Botton's AS START
///////////////

function movie_move(about) {
	if (moveing && canmove) {

	///////////
	//
	///////////start///////////
	//trace()
	moviesX=_root.Movie._x+_root.Movie.movies._x
```

```
	copyMoviesX=_root.Movie._x+_root.Movie.copyMovies._x
	//trace(moveLeftLimit+"==moveRightLimit")
		if (moviesX>=moveLeftLimit && moviesX<=moveRightLimit) {
			_root.Movie.copyMovies._x = _root.Movie.movies._x-
moviewidth+movieset;

		} else if (moviesX+moviewidth<=moveRightLimit &&
moviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.copyMovies._x =
_root.Movie.movies._x+moviewidth-movieset;

		} else if (copyMoviesX>=moveLeftLimit &&
copyMoviesX<=moveRightLimit) {
			_root.Movie.movies._x = _root.Movie.copyMovies._x-
moviewidth+movieset;

		} else if (copyMoviesX+moviewidth<=moveRightLimit &&
copyMoviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.movies._x =
_root.Movie.copyMovies._x+moviewidth-movieset;
		}

		_root.Movie.movies._x += about*speed;
		_root.Movie.copyMovies._x += about*speed;
		mapx+=about*speed
		siderotation((mapx)/(-1*moviewidth)*360)
	////////////end////////////

	} else {
		delete tempmovie.onEnterFrame;
	}
}
function movie_udmove(about){
if(updown && canmove){
		if(about>0){
			if(Movie.copyMovies.hitTest(HT_top) ||
Movie.movies.hitTest(HT_top)){
				Movie.copyMovies._y += about*speed;
//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
				Movie.movies._y += about*speed;
	//Movie.movies._y=Movie.movies._y+about*speed
			}
		}else{
			if(Movie.copyMovies.hitTest(HT_down) ||
Movie.movies.hitTest(HT_down)){
				Movie.copyMovies._y += about*speed;
	//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
				Movie.movies._y += about*speed;
	//Movie.movies._y=Movie.movies._y+about*speed
			}
```

```
		}

	}else{
		delete tempmovie.onEnterFrame;
	}
}
////////////////
//move Botton's AS START
////////////////

onMouseDown=function(){
	mousex=_root._xmouse
	mousey=_root._ymouse
	mousemovie.onEnterFrame=function(){
		moveing = true
		updown=true
		movesx=(mousex-_root._xmouse)/200
		movesy=(mousey-_root._ymouse)/200
		movie_move(movesx)
		movie_udmove(movesy)

	}
}
onMouseUp=function(){
	moveing = false
	updown=false
	delete mousemovie.onEnterFrame
}

keyListener.onKeyDown = function () {
	if(Key.getCode()==17){
		zoomMovie(true,-1);
	}else if(Key.getCode()==16){
		zoomMovie(true,1);
	}
}
keyListener.onKeyUp = function () {
	zoomMovie(false,0);

}
Key.addListener(keyListener);


function siderotation(angle){
	side._rotation=angle+srotation
}
function lookat(taget){
	taget=this[taget]
	me=this[nowpoint]
	point1x=me._x
```

```
	point1y=me._y+5
	point2x=me._x
	point2y=me._y
	point3x=taget._x
	point3y=taget._y
	bc=Math.sqrt((point2x-point3x)*(point2x-point3x)+(point2y-
point3y)*(point2y-point3y))
	ab=Math.sqrt((point2x-point1x)*(point2x-point1x)+(point2y-
point1y)*(point2y-point1y))
	lookatt=Math.acos(((point3x-point2x)*(point1x-point2x)+(point3y-
point2y)*(point1y-point2y))/(ab*bc))
	if(point3x<=point2x){
		lookatt=-lookatt
	}
	side._rotation=-(lookatt*180) / 3.14-180
	srotation=side._rotation
	mapx=0

}
movetoReset=1
function moveto(taget,totalframe,nowframe){
	taget=this[taget]
	if(_root.movetoReset==1){
		lengthsX=taget._x-side._x
		lengthsY=taget._y-side._y
		sideX=side._x
		sideY=side._y
		_root.movetoReset=2
	}
	side._x=sideX+(lengthsX*((nowframe)/totalframe))
	side._y=sideY+(lengthsY*((nowframe)/totalframe))

}
```

# APPENDIX II (4)

## The Virtual Zoo project (chapter Seven)

```
moviesetArray = new Array(0, 64, 49, 15);
nowstop = "null";
nowpoint = "A";
srotation = 30;
canmove = true;
showtxt = false;

yy = Movie.movies._y*2-30;
side._x = this[nowpoint]._x;
side._y = this[nowpoint]._y;
side._rotation = srotation;
mapx = 0;
function showtext(value) {
	textmovie.gotoAndStop(value);
}
function movieload(file:String, setM:Number) {
	title.gotoAndStop(setM);
	textmovie.soundout.my_sound.stop();
	textmovie.gotoAndStop(1);
	movieset = moviesetArray[setM];
	Movie.movies.loadMovie(file);
	Movie.createEmptyMovieClip("copyMovies",10);
	Movie.movies.swapDepths(20);
	//trace(Movie.movies.getDepth())
	Movie.copyMovies.loadMovie(file);
	Movie.movies._y = yy;
	Movie.copyMovies._y = yy;
	Movie.copyMovies._x = 0;
	Movie.movies._x = 0;
	movieScale = 100;
	speed = 30;
	moveing = false;
	updown = false;
	Movie._xscale = movieScale;
	Movie._yscale = movieScale;
	moveLeftLimit = _root.masks._x;
	moveRightLimit = _root.masks._x+_root.masks._width;
	trace(file.slice(0, 5));
	controlmovie._visible = file.slice(0, 5) != "movie";
	if (file.slice(0, 5) != "movie") {
		title.gotoAndStop(Number(file.slice(2, 3))+4);
	} else {
		title.gotoAndStop(setM+1);
	}
}
function movetoline(xpoint) {
	moviewidth = _root.Movie.movies._width;
	Movie.copyMovies._x = 0;
	Movie.movies._x = 0;
	Movie.copyMovies._x -= xpoint;//-_root.masks._width/2
```

```
	Movie.movies._x -= xpoint;
	moveing = true;
	movie_move(0);
	moveing = false;
}
movieload("movie3.swf",3);
var tempmovie = this.createEmptyMovieClip("tempmv", 998);
var mousemovie = this.createEmptyMovieClip("mousemv", 999);
var keyListener:Object = new Object();
///////////////
//zoom in and zoom out Botton's AS START
///////////////
function zoomMovie(boo, scales) {
	tempmovie.onEnterFrame = function() {
		if (scales<0) {
			if (Movie.hitTest(HT_top) && Movie.hitTest(HT_down)) {
				if (boo) {
					movieScale +=
scales;//moviescale=scales+moviescale
					Movie._xscale = movieScale;
					Movie._yscale = movieScale;
				} else {
					boo = false;
					delete tempmovie.onEnterFrame;
				}
			} else {
				boo = false;
				delete tempmovie.onEnterFrame;
			}
		} else {
			movieScale += scales;//moviescale=scales+moviescale
			if (boo) {
				if (movieScale>150) {
					movieScale = 150;
					boo = false;
				}
				Movie._xscale = movieScale;
				Movie._yscale = movieScale;
			} else {

				delete tempmovie.onEnterFrame;
			}
		}
	};
}
///////////////
//zoom in and zoom out Botton's AS End
///////////////
```

```
////////////////
//move Botton's AS START
////////////////

function movie_move(about) {
	if (moveing && canmove) {

		////////////
		//
		////////////start////////////
		moviesX = _root.Movie._x+_root.Movie.movies._x;
		copyMoviesX = _root.Movie._x+_root.Movie.copyMovies._x;
		if (moviesX>=moveLeftLimit && moviesX<=moveRightLimit) {
			_root.Movie.copyMovies._x = _root.Movie.movies._x-
moviewidth+movieset;

		} else if (moviesX+moviewidth<=moveRightLimit &&
moviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.copyMovies._x =
_root.Movie.movies._x+moviewidth-movieset;

		} else if (copyMoviesX>=moveLeftLimit &&
copyMoviesX<=moveRightLimit) {
			_root.Movie.movies._x = _root.Movie.copyMovies._x-
moviewidth+movieset;

		} else if (copyMoviesX+moviewidth<=moveRightLimit &&
copyMoviesX+moviewidth>=moveLeftLimit) {
			_root.Movie.movies._x =
_root.Movie.copyMovies._x+moviewidth-movieset;
		}
		_root.Movie.movies._x += about*speed;
		_root.Movie.copyMovies._x += about*speed;
		mapx += about*speed;
		siderotation((mapx)/(-1*moviewidth)*360);
		////////////end////////////

	} else {
		delete tempmovie.onEnterFrame;

	}
}
function movie_udmove(about) {
	if (updown && canmove) {
		if (about>0) {
			if (Movie.copyMovies.hitTest(HT_top) ||
Movie.movies.hitTest(HT_top)) {
				Movie.copyMovies._y +=
about*speed;//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
```

```
					Movie.movies._y += 
about*speed;//Movie.movies._y=Movie.movies._y+about*speed
				}
			} else {
				if (Movie.copyMovies.hitTest(HT_down) || 
Movie.movies.hitTest(HT_down)) {
					Movie.copyMovies._y += 
about*speed;//Movie.copyMovies._y=Movie.copyMovies._y+about*speed
					Movie.movies._y += 
about*speed;//Movie.movies._y=Movie.movies._y+about*speed
				}
			}
		} else {
			delete tempmovie.onEnterFrame;
		}
}
////////////////
//move Botton's AS START
////////////////

onMouseDown=function(){;
mousex=_root._xmouse;
mousey=_root._ymouse;
mousemovie.onEnterFrame=function(){;
moveing = true;
updown=true;
movesx=(mousex-_root._xmouse)/200;
movesy=(mousey-_root._ymouse)/200;
movie_move(movesx);
movie_udmove(movesy);

};
};
onMouseUp=function(){;
moveing = false;
updown=false;
delete mousemovie.onEnterFrame;
};

keyListener.onKeyDown = function() {
if (Key.getCode() == 17) {
zoomMovie(true,-1);
} else if (Key.getCode() == 16) {
zoomMovie(true,1);
}
};
keyListener.onKeyUp = function() {
zoomMovie(false,0);
};
Key.addListener(keyListener);
```

## APPENDIX III - PUBLISHED PAPERS AND EXHIBITIONS

**APPENDIX III (1)**

Online Panoramic Video approach by Multimedia Design

*Note: Paper presented to the 2008 International Conference on Image Processing, Computer Vision, and Pattern Recognition (IPCV08), Processing WORLDCOMP'08, Las Vegas, U.S.A.*

# Online Panoramic Video Approach by Multimedia Design

**Wu-Hsiung Chen [#1], Gary Fozzard[# 2], and Nicholas Higgett [*2]**
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De Montfort University, Leicester, UK

**Abstract -** *As the development of online panorama VR is starting to augment reality in many applications, it is difficult to ignore potential improvements in panorama VR technology itself, that makes the user experience more immersive and offers a greater feeling of presence.*

*An overview of Panorama VR evolution is given and current research issues are highlighted. We then focus on one aspect of online panorama VR; that is online Panoramic Video. We present a model for online virtual navigation in environments using video-based panorama rendering. This utilizes multiple overlapping videos that are captured using a multi camera approach.*

*The paper also considers control and navigation within such environments. The online panoramic video utilizes frame-rate coherent technology between video fields of views, enabling users to navigate online in a dynamic virtual world in a manner that is more similar to real world.*

*The online panoramic video we present is designed to enhance presence, and can be used to enrich users' immersive experience in this type of environment. We believe the approach is presently unique. Potential uses of the technology are illustrated.*

**Keywords:** online virtual navigation, immersive video, panoramic video, virtual reality (VR), panorama VR

## 1. Introduction

### 1.1 Panorama VR evolution

Since Mr. James Baker demonstrated a panorama of Edinburgh by dim candlelight in the Haymarket in 1789, the demonstration was to from the core idea of modern panorama and the representation of nature in an illusion [1]. The term "panorama" is derived from ancient Greek and refers to an elevated geological formation or the view from such a lookout point. Panorama represents the first true visual "mass medium". As voyager Louis Antoine de Bougainville said "nothing is more precious than the view of a landscape that is open on every side" [2][3]. There are more and more studies on the field of augmented reality to give more immersive benefits of Virtual Reality in realistic. Panorama has become reinterpreted by modern camera manufacturers which create digital facilities to reach the new translation, digital Panoramas, and post online for delivering information in different applications [4][5][6][7][8]. Panorama is development from painting to digital images stitched, then to enhance more reality, Panoramic Video (Fig.1)

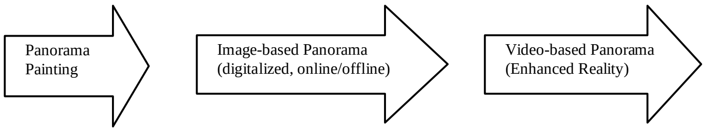


Figure 1, Panorama VR evolution

Panorama VR has the benefit allows fast visualization without the limits of computer calculations, different from 3D geometries which rely on computer capability to display in real-time [9].

### 1.2 Virtual Reality issues – realistic

Virtual Reality provides both optical and sound immersion, aspects that impact to human understanding of design. Virtual Reality suggests a scene or make-believe [10]. Despite its advantages, Virtual Reality can be disadvantage with problems that affect the realistic [11][12]. Augmented reality is a field of computer research which deals with the combination of real world and computer generated graphic. Currently there are many Augmented Reality studies concerned with the use of live video pictures, processed digitally and augmented reality [13]. Furthermore, the augmented components, such as video has introduced to users experience a semblance of the real world. [14]. A new area of current research of Panoramic Video is into the use of Augmented Reality in the game's industry to enhance realistic characters [15], indeed, Virtual Reality requires more realistic in many areas.

### 1.3 Motivation

World Wide Web is preferred medium for information transfer. World Wide Web application which integrated Virtual Reality delivered Virtual Environments to users in gathering and experiencing environment information. The reason why images-based Virtual Environment is called non-immersive VR technique is the images are static. It is difficult to image the world that people lived is motionless. The birds fly through and car pass by will create 3D effect when users navigate inside. In order to update the motionless (still images) limitation of the online image-based Virtual Environment system and bring more convince experience to the users to manipulate the virtual space, a new navigation approach, online Panoramic Video, is developed in this paper by extending augmented reality technology to the online images-based virtual reality system. This new approach consolidates the ripe frame-rate display theory and the manipulation of programming into a frame-based integration system. This is the main purpose of this paper to create an online dynamic Panoramic Virtual Environment, online Panoramic Video, by using Multimedia software which generated webpage layout integrating Panoramic Video for flexible application design.

# 2. Online Panoramic Video building

## 2.1 Online Panoramic Video design principle

The major factors to consider in creating the Panoramic Video are frame-rate, and stitching and navigation technology. The former is controlled by using same digital video camera in same output setting (fps) to take videos (Fig.2), and the latter can be achieved by computer programming to control motion purpose. By measuring the lens's wide angle of the digital camera (Fig.3), we obtained the amount of videos to produce a panorama environment. After calculating, located the amount cameras face in different direction (Fig.4), then remote the cameras to record, start and stop, at the same time. The individual record sequence, can be treated like an image, aligned and stitched together to a cylindrical panorama (Fig.5) [16]. By adding programme to the selected software, then output the web format directly to create the entire online Panoramic Video (Fig.6) on the display. The layout of the webpage flexibly depends on the application applied to.

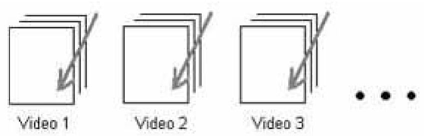



Figure 2, Same digital Video Camera has same frame-rate (fps)

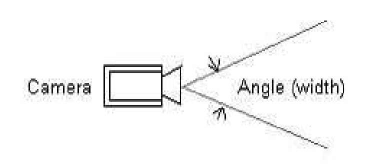



Figure 3, Top view: Measure the angle of lens of digital video camera to know how many cameras to form a dynamic panorama

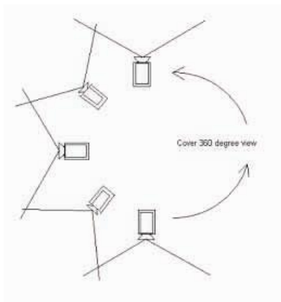



Figure 4, Locate cameras to cover 360 degree view

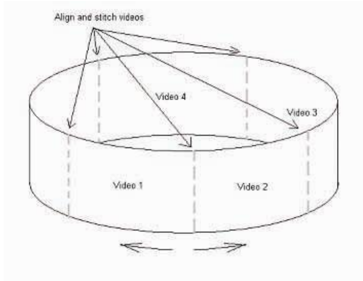



Figure 5, Align and stitch videos to a belt

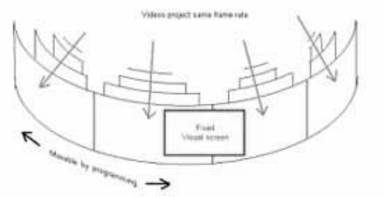



Figure 6, A dynamic Panorama Virtual Environment illustration, the red rectangle is the field of screen view

## 2.2 Videos capturing system

There are a number of digital video cameras on the market that take good quality record. Most of them can be very expensive and tend to be specialized tools rather than general-purpose cameras. The cameras for the experiment are considered cost effective and have well performance. The digital video cameras we have for the experiment is Panasonic, type AG-DVX100B. The general specification of the camera is 410,000-Pixel in NTSC, 470,000-Pixel in PAL, and 3CCD Image System Provides F11 Sensitivity for Superior Image Quality and provides Wide-Angle/Zoom Lens for Professional. The camera maker makes the camera easy for one person to operate more than two cameras. The cameras include remote controls setting in same frequency. This makes one person to operate more than two cameras in the same time.

After measure the horizontal view angle of the camera lens, the level angle of camera lens is around 50 degree which means we need 8 cameras at least to form a 360 degree view (Fig. 7). Before shooting, the tripods must be level perfectly. We took 40 seconds recording videos at the same time to the experiment.

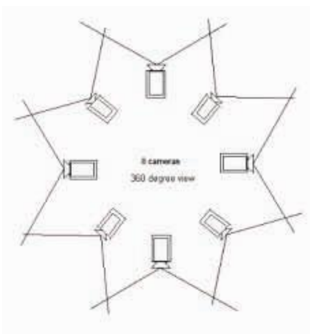



Figure 7, Eight cameras to form a 360 degree view

## 2.3 Developing online Panoramic Video model with Actionscript programming

We used Macromedia© Flash 8 to be the basic platform to develop the online Panoramic Video model. Flash as the solution for creating online Panoramic Video, it is with real-time optical correction and can flexible integrating different media to produce different webpage layouts. No other plug-ins required is the vital benefit of using Flash. There are more than 95% of all internet users worldwide without additional installation and Flash has evolved into a ubiquitous multi-faceted tool for deploying all kinds of content on to the World Wild Web. The video format we applied to online Panoramic Video model is AVI format. The flowchart (Fig. 8) illustrated the procedure of creating online Panoramic Video. Figure 9 is the Actionscipt, programme used in Flash, on the control buttons for manipulating the videos as look around performance. Online Panoramic Video created by Flash platform provides flexible webpage interface design to any application (Fig. 10).

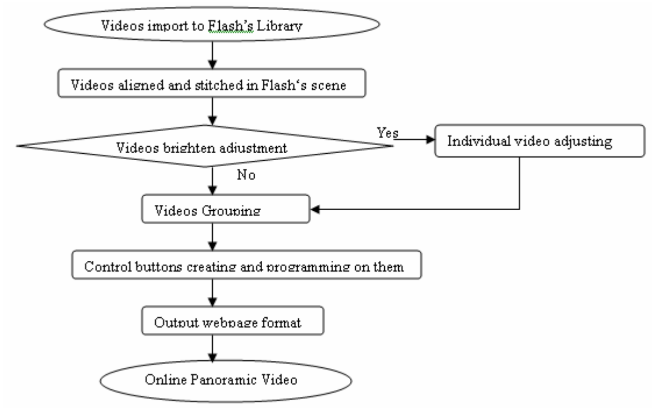
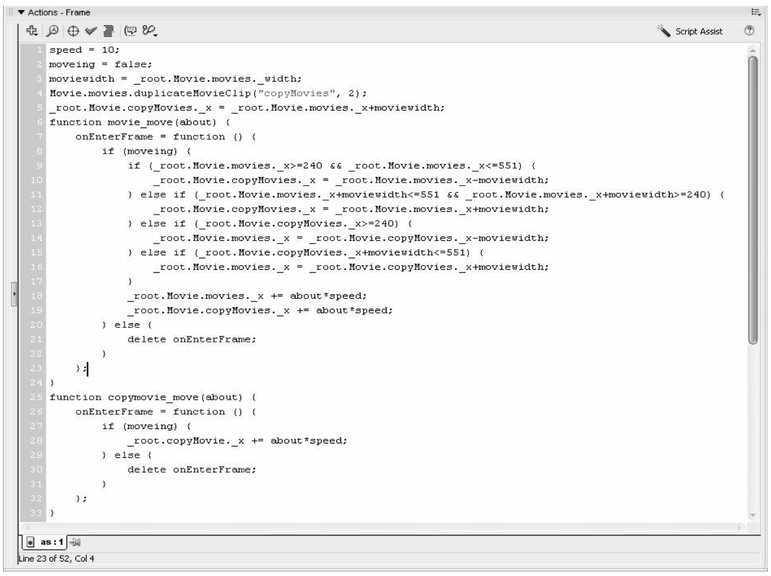



Figure 8, The flowchart of making online Panoramic video by selected software




```
speed = 10;
moveing = false;
moviewidth = _root.Movie.movies._width;
Movie.movies.duplicateMovieClip("copyMovies", 2);
_root.Movie.copyMovies._x = _root.Movie.movies._x+moviewidth;
function movie_move(about) {
    onEnterFrame = function () {
        if (moveing) {
            if (_root.Movie.movies._x>=240 && _root.Movie.movies._x<=551) {
                _root.Movie.copyMovies._x = _root.Movie.movies._x-moviewidth;
            } else if (_root.Movie.movies._x+moviewidth<=551 && _root.Movie.movies._x+moviewidth>=240) {
                _root.Movie.copyMovies._x = _root.Movie.movies._x+moviewidth;
            } else if (_root.Movie.copyMovies._x>=240) {
                _root.Movie.movies._x = _root.Movie.copyMovies._x-moviewidth;
            } else if (_root.Movie.copyMovies._x+moviewidth<=551) {
                _root.Movie.movies._x = _root.Movie.copyMovies._x+moviewidth;
            }
            _root.Movie.movies._x += about*speed;
            _root.Movie.copyMovies._x += about*speed;
        } else {
            delete onEnterFrame;
        }
    };
}
function copymovie_move(about) {
    onEnterFrame = function () {
        if (moveing) {
            _root.copyMovie._x += about*speed;
        } else {
            delete onEnterFrame;
        }
    };
}
```

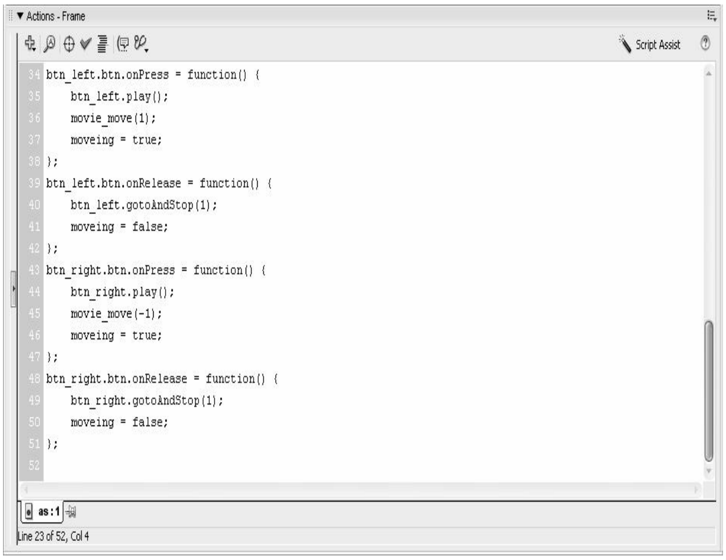



Figure 9, Program on the control buttons to manipulate Panoramic Video


Figure 10, A flexible layout design of the webpage output

## 3. Experimental Results, and discussions

Currently, the online Panoramic Video performed on an Intel Core 2 Duo personal computer over a Microsoft XP professional platform with a 3D graphic device. The harmonic frame rate of videos causes the fantabulous result in which users can navigation by clicking the control buttons (Fig 10). The model is significantly affected by two factors. (1) The cameras must be level perfectly. (2) The cameras must be located in same highness. Experimental results show that online Panoramic Video can be simply made by general digital video cameras and with the method provided by this paper. Figure 11 is an example of operating the Panoramic Video by clicking the control buttons. A random selected frames of wide angle image series provided dynamic panoramic view (Fig. 12).

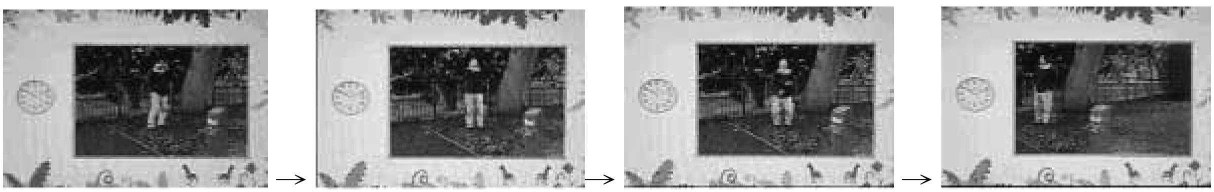


Figure 11, Sequent operation by clicking control buttons to move the view point

(a) 13th second frame

(b) 36th second frame

Figure 12, Wide angle image in different frame rate displayed the dynamic virtual environment of the online Panoramic Video

## 4. Conclusion and Future Work

In this paper, we addressed the problem of realistic online video-based virtual environments. So far, we have not seen any other approach towards providing online Panoramic Video to enhance animated reality by this method.

Further developments to the model are proposed to improve the prototype in various ways ie: improve the leveling issue, add linkages for users to navigate between different panoramas, integrate environment sound to have acoustic expression, integrate annotations for offering information purpose.

Virtual reality is not merely visualizations, it is for users to experience, observe and understand relationships within the environment. The application of the model should be investigated, such as virtual tour, virtual zoo, virtual museum, virtual gallery, preservation issues, ecological protection issue, and zoological related information presentation and so on. That will be next step to us to investigate as well.

## 5. Acknowledgement

This study was sponsored by the Scholarship of the Republic of China as part of PhD research.

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# APPENDIX III (2)

Online Navigation in Environments Using Panoramic Video

*Note: Paper presented to the 10th Annual Conference on World Wide Web (ZA-WWW 2008), Cape Town, South Africa*

## Online Navigation in Environments Using Panoramic Video

W. H. Chen [#1], G. Fozzard [# 2], and N. Higgett [*2]
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**Abstract**:

The development of online panorama VR is starting to augment reality in many applications. It is difficult to ignore potential improvements in panorama VR technology itself which makes the user experience more immersive and offers a greater feeling of presence.

An overview of Panorama VR evolution is given and current research issues are highlighted. We then focus on one aspect of online panorama VR; that is Panoramic Video. We present a model for online virtual navigation in environments using video-based panorama rendering. This utilizes multiple overlapping videos that are captured using a multi camera to approach Panoramic Video building and also considers control and navigation within each scene to enable users to navigate online in dynamic virtual worlds by World Wide Web conception.

The online Panoramic Video we constructed is designed to provide navigation in environment and used to enrich users' immersive experience in this type of surroundings. We believe the approach by this method is presently unique. Potential uses of the technology are illustrated.

**Keywords**: online virtual navigation, immersive, panoramic video, virtual reality (VR), panorama VR

## 1. Introduction

### 1.1 Panorama VR development

A painting panorama of Edinburgh demonstrated by Mr. James Baker in Haymarket in 1789 unfolded the core idea of modern panorama and the representation of nature in an illusion (Grau, 2003). The term "panorama" is derived from ancient Greek and refers to an elevated geological formation or the view from such a lookout point. The natural perceiving of Panorama VR represents the first true visual "mass medium" as voyager Louis Antoine de Bougainville claimed "nothing is more precious than the view of a landscape that is open on every side" (Oettermann, 1997; Bougainville, 2002). There is increasing number of studies on the field of enhancing reality to give more immersive benefits of Virtual Reality in realistic. Panorama has become reinterpreted by modern camera manufacturers which create digital facilities to reach the new translation, digital Panorama, and post online for delivering data/information of environments (Kimber et al., 2001; Sun et al., 2002; Tang et al., 2003; Wekbel, 2007; Futurelab, 2007). The development of Panorama is from painting to digital images stitched, and then comes to better reality, Panoramic Video (Figure 1).

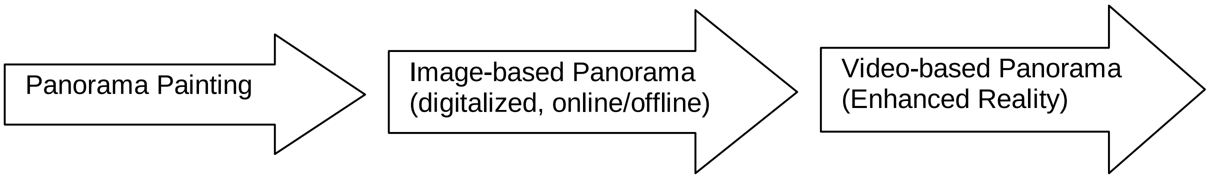


Figure 1, Panorama VR evolution

Compare to three-dimensional environment which depends on computer capability to display in real-time, Panorama VR has the benefit to allow fast visualization and less limitation of computer specification (Dorta, 2004).

### 1.2 Motivation

World Wide Web is preferred medium for data/information distribution. World Wide Web application which integrated Virtual Reality delivered Virtual Environments to users in gathering and experiencing environment information. The reason why images-based Virtual Environment is called non-immersive VR technique is the images are static. It is difficult to image the world that people living is motionless. The birds fly through and car pass by will create 3D effect when users navigate inside. In order to update the motionless (still images) limitation of the online image-based Virtual Environment system and bring more convince experience to the users to manipulate the virtual space, a new visual navigation approach, online Panoramic Video, created by selected World Wide Web tool is developed in this paper by extending augmented reality technology to the online images-based virtual reality system. This new approach consolidates the ripe frame-rate display theory and the manipulation of programming into a frame-based integration system. This is the main purpose of this paper to create an online dynamic Panoramic Virtual Environment, online Panoramic Video, by using Multimedia software which generated webpage layout integrating Panoramic Video for flexible application design.

## 2. Online Panoramic Video establishing

### 2.1 Design principle

The main considerations to construct the online Panoramic Video are building Panoramic Video delivered online and linkage between each Panorama for navigation purpose. The major factors to consider in creating the Panoramic Video are frame-rate, and stitching and navigation technology. The usage of same digital video camera can provide harmonize frame-rate sequence to reach the former issue. The individual recorded sequence can be treated like an image, aligned and stitched together to form a cylindrical panorama (Figure 2). The navigation capability can be achieved by computer programming in a selected software to control motion and to navigate between scenes (Figure 3) (Chen, 1995), then output the web format directly to create the entire online Panoramic Video. Figure 4 illustrate the web structure which indicates the design notion of unlimited scenes connection. In other word, more panoramas can be added to extend the navigation fields afterward. The layout of the webpage flexibly depends on the application applied to.

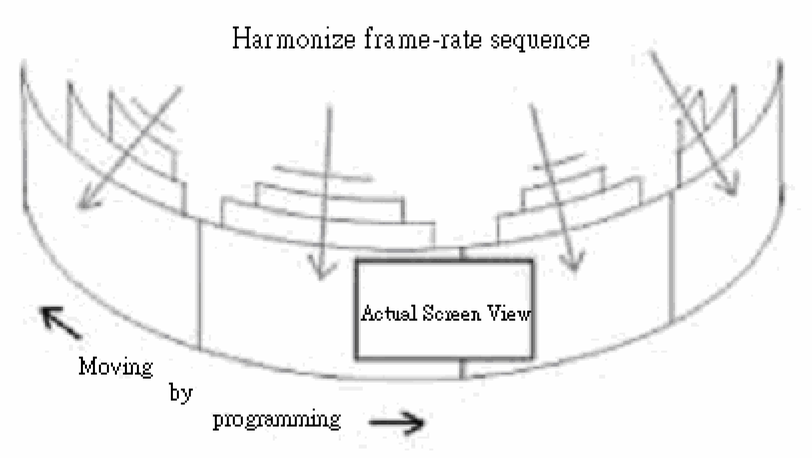


Figure 2. A dynamic Panorama Virtual Environment illustration, the black rectangle is the field of screen view

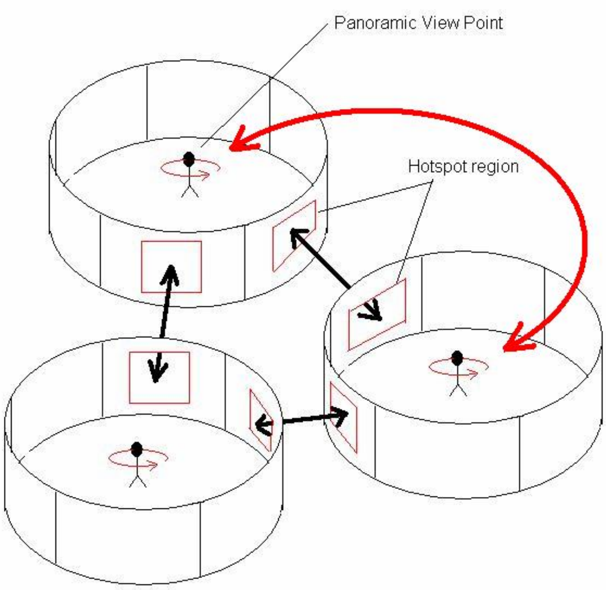


Figure 3. By click on the attached hotspot regions (red rectangle area) to hop to another panorama view point

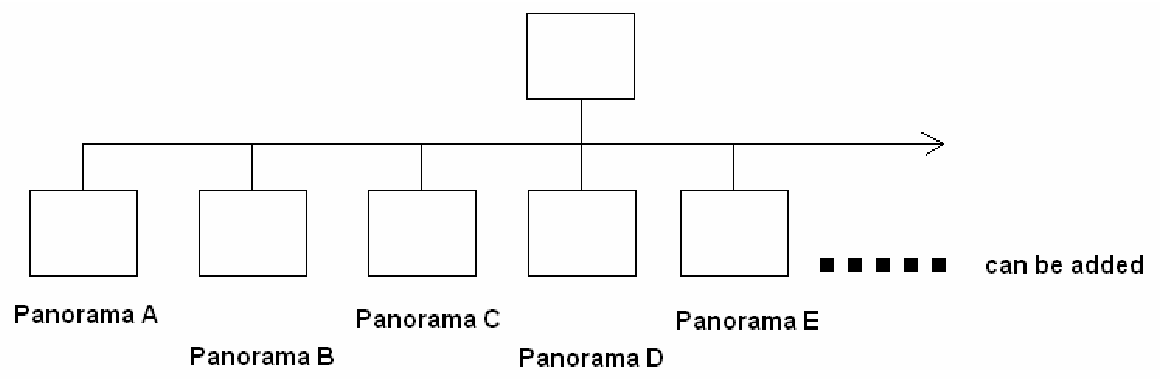


Figure 4. The Web structure illustrates the unlimited extend of navigation by adding more panoramas' scene

### 2.2 Videos capturing system

There are a many digital video cameras can be selected in the market to offer good quality record. Most of them can be very expensive and tend to be specialized tools rather than general-purpose cameras. The camera we have for the experiment is Panasonic, type AG-DVX100B which is considered cost effective and well performance. The general specification of the camera is 410,000-Pixel in NTSC, 470,000-Pixel in PAL, and 3CCD Image System Provides F11 Sensitivity for Superior Image Quality and provides Wide-Angle/Zoom Lens for Professional. The camera maker makes the camera easy for one person to operate more than two cameras. The cameras include remote controls setting in same frequency. This makes one person to operate more than two cameras in the same time to ensure to capture same length of sequence.

After measure the horizontal view angle of the camera lens, we obtained a number of cameras to form a panorama which needs 8 cameras (Figure 5). We took 40 seconds recording videos from each camera at the same time to the experiment.

Figure 5, Eight Cameras to form a 360 degree view

## 2.3 Constructing online Panoramic Video model with Actionscript programming

We used Macromedia© Flash CS3 to be the basic platform to develop the online Panoramic Video model. Flash as the solution for creating online Panoramic Video, it is with real-time optical correction and can flexibly integrating different media to produce different webpage layouts. No other plug-ins required is the vital benefit of using Flash. There are more than 95% of all internet users worldwide without additional installation and Flash has evolved into a ubiquitous multi-faceted tool for deploying all kinds of content on the World Wild Web. The video format we applied to online Panoramic Video model is WMA format. Figure 6 is the Actionscipt, programme used in Flash for manipulating the videos in looking around performance. Figure 7 is the programme written for hop to another panorama in hotspot area. Online Panoramic Video created by Flash platform provides flexible webpage interface design to any application. Figure 8 shows a flexible layout design of the webpage output in environment.

Figure 6, Actionscript programme to manipulate Panoramic Video


Figure 7, Actionscript programme on the hotspot area for jumping to another panorama


Figure 8, A screen shoot of flexible layout design

## 3. Experimental result and discussion

The created online Panoramic Video was performed on an Intel Core 2 Duo personal computer over a Microsoft XP professional platform with a 3D graphic Device. The harmonic frame rate of videos causes the fantabulous result in which users can look around the environment by moving mouse on the scene (Figure 9) and navigation between two panoramas by clicking hotspot area display on the scene (Figure 10). The model reflected two factors affecting the performance. (1) The rays of light in the environment needed to be considered properly when shooting. (2) The movement from one panorama to another by hotspots can reach the extended field of navigation purpose but lack of orientation perceiving. Experimental results showed that online Panoramic Video can be simply created by general digital video cameras and with the method provided by this paper. Figure 9 gives an example of controlling movement in a scene. A hotspot attached in a panorama's wide angle images for jumping purpose (Figure 11).

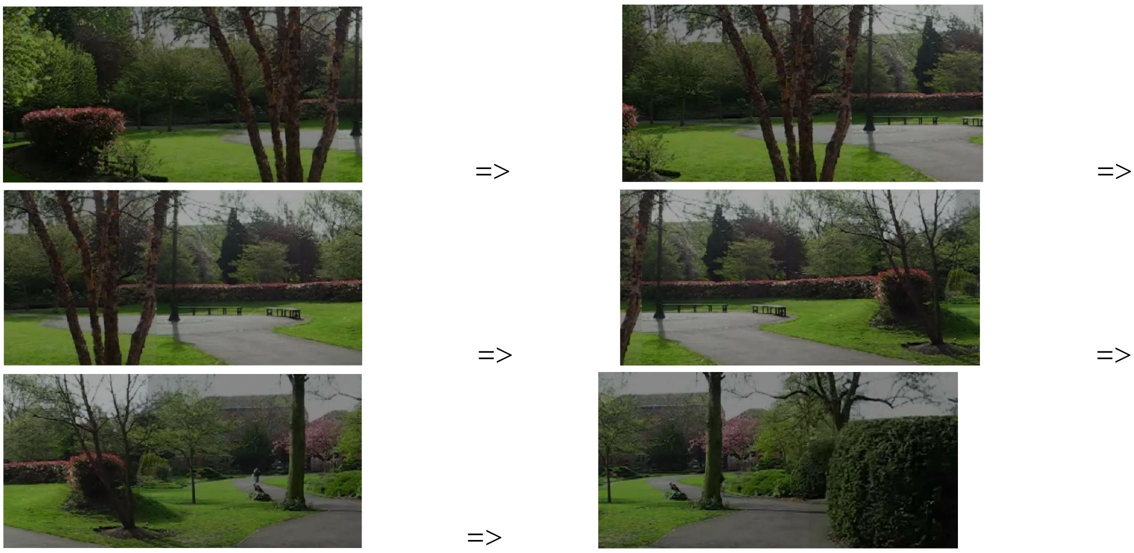

Figure 9, Sequent operation by moving the view point


Figure 10, The hotspot area will display when mouse rollover ready for jumping to another panorama

Figure 11, A hotspot (green frame) attached on a panorama displayed in wide angle image

## 4. Conclusion and Future Work

The paper addressed a realistic video-based virtual environment post on World Wide Web directly by multimedia technology. Users can not only navigate in a scene but also in panoramas, and more panoramas can be added afterward by hotspots connection. So far, we have not seen any other approach towards providing navigation in online Panoramic Video by this method.

Virtual reality which utility video-based is for users to experience, observe and understand relationship within the natural environment. Further developments to the model are proposed to improve the prototype in various ways i.e.: improve the navigation style for orientation and immersive perceiving; integrate environment sound to have acoustic expression and annotations for offering environment information purpose.

The application of the model can be in the fields of environment presentation accompanies with related data/information display, such as virtual tour, virtual museum, and zoological related data/information presentation and so on. That will be next step to us to investigate as well.

## 5. Acknowledgement

This study was sponsored by the Scholarship of the Republic of China as part of PhD study.

## 6. References

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## APPENDIX III (3)

“Image Channel” in Panoramic Video: a method to improve presence in virtual environments

*Note: Paper and project presented to the CREATE 2008 (Creative Inventions and Innovations for Everyday HCI), British Computer Society, Covent Garden, London, United Kingdom*

london2008 **create** Design Showcase

## "Image Channel" in Panoramic Video: a method to improve presence in virtual environments

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Mr. Nicholas Higgett, De Montfort University
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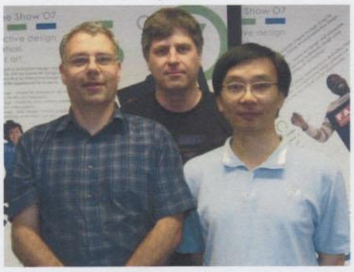
### Objectives

A vital component in many virtual reality systems is the ability to perform a walkthrough from different view positions. Traditionally, Panorama VR and image/video based VR use a hotspot to hop from a panoramic view point to another directly. This can make users feel lost and disorientated in the virtual environment. The aim of the project/research is to improve this issue. This innovative interaction method lets the users travel in the scenes of Panoramic, 360 degree dynamic videos in a very similar experience to a real world daily life.

### About the project



The project integrates both the product design and development process as well as embedding within users' experience and traditional design thinking, and applied it to new interaction design of Panoramic Video by Multimedia design. The method and project's presentation is serving as example and inspiration for multidisciplinary application and critical interaction design to the product development.

Panorama VR has been developed by several companies, such as Apple's QuickTime VR, RealViz's Stitcher 5, and Ulead's Cool 360. These enable users to experience and interact with spatial scenery of images/videos stitched on their computer. Panorama VR has been widely used in tourism, architecture, heritage, medical, and education.

In this work, we proposed the use of an "Image Channel", as an image sequence, to provide a new interaction and navigation style for users to feel walkthrough from one panorama zone to another. The design is based on simple concept: to put people's everyday experience into the design process, to reach the aim of the research.

In this demonstration, there are two navigation styles which are Image Channel (proposed new style) and Hotspot (traditional style) for users to experience on the laptop, and we expect to receive experts and public comments.

### Project sponsors

TAIPEI REPRESENTATIVE OFFICE IN THE U.K. dmu.ac.uk DE MONTFORT UNIVERSITY LEICESTER visualize it.

The Ergonomics Society interaction CREATE 2008 Design Showcase systemconcepts

**APPENDIX III (4)**

An Investigation into Web-based Panoramic Video VR Environments Applied to Zoological Informaiton

*Note: Paper and project presented to the 2009 TELDAP International Conference in conjunction with GRL 2020 and MCN Taiwan Meeting, Taiwan*

# An investigation into web-based panoramic video VR environments applied to zoological information

Wu-Hsiung Chen, Gary Fozzard, and Nick Higgett

**Abstract**

There is considerable pressure on animal extinction and animal habitat degradation that affect humans. A Zoo's environments, along with the way in which the zoo presents animals and animal habitats play a vital role in preserving biodiversity and promoting ecological protection. As a way of presenting zoological information, we consider online Panoramic Video, as a kind of Virtual Reality (VR), which permitted visitors to interact and navigate the scenes with information supplied.

This paper presents the first prototype of online Panoramic Video in presenting zoological information. A total of 3 adjacent Panoramic Videos with embedding navigational "walkthrough" using "Image Channels" is presented. A selected animal's habitat: the Formosan Rock-Monkey, was used during the filming. The monkey is living in Taiwan and the conservation status is under vulnerable of the IUCN Red List.

A task was given to subjects to experience the system. The evaluation included the experience in three portions which are knowledge provision (Education role), preservation attention (Conservation role), and entertaining the visitor in an enjoyable and safe manner. Initial response to the work has been very positive and evaluation work is ongoing.

**Keywords:** Virtual Reality (VR), Panoramic Video, Image Channel, Conservation, Entertainment

# An Investigation into web-based Panoramic Video VR environments applied to zoological information

**Wu-Hsiung Chen** **Dr. Gary Fozzard** **Nick Higgett**

*Dept. of Imaging and Communication Design*
*Faculty of Art and Design*
*De Montfort University*

*Digital Media Lab*
*De Montfort University*

## Introduction

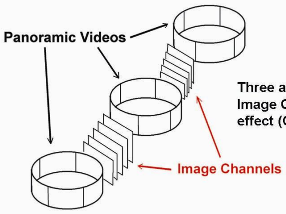
1. Animal extinction and habitat degradation affect humans.
2. A zoo's website plays a vital role in delivering zoological information to visitors.
3. Online Panoramic Video has potential to improve how this information is presented.

## Objectives

1. To investigate how web based panoramic video could be used to present animal habitats and zoological information.
2. To study the efficiency of the technology in terms of a zoo's website and its roles
3. To increase the functionality and usage of a zoo's website

## Making the panoramas

Digital Camera system for acquiring the videos for the stitched Panoramic Vide (Chen et al, 2008 [1] [2]) (Figure 1)




Three adjacent Panoramic Videos with Image Channel to offer walkthrough effect (Chen et al, 2008 [3]) (Figure 2)

Panoramic Video - a full screenshot of the environment (scene 3) (Figure 3)

## Evaluation

- 20 subjects, project presented on Desktop PC
- A task including a searching process was given
- Subjects were asked to answer the questions opposite on five point Likert scale from strongly agree (5) to strongly disagree (1) after the task

## Results and Conclusion

The initial results (Figure 4) indicate a high level of acceptance of the technology applied to the application. The evaluation is ongoing.

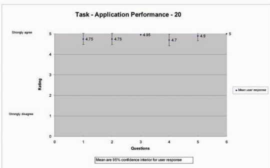



Figure 4, mean and 95% confidence interval of user response

## The questions

Q1. The knowledge provision method in this technology enriched my understanding of the animal and its habitat
Q2. This technology increased my awareness of the animal and its habitat protection
Q3. The experience was fun
Q4. The overall design of this application was good
Q5. This technology would encourage me to visit this site again
Q6. The sound made me feel I was in the environment

## References

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[2] Chen, W.H, Fozzard, G., and Higgett, N. (2008), Online Navigation in Environments Using Panoramic Video, ZA-WWW 2008, Sept., South Africa

[3] Chen, W.H, Fozzard, G., and Higgett, N. (2008), "Image Channel" in Panoramic Video: a Method to improve presence in virtual environment, CREATE 2008, June, London, UK

**Please contact *wchen@dmu.ac.uk* for more information!!**

**Acknowledgement:** We would like to thank Dr. Jackie Hooley, the education researcher of Twycross Zoo, as the project collaborator.

**2009 TELDAP Taipei**

## APPENDIX IV - THE RESEARCH'S SPONSOR AND COLLABORATOR

**APPENDIX IV (1)**

**Sponsor of the research: The Ministry of Education (Taiwan)**

教 育 部
**MINISTRY OF EDUCATION**
5, Chung Shan South Road
Taipei, Taiwan 10040
Republic of China
Tel: (886-2) 2356-5731
Fax: (886-2) 2397-6980
E-mail: intl@mail.moe.gov.tw

August 30,2006

To Whom It May Concern:

This is to certify that Mr. Chen,Wu-Hsiung was born on December 06th 1963, is a citizen of the Republic of China (Taiwan), and a graduate of Master of Art of Oxford Brookes University and has been awarded a government scholarship by this Ministry to study in United Kingdom.

This scholarship is for three years and includes the following expense items:

| | |
|---|---|
| Tuition and fees: | U.S.$: full |
| Living expenses: | U.S.$: as follows |
| London | U.S.$: 20,000 (per year) |
| Oxford | U.S.$: 19,000 (per year) |
| Cambridge | U.S.$: 19,000 (per year) |
| Other U.K. cities | U.S.$: 18,000 (per year) |

Mr. Chen,Wu-Hsiung will be responsible for direct payment to the university bursar of the tuition, and any required fees.

Furthermore, any assistance or advice that you could provide for Mr. Chen,Wu-Hsiung will be greatly appreciated.

Sincerely,

Chang Chin-sheng

Chang Chin-sheng, Ph.D.
Director General
Bureau of International Cultural and Educational Relations

**APPENDIX IV (2)**

**Collaboration certificate - Twycross Zoo**

Twycross Zoo
The World Primate Centre

21 June 2007

Dear Wu-Hsiung Chen

The management committee of the zoo have considered the research proposal that you submitted entitled “Improvements to web-based virtual reality environments as applied to zoological data”. I am pleased to confirm that they have approved your research based on the zoo. We will support your project with free access to the zoo, allowing filming of the zoo and the animals and any other help we can reasonably give while you are working here, within the operational constraints that we talked about.

We consider this to be an interesting and potentially worthwhile project and look forward to working with you.

Yours sincerely

J. L. Hooley.

Dr Jackie Hooley
Research co-ordiantor

East Midland Zoological Society, Atherstone, Warwickshire CV9 3PX Tel. 01827 880250 Fax. 01827 880700 www.twycrosszoo.org
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IUCN

**APPENDIX IV (3)**

**Sponsor of the research: The Ministry of Education (Taiwan)**

You replied on 16/01/2009 17:41.

**Wu-Hsiung Chen**

**From:** Jackie Hooley [jackie.hooley@twycrosszoo.org] **Sent:** Fri 16/01/2009 13:12
**To:** Wu-Hsiung Chen
**Cc:**
**Subject:** RE: Research progress report and require evaluation
**Attachments:**

Hello Max

I hope you got what you needed yesterday. All of the staff that I have talked to since were very enthusiastic about your panoramas and I'm sure you will have a lot of success at the conference.

I would love to have an electronic copy of the poster. We are thinking of having research posters on an interactive display somewhere and yours would be a lovely addition to the mainly animal ones that we already have.

Good luck with your write-up. If you need any further help from us then just let me know. Once you are written up remember I would love an abstract for the BIAZA research news and would be keen to work on a publication with you if you would like that.

I hope we see you here again soon and that we can use your work to enhance our web site and help get our conservation message to the public.

All good wishes

Jackie

**Dr Jackie Hooley**

**Research Officer**

**Twycross Zoo**

**East Midlands Zoological Society**

**Atherstone**

https://webmail.dmu.ac.uk/exchange/wchen/Inbox/RE:%20Research%20progress%20... 19/01/2009

YAHOO! 奇摩 電子信箱

FW: Max 2009/1/16(星期五) 下午8:42
寄件者: "Martin Richardson" <mrichardson@dmu.ac.uk>
收件者: cjumax@yahoo.com.tw

------ Forwarded Message
**From:** Jackie Hooley <jackie.hooley@twycrosszoo.org>
**Date:** Thu, 15 Jan 2009 13:12:37 -0000
**To:** <gfo@dmu.ac.uk>, <MRichardson@dmu.ac.uk>
**Cc:** Bhav Mistry <bhav.mistry@twycrosszoo.org>
**Conversation:** Max
**Subject:** Max

Hello

We have just given feedback to Max (Wu Hsiung Chen) for his project. I understand that you are both supervisors for this. I met Martin when you first came here at the beginning of the project.

I just wanted to say that all of the staff who provided feedback for Max were very impressed with what he has created and enthusiastic to encourage him to help us provide something similar for our web site in due course.

Our IT staff (Head of IT Bhav Mistry) were keen to find out if other students wanted projects. We can't offer funding, being a charity, but we can offer a friendly, enthusiastic and supportive staff and a very worthwhile cause. One potential project that has been mentioned is the development of an interactive map for our new web site but any ideas are welcome.

We wish Max all the best for the future and look forward to seeing him here again.

Jackie

Dr Jackie Hooley
Research Officer

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