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Realistic Virtual Human Character Design Strategy and Experience for Supporting Serious Role-Playing Simulations on Mobile Devices

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REALISTIC VIRTUAL HUMAN CHARACTER DESIGN STRATEGY AND
EXPERIENCE FOR SUPPORTING SERIOUS ROLE-PLAYING SIMULATIONS ON
MOBILE DEVICES

A Thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Science

by

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2022

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WRIGHT STATE UNIVERSITY
GRADUATE SCHOOL

April 26, 2022

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY
SUPERVISION BY Sindhu Kumari ENTITLED Realistic Virtual Human Character
Design Strategy and Experience for Supporting Serious Role-Playing Simulations on
Mobile Devices BE ACCEPTED IN PARTIAL FULFILLMENT OF THE
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ABSTRACT

Kumari, Sindhu. M.S., Department of Computer Science and Engineering, Wright State University, 2022. Realistic Virtual Human Character Design Strategy and Experience for Supporting Serious Role-Playing Simulations on Mobile Devices.

Promoting awareness of social determinants of health (SDoH) among healthcare providers is important to improve the patient care experience and outcome as it helps providers understand their patients in a better way which can facilitate more efficient and effective communication about health conditions.

Healthcare professionals are typically educated about SDoH through lectures, questionnaires, or role-play-based approaches; but in today's world, it is becoming increasingly possible to leverage modern technology to create more impactful and accessible tools for SDoH education. Wright LIFE (Lifelike Immersion for Equity) is a simulation-based training tool especially created for this purpose. It is a mobile app that would be available on both Google Play and Apple Store for easy access to the providers. This highly realistic, interactive, and captivating app is essential for creating mindfulness about SDoH and generating long-lasting compassion and empathy in health care workers for their real patients and helping them to build a good clinician-patient relationship.

An important aspect of this simulation is the realism of the characters and their behavior. This thesis specifically focuses on the strategy and experience of designing and developing realistic human character models and animations so that the players connect naturally and deeply with the virtual characters. This contributes to the generation of a

greater level of empathy in the providers and decreases the level of biases. In addition to its contribution to creating efficient design methodologies, this effort also resulted in a portfolio of high-quality, low-memory multi-modal avatars resembling diverse people of various ethnicities, ages, body types, and gender.

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	OVERVIEW OF THESIS	3
2	REVIEW OF TOOLS	4
2.1	Character Creator 3	5
2.2	Crazy Talk 8	6
2.3	iClone 7	7
2.4	iClone7 3DXchange 7	8
2.5	Unity 3D	9
2.6	Kukerella	9
2.7	Blender	10
3	3D CHARACTER DEVELOPMENT	11
3.1	LGBTQ+ Case	12
3.2	ASD Case	17
3.3	Common Characters	20
3.4	Extra Characters	23
3.5	Life Course	25
4	ANIMATION DEVELOPMENT	29
4.1	Pose	29
4.2	Facial Expressions and Lip-sync	34
4.2.1	Idle animations	36
4.3	Hand Gestures	37
5	OPTIMIZATION	40
5.1	Manual Poly reduction	40
5.2	InstaLOD Remesher	42
6	WORKFLOW	47
7	CHALLENGES	49
8	CONCLUSION	53
	REFERENCES	55

LIST OF FIGURES

Figure 1:	Initial version of Charles’s full-body.....	13
Figure 2:	Initial version of Charles’s face.....	13
Figure 3:	Version 2 of Charles Full Body.....	13
Figure 4:	Version 2 of Charles Face.....	13
Figure 5:	Final version of Charles.....	14
Figure 6:	Charles in Gym Clothes.....	14
Figure 7:	Initial version of Dani's Body.....	15
Figure 8:	Initial version of Dani's Face.....	15
Figure 9:	Version 2 of Dani's Body.....	15
Figure 10:	Version 2 of Dani's Face.....	15
Figure 11:	Final Version of Dani's Body.....	16
Figure 12:	Final Version of Dani's Face.....	16
Figure 13:	Dani’s Body in Gym Clothes.....	17
Figure 14:	Dani's Face in Gym Clothes.....	17
Figure 15:	Ashley's Full Body.....	18
Figure 16:	Ashley's Face.....	18
Figure 17:	Initial version of Andy.....	19
Figure 18:	Initial version of Andy's face.....	19
Figure 19:	Final version of Andy's body.....	19
Figure 20:	Final version of Andy's Face.....	19
Figure 21:	Initial version of MA Body.....	20
Figure 22:	Initial Version of MA Face.....	20
Figure 23:	Final version of MA’s body.....	21
Figure 24:	Final version of MA’s face.....	21
Figure 25:	Final version of Receptionist body.....	22
Figure 26:	Final version of Receptionist’s Face.....	22
Figure 27:	Final version of Dr. Parker’s body.....	23
Figure 28:	Final version of Dr. Parker’s face.....	23
Figure 29:	White Male in 30s.....	24
Figure 30:	White Female in 30s.....	24
Figure 31:	White Female in 20s.....	24

Figure 32:	Latina Female in 30s.....	24
Figure 33:	Brown Male in 60s.....	25
Figure 34:	Brown Male in 30s.....	25
Figure 35:	Black Male in 60s.....	25
Figure 36:	Baby – 1 year old.....	25
Figure 37:	Ashley’s mother – Full Body.....	26
Figure 38:	Ashley’s mother – Face.....	26
Figure 39:	Child 1.....	27
Figure 40:	Child 2.....	27
Figure 41:	Child 3.....	27
Figure 42:	Child 4.....	27
Figure 43:	Child 5.....	28
Figure 44:	MA-Stand Pose.....	30
Figure 45:	MA-Sit Pose.....	30
Figure 46:	Charles- Hands down holding dumbbells Pose.....	31
Figure 47:	Charles- Lifting the dumbbells Pose.....	32
Figure 48:	Ashley – Leaning Backward.....	33
Figure 49:	Ashley – Leaning forward.....	33
Figure 50:	Crazy Talk talking scenarios.....	34
Figure 51:	iClone Lip Editor.....	35
Figure 52:	Dr. Parker- talking.....	36
Figure 53:	iClone-Motion Puppet panel.....	38
Figure 54:	Hand Gesture 1.....	38
Figure 55:	Hand Gesture 2.....	38
Figure 56:	Hand Gesture 3.....	39
Figure 57:	Hand Gesture 4.....	39
Figure 58:	High polycount.....	41
Figure 59:	Reduced polycount.....	41
Figure 60:	InstaLOD- Polygon Reduction- Wearables panel.....	42
Figure 61:	Polygons of generated models with different LODs.....	43
Figure 62:	Generated models with different LODs.....	43
Figure 63:	InstaLOD- Remesher panel.....	44
Figure 64:	Extra character- High Quality- Body.....	45
Figure 65:	Extra character- High Quality- Face.....	45

Figure 66:	Extra character- Low Quality- Body.....	45
Figure 67:	Extra character- Low Quality- Face.....	45
Figure 68:	Workflow.....	47
Figure 69:	Alternate Workflow.....	48
Figure 70:	Charles- Shoe fitting issue.....	50
Figure 71:	Charles- Shoe fitting issue – fixed.....	50
Figure 72:	Ashley- Hair Issue.....	52

ACKNOWLEDGMENT

I would like to express my sincerest gratitude to Dr. Pei, my advisor, to give me an opportunity to be a part of the “Wright Life (Lifelike Immersion for Equity)” project. I am grateful that he accepted me as a student and continued to believe in me. Dr. Pei is a wonderful teacher, mentor, and thesis advisor, imparting good advice and encouragement with just the right amount of insight and humor. I'm proud and appreciative of the opportunity to work with him.

Next, I'd like to extend my gratitude to Dr. Hershberger and Dr. Wischgoll, not only for serving on the committee but also for their invaluable guidance and counsel throughout this project. I am indebted also to my incredible computer science colleagues as well as the medical team. Thank you for all your help and support throughout the project. I will always remember our time together on this endeavor.

I would thank my husband, Tushar, for always listening to me and talking things out, for consistently reviewing my work (even after heavy days at the job and during challenging times), for being happy relief when things were too serious, and for making sacrifices for me to pursue this master's degree. And a very special thanks to Mrinaank, my child, for being such a wonderful boy and letting mommy perform her work.

Lastly, I would like to thank the Ohio Department of Medicaid for funding my thesis research which is part of The Medicaid Care Experience Simulation Project. The Medicaid Care Experience Simulation (MCarES) project is funded by the Ohio Department of Medicaid and administered by the Ohio Colleges of Medicine Government Resource Center. The views expressed in this thesis are solely those of the author and do not represent the views of the state of Ohio or federal Medicaid programs.

1 INTRODUCTION

It is no secret that the greatest social capital a nation can have is health. Without healthy, productive citizens, a country can't be economically stable. Health outcomes are largely shaped by genetics and a person's lifestyle, but the conditions in the environment in which people are born, live, learn, work, and age also plays a substantial role [1].

Owing to social and economic circumstances, people with lower resources and money are more likely to experience obstacles in their health and their access to adequate health care compared to others [2]. Certain people, especially racial and ethnic minorities, are more likely to be under-resourced than others [3]. Medicaid is a state and federally funded program that assists these people with medical care and has been the main contributor to health insurance coverage for low-income people in the United States [4]. Yet, as each patient is different, providing good-quality care for everyone continues to be a challenge. The clinical interaction with the patient is essential for gaining a better knowledge of the patient's health problems. Providers who are aware of the patient's backstory may typically carry out the conversation more successfully and efficiently, especially when the clinical visit is constrained by the time [5].

Thus, promoting awareness of social determinants of health (SDoH) among healthcare providers is important to help them understand their patients better, which can facilitate efficient communication about health conditions leading to enhanced health results [5].

Healthcare professionals are typically educated about SDoH through lectures, questionnaires, or role-play-based approaches; but in today's world, it is becoming increasingly possible to leverage modern technology to create more impactful tools for

SDoH education [6] [7] [8]. Wright LIFE (Lifelike Immersion for Equity) is a simulation-based training tool especially created for this purpose. It is a mobile app that would be available on both Google Play and Apple Store for easy access to the players. This highly realistic, interactive, and captivating app is essential for creating mindfulness about SDoH and generating long-lasting compassion and empathy in health care workers for their real patients and helping them to build a good clinician-patient relationship. This healthy and compassionate relationship can affect the patient's willingness, to be honest, and forthright and may minimize the effects of any bias towards the patient that may be present.

An important aspect of this simulation is the realism of the characters and their behavior [9] [10]. One of the major considerations in grabbing users' interest in a game is how the characters engage, appear, and perform [9]. It keeps players interested and improves their gaming experience. This thesis specifically focuses on the strategy and experience of designing and developing realistic human character models and animations from a beginner's perspective so that the players connect naturally and deeply with the virtual characters. This contributes to the generation of a greater level of empathy in the providers and decreases the level of biases.

The social determinants of health that this Wright LIFE simulation particularly addresses are numerous Adverse Childhood Experiences (ACEs), Housing Instability, Early Childhood Education and Development, Quality of Housing, Access to Health Care, Health Literacy, Crime and Violence, Unemployment, Poverty, Discrimination. Since the simulation addresses a wide range of SDoHs, the necessity for creating a varied set of human avatars becomes even more crucial. Hence, this effort has also resulted in a portfolio

of multi-modal avatars resembling diverse people of various ethnicities, ages, body types, and genders.

Maintaining a minimal memory size for avatars is also critical for keeping the overall size of the application under control and ensuring that the simulation runs smoothly on mobile devices such as smartphones. At the same time, avatars need to be of high quality while appearing and behaving realistically to induce a greater impact on the players. This thesis thus also focuses on building optimized high-quality, low-memory multi-modal avatars.

1.1 OVERVIEW OF THESIS

There are multiple chapters in this document. The second chapter discusses the tools used to develop the avatars for this simulation. In Chapters 3 and 4, the process of creating characters and animating them has been described in detail. The optimization of characters is the subject of Chapter 5, and the workflow of the entire process is the topic of Chapter 6. Chapter 7 outlines the issues that were encountered, and Chapter 8 concludes the paper by discussing the contributions and future work.

2 REVIEW OF TOOLS

Because gaming characters play such an important part in player engagement and enhancing their overall experience, it's imperative to develop better human character models that appear and feel more genuine and relatable to the users. To build, animate, voice, and eventually load the virtual 3D characters and animations into the game engine, several tools were used. While there are many options for completing the tasks listed above, for this project, products that can generate maximum results in a short amount of time and with a low learning curve have been chosen.

Autodesk Maya is a professional 3D software that can be used to create lifelike characters and major studio effects, but it is complex, quite costly and crashes often [11] [12]. Blender is a free program that does the same thing, but it demands strong modeling, rigging, and animation expertise [13]. 3ds Max is also pricey [14]. However, the problem with traditional software is that they are quite granular. Each and every polygon and frame must be measured. Not only should users create these assets from the scratch but must also develop their own production workflow to ensure that everything runs efficiently and modularly. For beginners, that is far too much work and effort.

Amid all of this, Reallusion Products are a welcome relief. The complete Reallusion pipeline has been deciphered. Because all characters are based on the same topology, it's simple to fix anything down the road. UVs, rigs, animations, and morphs are all modular and sustainable as if we live on a planet where all is reusable there are very few landfills. Furthermore, Reallusion's products are far more stable than those of AutoDesk [11] [12]. Daz Studio is a freeware program that includes some good base characters as well as a

nonlinear animation clip mechanism that is comparable to iClone's but not quite as powerful [15].

Reallusion provides excellent commercial solutions for constructing, animating, and finally, loading the virtual 3D characters and animations into the game engine with commercial quality rendering [16] [17]. They are heavily used in this simulation as discussed in detail in this chapter. Apart from that, other technologies were utilized to generate speech and create customized assets, which are both mentioned further below.

2.1 Character Creator 3

Character Creator 3 aka CC3 from Reallusion is a comprehensive character creation program that lets designers easily build, import, and customize stylized or realistic character assets to be used in 3D applications like iClone, Maya, Blender, Unreal Engine 4, Unity, and others [18]. While Autodesk Maya, Blender, Design Doll, DAZ 3D, ZBrush, Make Human, and other software on the market are also available for designing 3D characters, many of them are also free. Character Creator is without a doubt the best for beginners because of its rich asset library, smooth learning curve, and affordable cost.

It ships with many ready-to-use human models, and a good collection of assets like clothes, footwear, hair, eyes, make-up assets, and many other things including, e.g., a child avatar called “Baby Luna”. Drag-and-drop menus, value sliders, and guided sculpting tools can be used to modify the physical traits of the characters. These capabilities make it possible to create models without having to know anything about 3D modeling, rigging or texturing thus greatly reducing the learning curve for a beginner and in turn saving a lot of time. The SkinGen plugin, which is a dynamic skin layer system, is another essential component of Character Creator 3. This, combined with the Digital Human Bundle, allows

you to add high-quality detail, such as wrinkles, scars, and pores, to the face and other body parts, allowing you to quickly build beautifully hyper-realistic figures. Because of all these features, CC3 was the best choice for this project.

Although CC3 is quite powerful, there is still room for growth. It would be wonderful, for example, if the free resources included head-body morphs and assets for a variety of ethnicities. The majority of the free models, hairstyles, and other accessories appear to be designed for Caucasian people. Although the Reallusion Marketplace allows you to purchase assets, there aren't many to choose from either. Additionally, because the CC3 license is already costly, purchasing assets raises the whole production budget. This may make this product costly for modest projects. Another area where improvements might be made is the size of the clothing and shoe accessories. Accessories for larger characters do not scale to fit the body, resulting in an unattractive appearance. They also don't have a version for Mac OS, which might displease many people.

2.2 Crazy Talk 8

Crazy talk is a popular facial animation software from Reallusion [19]. It comes preloaded with 2D and 3D actor models, as well as the ability to construct 3D models from character images and iAvatar files produced by other Reallusion products such as CC3 and iClone. Thereafter, these model heads can be used to create talking animations from voice and text. It's a powerful tool that lets you move face features and muscles to produce complex expressions in addition to making lip-syncs. One of the most noteworthy features is the ability to make lip-syncs utilizing auto-motions from a variety of scenarios, including Advice, Denial, Sympathy, Charge Attack, Mumbling, and many more. This feature has been used extensively in this project.

Crazy talk, like any other useful tool, has its limitations. The most significant is that Reallusion has stopped supporting version 8 of the product, forcing users to spend additional money to upgrade to the new version that they are releasing. Another issue is it crashes very frequently. Crazy talk poses a few further challenges, which will be covered in more detail in Chapter 8.

2.3 iClone 7

Reallusion's iClone 7 is another sophisticated tool for producing real-time 3D animations [20]. It features a variety of tools for creating movie/game scenes, lighting, camera systems, and so on, but in this simulation, it is used only to produce animations.

iClone has become quite popular for animation because of automated rigging, extremely user-friendly animation procedures, and far faster and easier animation creating process than many other software solutions. It can emulate full-body rigging and uses advanced tools for manipulating curves. Artists can use iClone to concentrate on minute things like facial animation and lip-sync to bring characters to life. In addition, iClone provides a ready-to-use library of postures, hand gestures, motion tools like Body Puppet, MixMoves, and character personalities that allow your character to talk, walk, and do other things in a certain manner, allowing users to really see their character perform in seconds. Despite the fact that iClone has a lot of options for artists, the software is fairly easy to use. The abundance of resources available on the internet also aids in reducing the learning curve. iClone perfectly aligned with this project's final goals, timing, budget, and skill level.

iClone 7 is a complete solution for producing 3D animations, but it comes with its own set of drawbacks, the most significant of which is the cost. Users can sign up for a free

trial of iClone, but the full program must be purchased. Expenses don't end at buying the complete license. To deliver or create animation in the shortest amount of time, you'll need to depend largely on assets that have been produced by specialists, which means you'll be working with templates and/or using other people's work that looks professional. The Reallusion marketplace's export version of paid assets is roughly 25% more expensive than its iContent rights, which are the exclusive content format for iClone and Character Creator.

Some experts believe that many of the functionalities are intentionally underdeveloped to get you to purchase additional plug-ins. For example, you'll need to purchase SkinGen Premium Plug-in if you want to customize the 3D texture on the skin, such as a tattoo or a specific scar. Furthermore, iClone requires specific system requirements and is not available on Mac. Another difficulty is the rendering of hair. It appears rigid and does not move naturally, thus taking away the realism.

2.4 iClone7 3DXchange 7

3DXchange Pipeline is a powerful, easy-to-use translation and editing tool that integrates iClone to the world of 3D content via FBX, obj, and other formats [21]. This could import and export static artifacts, animating props, skin-bone rigged characters, and motion clips, along with other 3D elements. You can also recycle them with Unity, Unreal, Maya, Blender, Cinema 4D, or Daz Studio-specific export settings.

This program is used in this project to combine and export the characters and their animations in an FBX format that is compatible with Unity. One thing to keep in mind is that 3DXchange is not backward compatible, therefore 3DXchange Pipeline 7 will only

operate with iClone 7, not iClone 6 or earlier versions. However, it didn't cause any issue in this project since iClone 7 is being used already.

2.5 Unity 3D

Unity3D is a very famous, free, cross-platform 3D engine with an easy-to-use development platform for making 2D/3D video games and apps for mobile devices, computers, web, and gaming consoles [22]. It can also be used to develop AR/VR applications. In this project, Unity3D is the game engine that has been used to bundle together everything by integrating the characters and animations all together into scenes, script the scenes, develop environments, and eventually the VR simulation app.

The only disadvantage is that it is quite complicated and has a steep learning curve. It does, however, have a large community and so a lot of assistance and resources to learn from.

2.6 Kukerella

Kukerella is an affordable subscription-based online tool used for generating synthetic speech from text and for transcribing audio [23]. It provides a large selection of voices in a variety of languages to choose from, as well as the ability to customize voices with accents and effects such as pitch, speed, and volume. It's also powered by Text to Speech (TTS) services from Google, Amazon, Microsoft, and IBM, which makes it a compelling option.

In this project, many characters are communicating with each other and thus we needed unique voices for each character to create an overall realistic effect. Hiring so many skilled voice artists is expensive as well as challenging. As a result, Kukerella fitted the bill and has been used extensively for voice generation in this simulation. It has a user-

friendly interface and allows input texts to be organized as projects. It also enables large sections of texts to be added and translated as a single audio or as paragraphs very quickly.

2.7 Blender

Blender is an open-source and free 3D computer graphics software toolkit that is used to construct animated movies, special effects, artwork, 3D-printed models, computer animations, interactive 3D apps, VR technology, and other things. However, it was solely used in this project to develop a custom Name Tag asset that wasn't available in either the CC3/iClone libraries or the Reallusion marketplace.

Blender is extremely versatile since it allows you to build anything from the scratch. But it is also its main drawback because developing something from scratch necessitates learning which makes the learning curve high for beginners working on tight deadlines.

3 3D CHARACTER DEVELOPMENT

The appearance and personality of the characters have a significant impact on how well the game is perceived by players. Therefore, it's critical to incorporate the essence that embodies the core of a character's personality, including their appearance, distinguishing characteristics, backstory, behavior, and habits, among other things [24]. To achieve great results, the process of developing 3D characters demands efficient communication among all teams involved. In this project, two interdisciplinary teams have worked seamlessly together: The Medical team acting as Subject Matter Experts (SME) and the Computer Science team doing the hands-on development work. This chapter discusses the strategy and iterative process of developing a diverse portfolio of character models.

This game simulation has 2 cases that mainly revolve around the clinical encounter of the protagonists and their experiences. Following is the summary of the simulations-

1) The LGBTQ+ case – It is about a 60-year-old African American gay man Charles, who is well-educated and has a history of serious asthma and bodyweight because of prescribed steroid use. Both he and his longtime companion (now spouse) have faced discrimination in employment and housing. Charles has been on antidepressant and anxiety medication for most of his adulthood, and he has also been a heavy smoker. Charles' visit to the community health center is due to growing knee pain, for which he has been informed that a surgeon will not perform a knee replacement unless his weight falls below a BMI of 35. Because his usual provider is on vacation, Charles sees a new provider at this visit.

2) The ASD Case – It's about an autistic 18-year-old woman, Ashley. Her mother's history of substance addiction caused her to be taken from her home. She was placed in foster care when she was five years old and has since lived with a variety of caregivers. She was

bullied in primary school after being diagnosed with an intellectual impairment and autistic spectrum disorder. Ashley has been dating a 19-year-old lad, whom she met at high school, for almost 2 years now. Since she turned 18, Ashley has been seeking autonomy and freedom. Ashley came to the community health clinic to discuss birth control and also to have a form signed for college so she could take tests in a quiet room. Because her normal provider has left the practice for a new position, Ashley sees a new provider at this visit.

The characters involved in these stories are categorized into 5 headings and are discussed in the subsequent sub-sections.

3.1 LGBTQ+ Case

Charles

Cues— 60-year-old African American Male, 300 pounds, Gay, Ph.D. degree holder, Married.

Charles is the main character in this story; therefore, he gets a lot of screen time. It's crucial for him to look the way he's depicted on paper. Figures 1 and 2 show the very first draft of Charles, which was created using the free content shipped with CC3. He is the first character built while learning character creation. It was challenging to design Charles' body morph because he is a large old African American man. The process started with an elderly white male body morph and was merged with an African male head morph. After that, it was aged and fattened to reach the body that was seen in version 1. The medical team recommended that he have his face and neck defined and less grumpy, that he wears spectacles on his face since he is old enough and educated, and that he wears a ring because he is married. The models represented in Figures 3 and 4 were constructed based on the feedback. This round saw the procurement of new assets such as a ring and spectacles, as

well as the modification of his attire to give him a more sophisticated appearance. A watch was also added to his wrist.



Figure 1: Initial version of Charles's full-body



Figure 2 : Initial version of Charles's face



Figure 3 : Version 2 of Charles Full Body



Figure 4 : Version 2 of Charles Face



Figure 5: Final version of Charles



Figure 6: Charles in Gym Clothes

The face was well-received in the next iteration, and the recommendation was to reduce the area around his abdomen and chest, as shown in Figure 5, which is the player's finalized version. There is an additional requirement in the script to depict Charles working out at home. As a result, a new version of Charles in gym attire is developed, as illustrated in Figure 6.

Dani

Cues— 55 years old African American, Non- binary, Gym Instructor, Married

Dani has been Charles' long-term partner and now spouse. They are Charles' support and are extremely caring. They must have a toned athletic body but an aged face because they're a 55-year-old gym instructor. They being non-binary is another challenging part of choosing their appearance because of lack of understanding about this group of people. Dani's first version is depicted in Figures 7 and 8. The model is dressed in workout clothing with braided long hair and a silver earring hanging from one ear.



Figure 7: Initial version of Dani's Body



Figure 8: Initial version of Dani's Face



Figure 9: Version 2 of Dani's Body



Figure 10: Version 2 of Dani's Face

The medical experts recommended that they be plumper and more face-friendly, as well as exploring more wardrobe possibilities. More research into non-binary people's

dressing was conducted, and a new version was developed, as seen in Figures 9 and 10. Gender-neutral clothing, such as jogger trousers, t-shirts, and cardigans, was introduced. To make the face more approachable, a new head morph was used. Aside from that, the face has been enhanced with new assets such as a metal nose ring and an emerald stud ring. To make the face appear older, more skin textures were applied, such as wrinkles, pores, and under-eye bags. Slight eye makeup is also applied.

The attire was largely well-received in this iteration. The suggestion was to tone up the face and keep the body as it was in the original version, with broader shoulders. Figures 11 and 12 illustrate the finalized version of Dani developed based on the feedback.



Figure 11: Final Version of Dani's Body



Figure 12: Final Version of Dani's Face

Dani's overall appearance was accepted by everyone in this round. There was also a requirement for one more variation of Dani dressed in fitness clothing. As a result, a new model was constructed using the clothing from the first iteration, as seen in Figures 13 and 14.



Figure 13: Dani's Body in Gym Clothes



Figure 14: Dani's Face in Gym Clothes

3.2 ASD Case

Ashley

Cues— 18-year-old White Female, Blonde, Blue eyes, College Student, Lives in Foster Care.

Ashley is the central character in the story, and as a result, she has a lot of screen presence. The prerequisite of this character is that Ashley's face shouldn't be mature since she's so young and her overall appearance to be nervous and timid. As she stays with a foster family, it is considered that she may not own valuable items and dresses simply. Her hair is pulled back into a ponytail, and she sports a watch and sneakers, as do most college students, and doesn't wear makeup. There are numerous body and head morphs available for white females. As a result, building this model was not very difficult, and it was widely accepted in the first iteration itself. Ashley's 3D model is shown in Figures 15 and 16.



Figure 15: Ashley's Full Body



Figure 16: Ashley's Face

Andy (Foster Father)

Cues – 50-year-old African American Male

Andy is Ashley's foster father and her major supporter. He respects Ashley's choices and is supportive of her choice. The requirements for building this model's body were fairly simple. The face needed a bit more detailing to make him look like someone with whom people will be more comfortable. Figures 17 and 18 show the first version of this character model.

This character was not well appreciated in the first edition by the medical team. He appears to be quite stressed, as per the feedback. This particular head morph, however, had version compatibility concerns and didn't allow for a lot of facial muscle adjustment. As a result, a different head morph was selected to achieve customization. Because CC3 doesn't include many head morphs for African people, generating several black characters for a simulation can be difficult. As a result, this head morph was combined with a Latin male

head morph to produce a new model, as seen in Figures 19 and 20. Apart from the face, the clothing was also changed to distinguish it from Charles's. At this time, the new model was well-received and finalized.



Figure 17: Initial version of Andy



Figure 18: Initial version of Andy's face



Figure 19: Final version of Andy's body



Figure 20: Final version of Andy's Face

3.3 Common Characters

Medical Assistant (MA)

Cues – 50-year-old White Female, Judgmental, Name- Barb

MA is a character who appears in both storylines and plays an important role. She looks to be ignorant, and judgmental and engages in microaggressions in both cases. She needs to be dressed in scrubs, wear a watch, and carry a stethoscope because she is a professional. It wasn't a problem because these assets are readily available on the Reallusion Marketplace. The real effort here was made on the face to create the appearance of a middle-aged healthcare worker. SkinGen was used extensively on her face and neck to add wrinkles and to apply subtle makeup. Hair is tied in a bun and the color was changed from the default blonde to a darker shade. Another idea was to put a name tag on her. Because no such asset could be found, a customized asset was developed in Blender and utilized on MA's body instead. The earliest version of MA is shown in Figures 21 and 22.



Figure 21: Initial version of MA Body



Figure 22: Initial Version of MA Face

This model was largely accepted. To make the character more realistic, MA also was supposed to have a little butterfly or flower tattoo on her nape and arm. But such an asset was not readily available and the only way to create custom skin texture in CC3 is to use the SkinGen Premium plug-in which comes for a good price. Since a tattoo was not a necessary but desirable attribute, this suggestion was taken back. Another remark was made concerning the scrubs' number of creases. So, the model was revised to have a new set of scrubs. Figures 23 and 24 portray the final version of this character.



Figure 23: Final version of MA's body

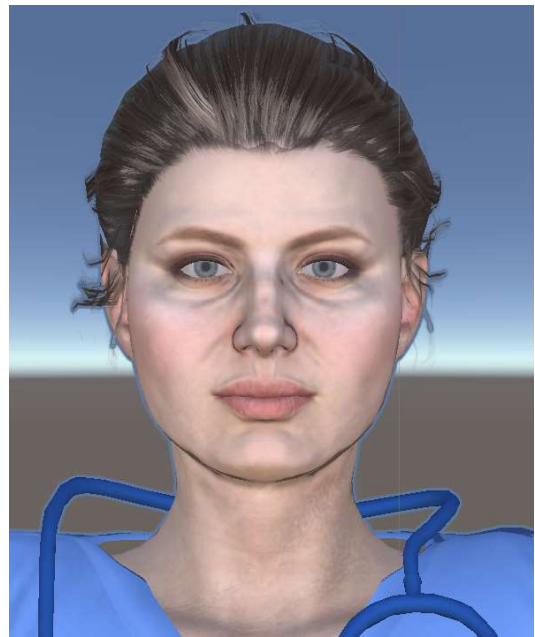


Figure 24: Final version of MA's face

Receptionist

Cues – 20-year-old Asian Female, Friendly

The Receptionist plays a significant part in both the stories. She greets the main protagonists Charles and Ashley and appears generally polite and cheerful. For diversity, she needed to be an Asian. This was an easy task since an Asian female head morph was included in the Digital Human pack that had already been purchased for the project Because

this pack is a bit pricey, it may be a problem for projects with a budget constraint. So, the Asian female head morph was customized to create a cheerful face, wearing makeup with dark hair tied back in a ponytail. Additional accessories like earrings, necklace, nail paint, and a watch are also used to make the figure more relatable. Also, as per the medical team's initial inputs, she is dressed in a different color scrub to appear more professional. This first edition of the model was approved at the very first iteration with minor suggestions about the accessories. Figures 25 and 26 show the 3D model for this character.



Figure 25: Final version of Receptionist body



Figure 26: Final version of Receptionist's Face

Dr. Erica Parker

Cues – 35-40-year-old African American Female, Expert Trainer

Dr. Erica Parker is the expert trainer that guides the player through the simulation and thus appears very frequently. She is in the age bracket of the late 30s to early 40s, should dress professionally, and appear approachable. This model was easy to make

because it is based on a black female head morph. Clothing was likewise simple to choose from the CC's free content. The hair is the most difficult aspect of making black characters. CC does not include even a single hairstyle for persons of this ethnicity. Erica's hair was still cut short, and the color was darkened to make it work. This character was also approved in the early stages of development. The finalized model is shown in Figures 27 and 28.

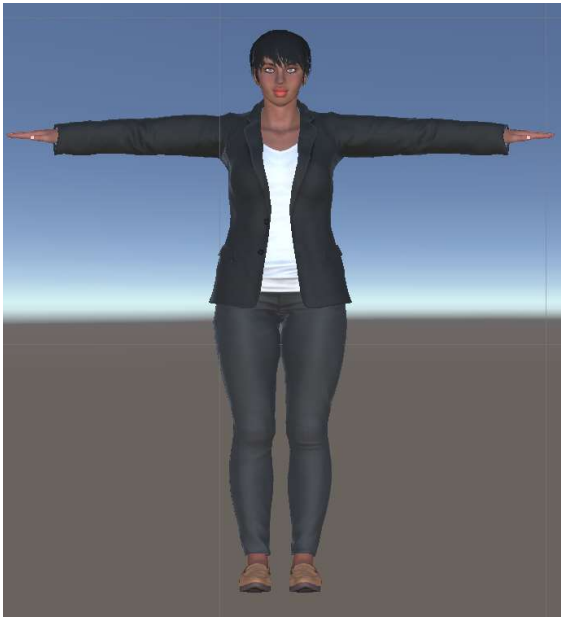


Figure 27: Final version of Dr. Parker's body



Figure 28: Final version of Dr. Parker's face

3.4 Extra Characters

Usually, public places have many people present at any given point in time. So, in this simulation also extra characters are developed and placed in the scenes set at the healthcare center in the waiting area and hallway, street, bus, and other locations for realistic portrayal. The portfolio of additional characters is depicted in the following sections in Figures 29 to 36.



Figure 29: White Male in 30s



Figure 30: White Female in 30s



Figure 31: White Female in 20s

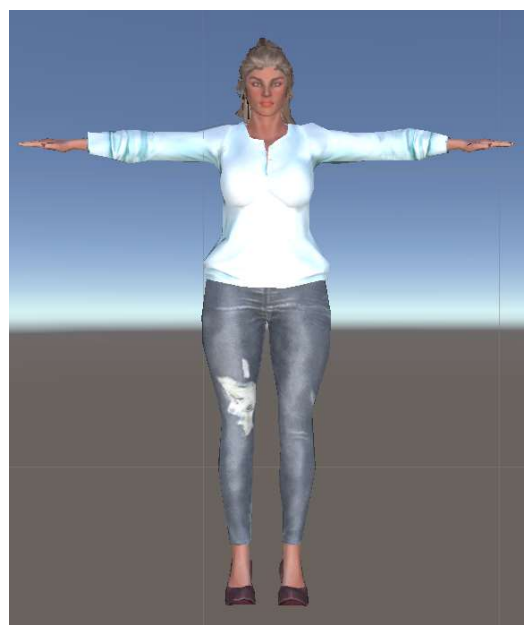


Figure 32: Latina Female in 30s



Figure 33: Brown Male in 60s



Figure 34: Brown Male in 30s



Figure 35: Black Male in 60s



Figure 36: Baby – 1 year old

3.5 Life Course

Social determinants of health in Ashley and Charles's life history are depicted in the Life course game portion of the simulation through photos and videos. For video portions,

models are mostly reused from the portfolio already developed. A few character models had to be created which are discussed as follows-

Ashley's mother

Cues- White female in early 30s, Blonde, Substance abuser

Ashley gets rescued from her house after she witnesses her mother lying unconscious on the floor when she is five years old. The mother character's model had to be dressed informally and have some blemishes and defects on her face for this scene. This model is seen in Figures 37 and 38.



Figure 37: Ashley's mother – Full Body



Figure 38: Ashley's mother – Face

Children playing at the park

Cues – 8-year-old kids

Ashley, who is eight years old, sees kids playing tag in the park but is hesitant to approach them. It was necessary to create a group of children for this scene. By default, CC comes with only one infant model, "Baby Luna," as illustrated in Figure 36. The goal was to have as many children as possible. During the creation of child characters, it was

discovered that Luna, the baby, may age up to a teenager using a morph slider. As a result, no child morphs were purchased and baby Luna morph was used to produce five alternative child character models, as seen in Figures 39 to 43. Kid models were also well-received.



Figure 39: Child 1



Figure 40: Child 2



Figure 41: Child 3



Figure 42: Child 4



Figure 43: Child 5

4 ANIMATION DEVELOPMENT

The behavior of the characters, in addition to their appearance and personality, has a big impact on how well the game is perceived by players. Animation is the final stage in the character development process. With facial emotions and body movements, the 3D character model takes on a life of its own. Each action should reflect the character's personality, and by being natural and authentic, certain responses in the player, such as joy, laughing, or empathy, can be evoked. All of this can be accomplished through the creation of high-quality character animation.

The story in this game involves the interaction of the characters at home, at the health center, and in the street/bus. So, the animations created can broadly be classified into 3 types:

4.1 Pose

A pose is simply a particular way of positioning the body. In this project, the Pose-to-Pose technique of animation is used, in which first the key poses are designed for characters, and then in-between frames are created so as they appear moving from one pose to another. For example, the first pose has an arm up and the second has an arm down, the intermediary space will have to be filled with at least one frame where the arm is somewhere in the middle. The smoother the animation seems, the more frames there are in this interval in between [25].

This technique evolved during the pre-digital animation era when animators had to hand-draw each movement. As a result of this methodical approach, they were able to construct the key poses first, and then the in-between poses for transitioning. This method is still useful as the key poses can be created using the “Edit Motion Layer” and “Direct

Puppet” options in iClone and in-between or transitioning frames can be generated in the iClone timeline, resulting in a moving animation. The iClone timeline of a Sit-to-Stand animation is shown in Figures 44 and 45.

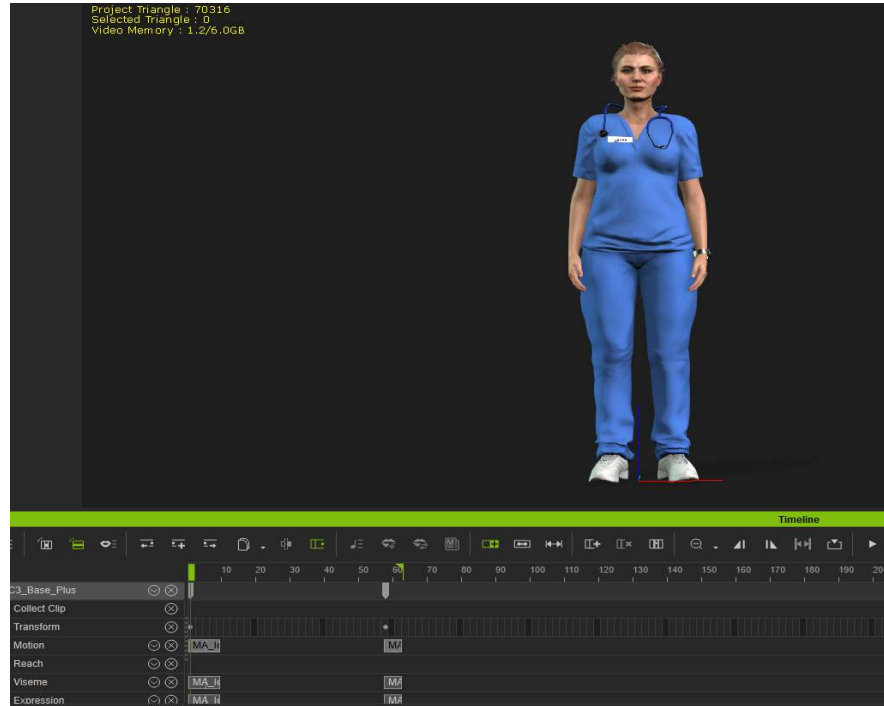


Figure 44: MA-Stand Pose

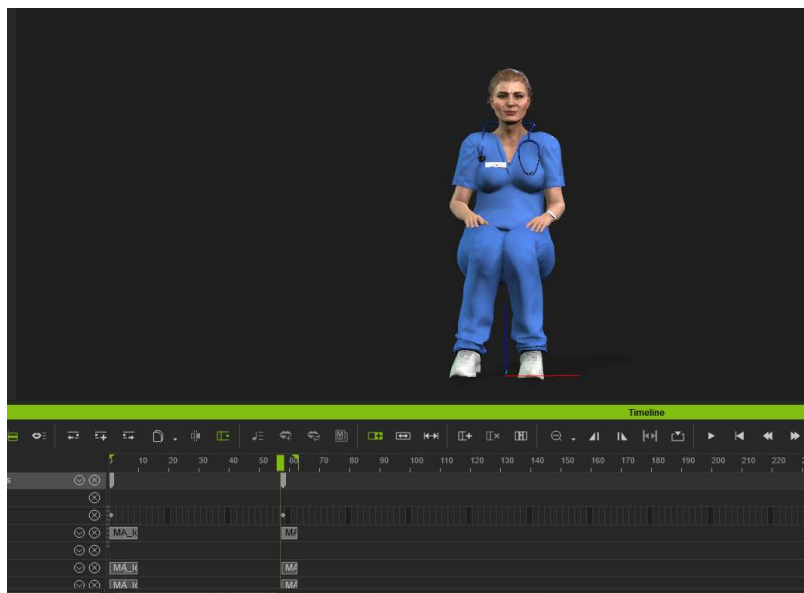


Figure 45: MA-Sit Pose

In addition to the regular sitting and standing animations, there were a few situations in this story that required the construction of a few interesting animations. In the LGBTQ+ case, there is a scene where Charles is using dumbbells to work out his upper body. Two poses were created for this animation: one with him keeping the dumbbells down and the other with him raising them. The poses were then used in the iClone timeline to produce the exercise animation. Figures 46 and 47 show the above-discussed poses.



Figure 46: Charles- Hands down holding dumbbells Pose

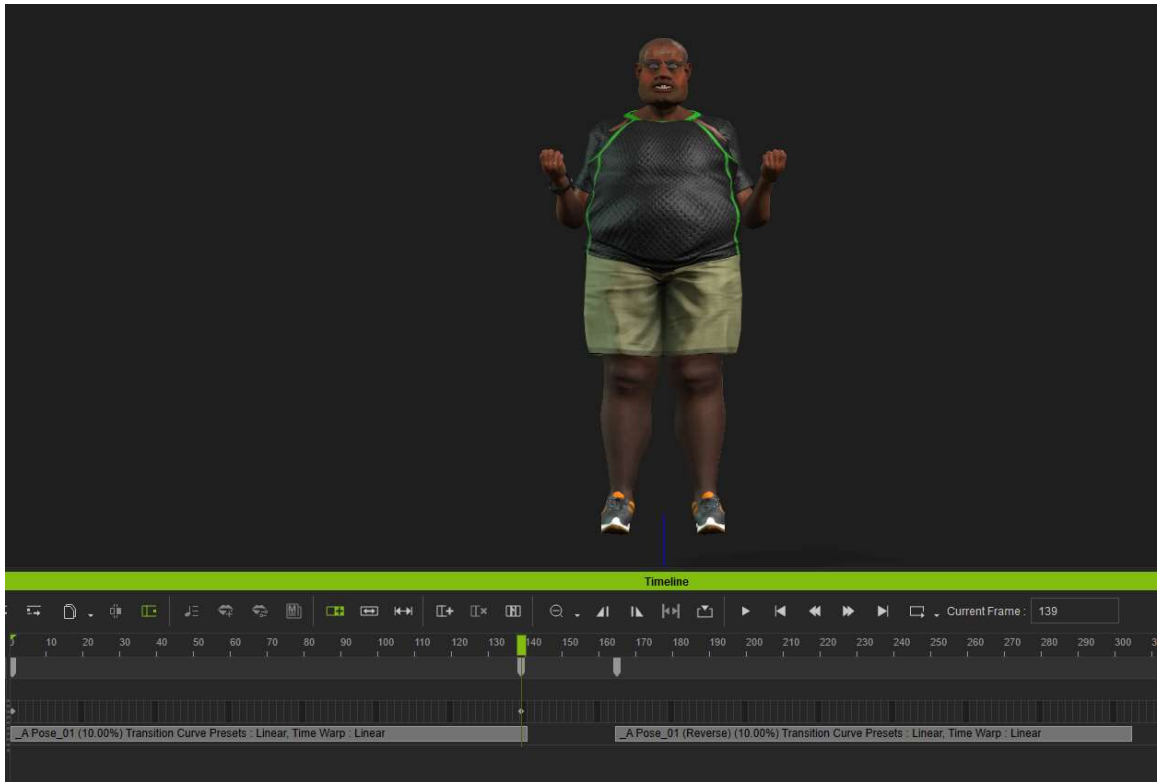


Figure 47: Charles- Lifting the dumbbells Pose

Another scenario involving Ashley was a little difficult to create. To cope with her discomfort in the new circumstance, Ashley rocks back and forth in the Ashley-Provider scenario. For this animation, two positions were created: one with her leaning forward and the other with her reclining backward. The rocking motions were created by looping these two poses together in the iClone timeline. To ensure that it looked authentic, it was necessary to keep in mind the degree to which Ashley bends as well as the speed at which she rocks. Look at Figures 48 and 49 to comprehend how the rocking positions work.

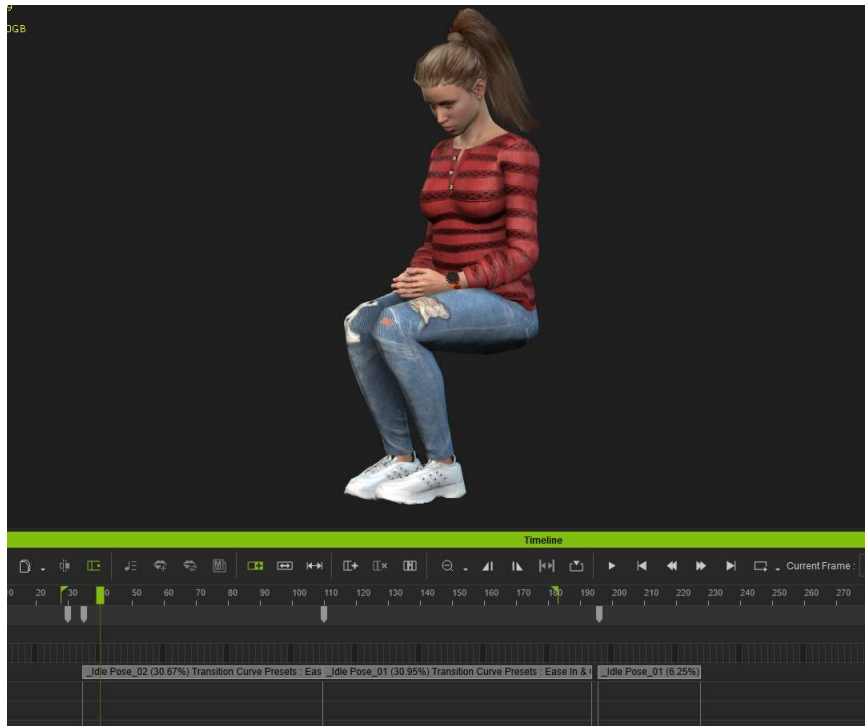


Figure 48: Ashley – Leaning Backward

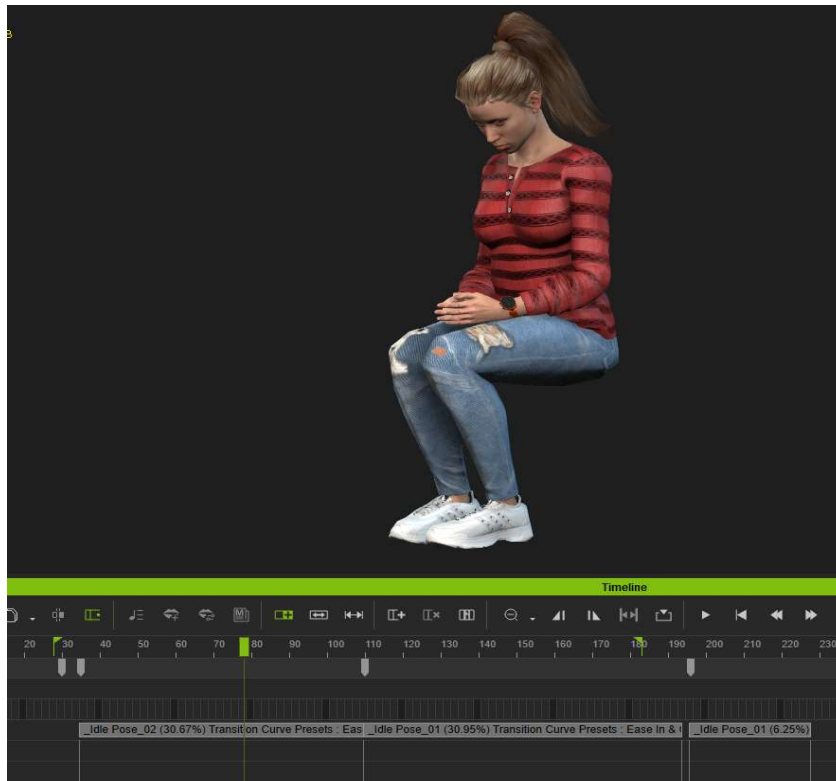


Figure 49: Ashley – Leaning forward

4.2 Facial Expressions and Lip-sync

The animated character seems to be more appealing with facial expressions. An expression is created by the movements of the brows, eyelids, and lips. For example, happiness has tightened muscle around the eyes, "crow's feet" wrinkles around the eyes, lifted cheeks, and lip corners raised diagonally, whereas sadness has raised inner corners of eyebrows, slack eyelids, and pulled down lip corners [26]. Figure 47 depicts Charles' face in a comically tense state as a result of carrying a hefty weight. Therefore, making talking animations involves not only moving lips but also considering facial expressions.

Because the characters in this simulation are mostly talking with one another, a large number of lip-syncs were required. Except for Dr. Erica Parker, all other characters' talking animation was produced using Crazy Talk and subsequently refined in iClone. Crazy Talk, as indicated in Section 3.2, allows you to generate animations based on the emotional scenarios you choose. The various options can be seen in Figure 50.



Figure 50: Crazy Talk talking scenarios

CrazyTalk's lip-syncs are incredibly lifelike, as they include facial expressions, neck-head movement, and eye blinks. The Advice, Confirmation, and Sympathize options were used for the majority of the project needs by feeding in voice recordings already prepared

by the voice generation tool Kukerella. After that, the created animations were exported as RLTalk files and imported into iClone. Figure 51 shows how the timeline in iClone is used to fine-tune these animations by modifying the viseme strength and correcting the lip movement in the Lip-Editor. To make a full-fledged animation, lip-sync animations are usually combined with standing, sitting, or walking movements.

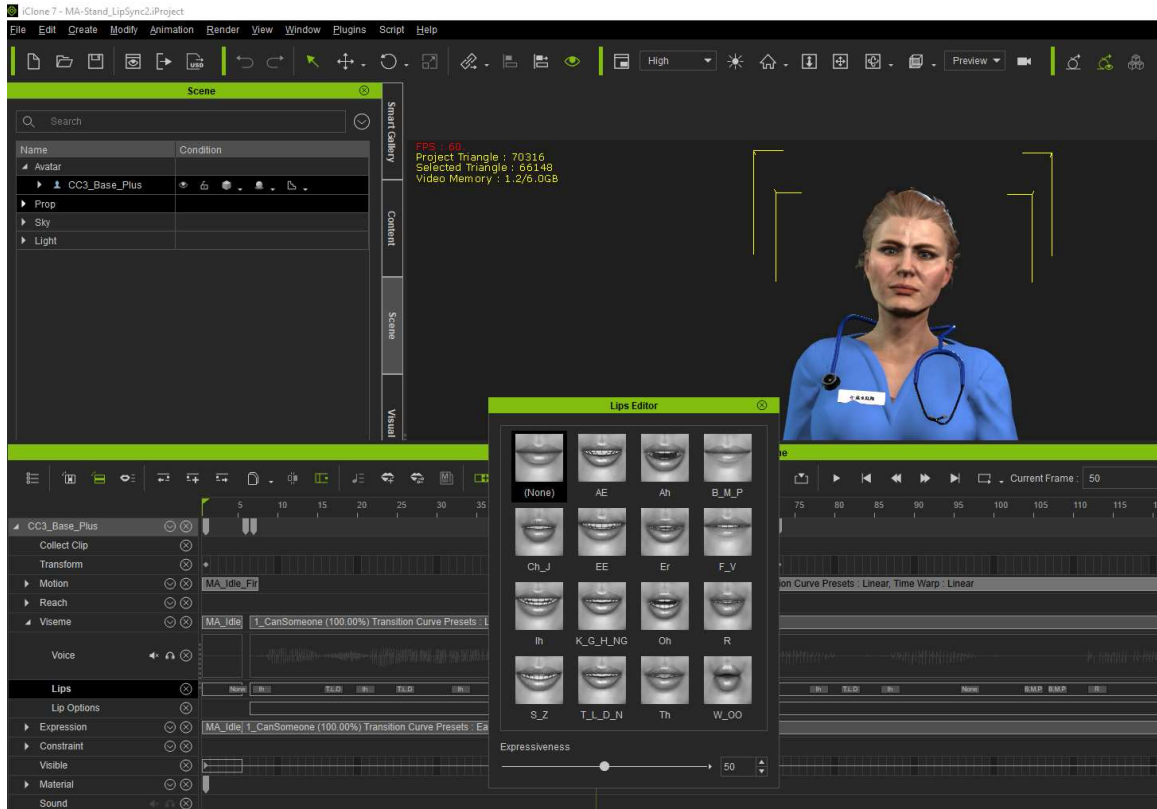


Figure 51: iClone Lip Editor

Dr. Erica Parker is the expert trainer in this game who guides the player through the simulation. Her job is to teach, which necessitates a lot of talking. As a result, a different strategy was used to speed up the development work. Characters can be given a "Persona" in iClone, which is a strong feature. A Persona is a character assigned to an actor so that he or she can animate distinctively. Several sets of movement behaviors, such as laughing, chatting, walking, dancing, and so on, may be included in a single Persona. Dr. Parker was

given the "Heidi" persona that comes with iClone, and her "talking" behavior was used to create the speaking animations. While the speaking style was good, the body movements were not what Dr. Parker intended, thus a lot of fine-tuning was required to attain the desired outcomes. Dr. Erica Parker is shown speaking in Figure 52.



Figure 52: Dr. Parker- talking

4.2.1 Idle animations

Idle animations are just as crucial as talking animations in building a more realistic experience. It's possible that a character isn't always talking or doing something. It could be listening to someone, reading/watching something on the phone, or waiting for anything, for instance. Making the character's head or body move a little and blinking their eyes can make a huge impact in these scenarios compared to keeping the character static.

Good idle animations are a bit challenging to make because they should be of the right length to avoid appearing monotonous. The trick here is to keep the head-body

movement and the facial expressions subtle, to match the start and end key poses, and to keep an eye blink interval of at least a few seconds. Making a short animation clip with subtle head-body movement and then copying it after the first one, but in reverse, is a nice technique to achieve this. The final clip will have a seamless transition and a start and finish key pose that match. Idle animations built with these points in mind would look smoother even if performed in a loop.

4.3 Hand Gestures

It is fairly typical for people to express themselves by moving their hands while speaking. As a result, adding hand motions to the animations gives that extra sense of realism. In this project, the motion puppet panel (Figure 53) was used extensively to simulate hand motions. It allows you to make clips by recording pre-defined gestures. It also allows you to mask specific body parts and alter postures in real-time to see how the animation will turn out. Figures 54 to 57 depict some of Dr. Parker's hand gestures in her scenes. Motion puppet panel was also used to restrict the default walking behavior of “Heidi” on Dr. Parker while talking and instead make her stand still using idle motion.

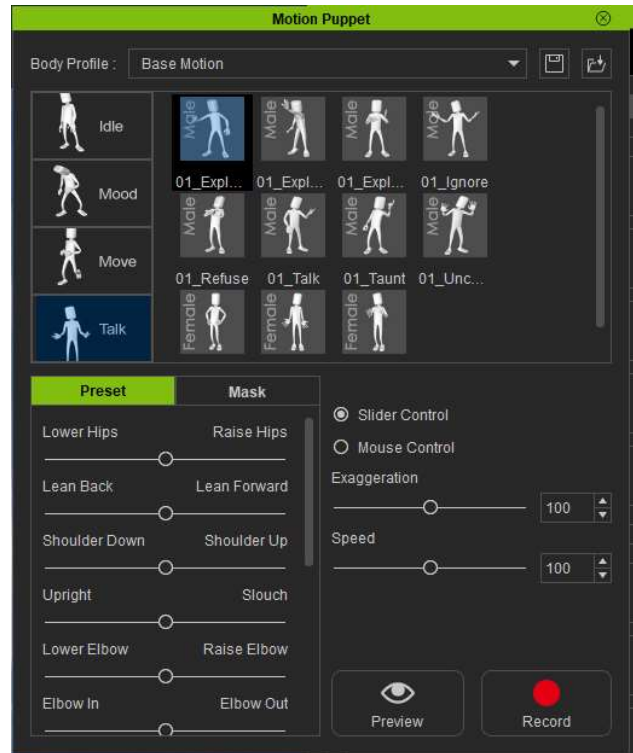


Figure 53: iClone-Motion Puppet panel



Figure 54: Hand Gesture 1



Figure 55: Hand Gesture 2



Figure 56: Hand Gesture 3



Figure 57: Hand Gesture 4

5 OPTIMIZATION

To have a greater effect on the players, virtual characters must be of good quality while looking and acting authentically. At the same time, keeping avatar memory usage to a minimum is vital for maintaining the application's overall size in check and assuring that the simulation runs smoothly. So, because this simulation's primary platform is mobile devices with limited memory and rendering speed, striking the correct balance between quality and memory size is critical.

Mesh is used to create the base of the body, garments, and any other item in computer graphics. Mesh is made up of polygons, which are triangles. The greater the number of vertices and polygons, the greater the character's quality. However, if the quality is higher, the file size will be larger as well. When there are numerous characters in a scene, the game's performance is burdened even more. Furthermore, high-quality characters typically have more textures, increasing the number of draw calls, which influences game rendering speed. As a result, polygon reduction is critical, and it can be accomplished in a variety of methods (separately or in combination) – using Mesh Simplifier script in Unity, manually in CC3, or using InstaLOD Remesher in CC3. Only the CC3 options have been used for character optimization in this thesis.

5.1 Manual Poly reduction

To optimize all of the objects that a character is wearing, Character Creator 3 has a feature that lets designers decrease polygons manually utilizing InstaLOD- Polygon Reduction- Wearables. Figure 58 displays a wireframe mode character in its original high-quality polygons. It has a total polycount of 66935 and is 144MB in size on the disc.

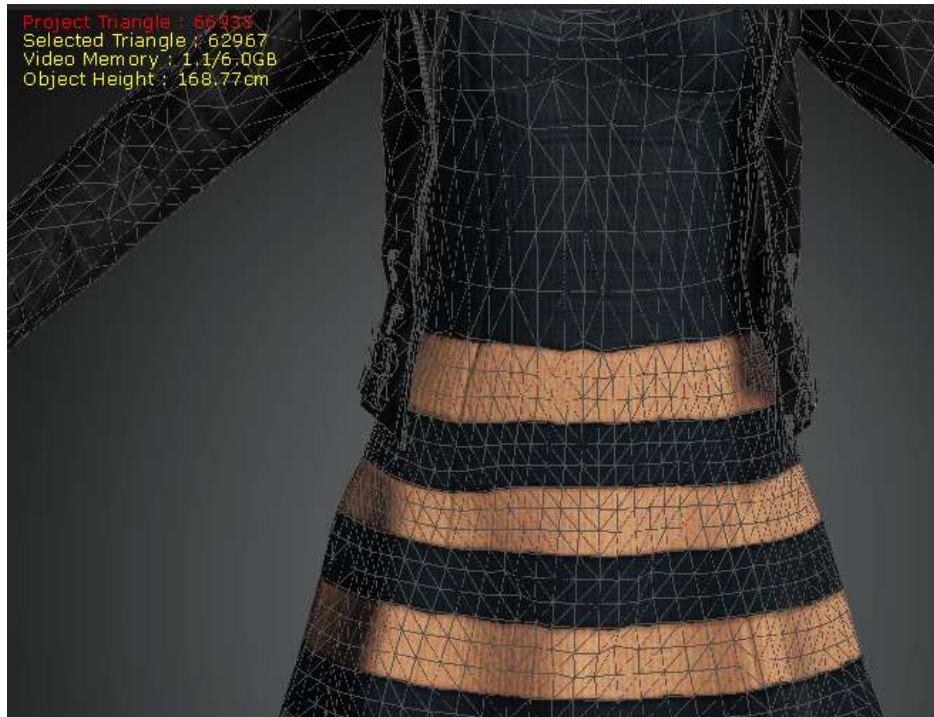


Figure 58: High polycount

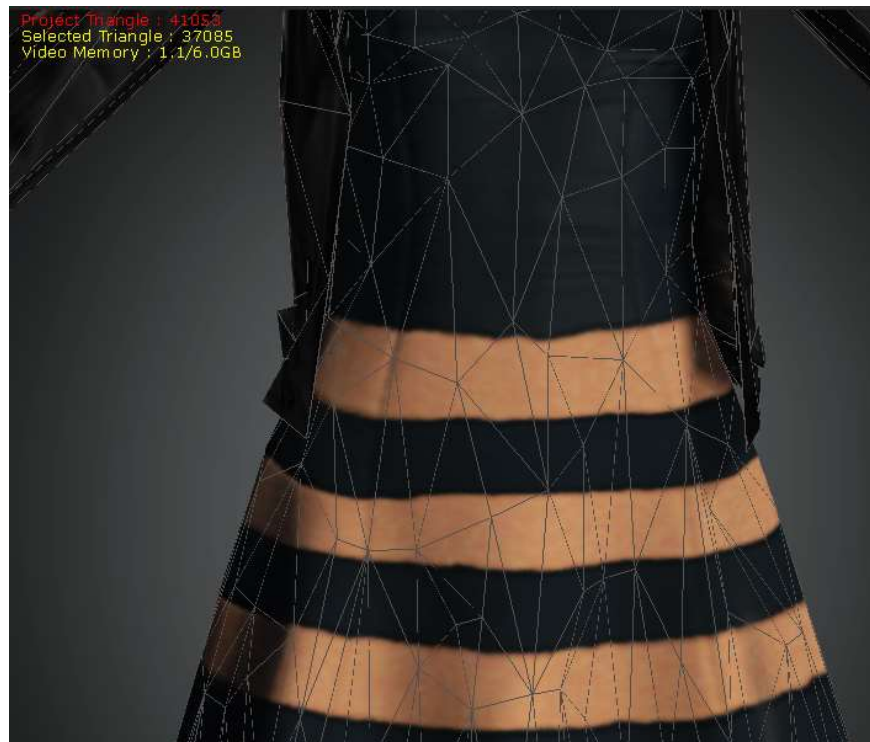


Figure 59: Reduced polycount

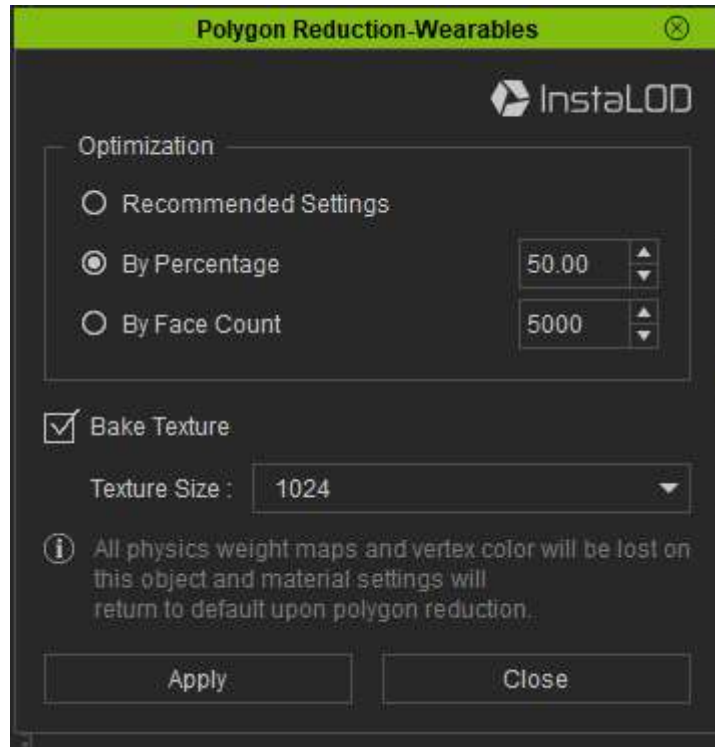


Figure 60: InstaLOD- Polygon Reduction- Wearables panel

As illustrated in Figure 60, the InstaLOD Polygon Reduction feature offers a variety of optimization choices. To achieve the desired results, any option can be chosen and applied several times. The polygons of all objects placed on the character will be rebuilt and decreased as a result of this. To combine all the textures into a single material, Bake Texture must also be selected. Figure 59 depicts the model wireframe after four iterations of 50% optimization. The total polycount has been lowered to 41053 and the disc size has been reduced to 116MB. The disc size and polygon count have both shrunk, although the difference isn't significant. We have used an optimization strategy on the key characters in this project to minimize polys while retaining great face quality.

5.2 InstaLOD Remesher

This CC3 function was heavily utilized in this project to optimize the extra characters for low-quality output. Remeshing is the process of reconfiguring a high-poly input mesh

with a minimal polygon count in thought. In the process, UVs are produced, and surface details and textures are baked automatically [27]. The Remesher feature in Character Creator can be used to quickly generate models in multiple LOD (Level of Detail) if the target software for using characters in FBX is a game engine [28]. When exporting the character as an FBX file, you can choose the LOD mesh level and some other details. Simultaneously, up to 5 LOD models can be created from the same character. Because the Remesher method works by combining numerous characters meshes into one, it's like to see this result on the kind of content which cover multiple objects. The polygons and quality of models generated by the Remesher with varying LODs are shown in Figures 61 and 62. Figure 63 shows an image of the InstaLOD – Remesher panel in CC3. To improve performance, the entire character is unified into a single mesh and material format.

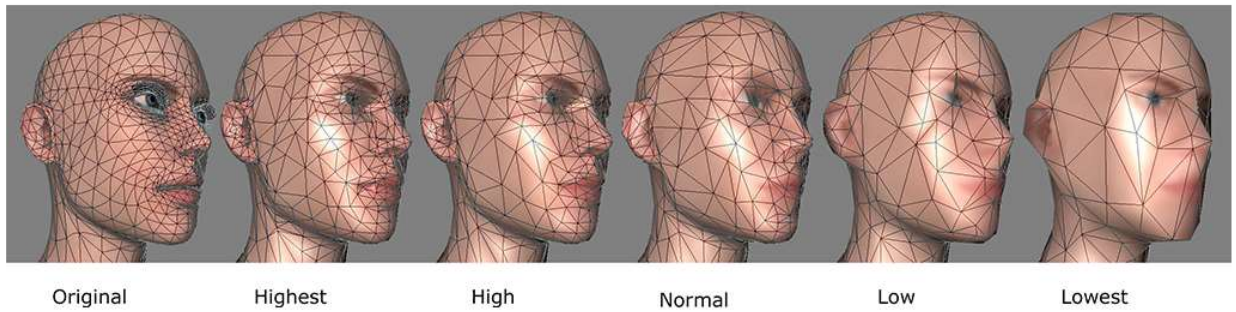


Figure 61: Polygons of generated models with different LODs [28]

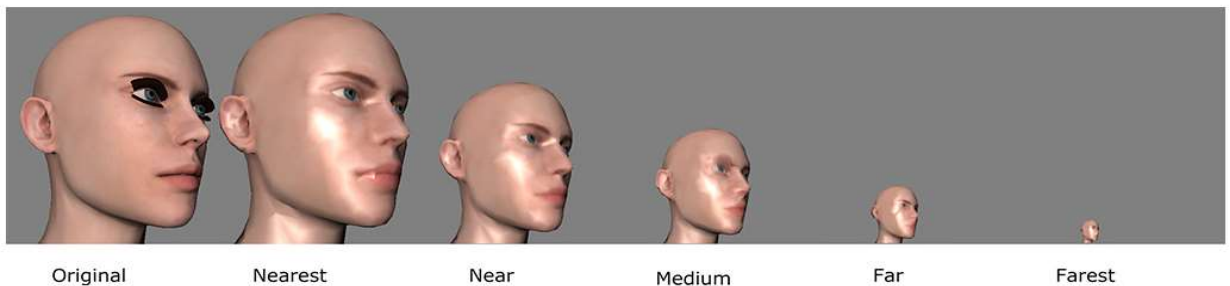


Figure 62: Generated models with different LODs [28]

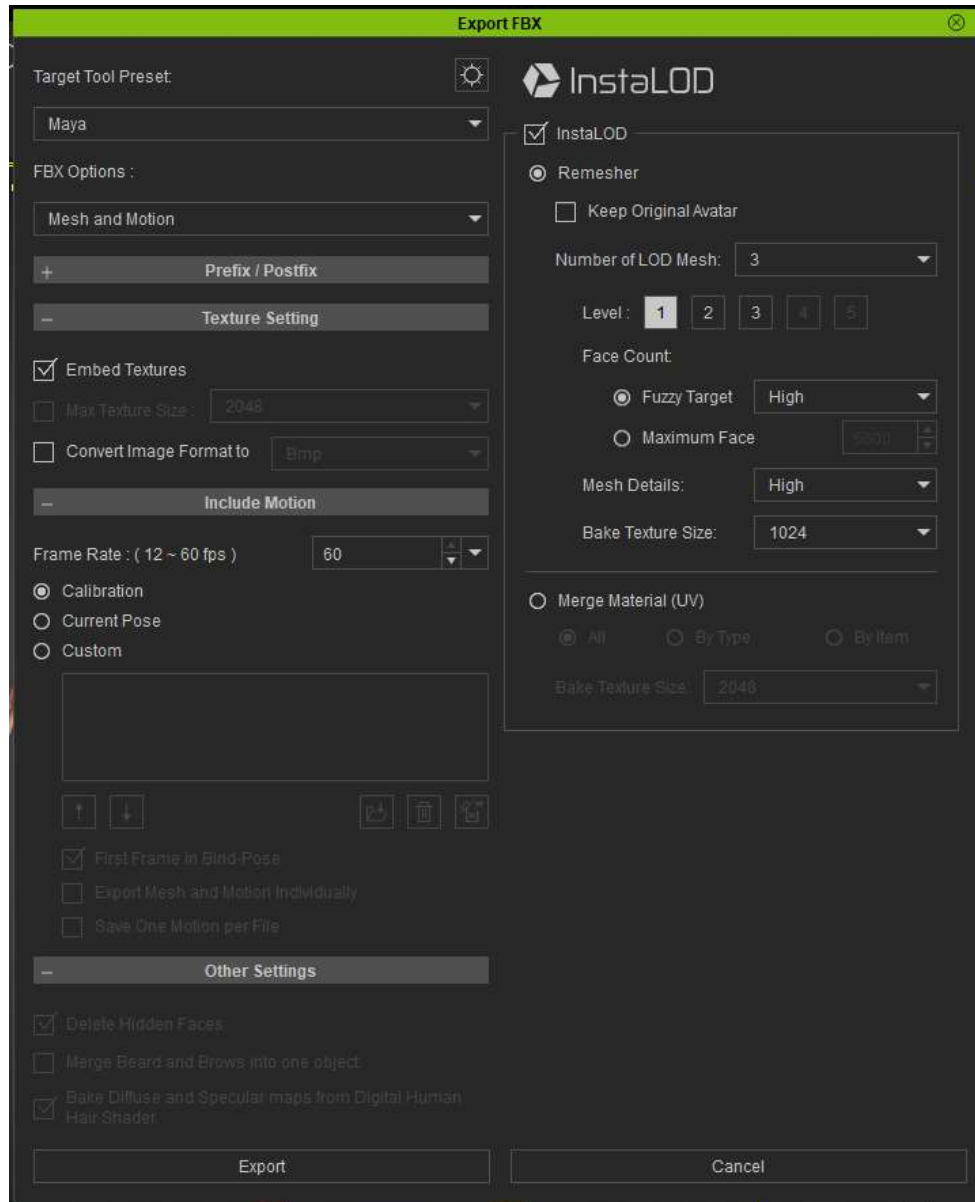


Figure 63: InstaLOD- Remesher panel

As a general guideline, the LOD level should be determined by the character's distance from the camera. Extra characters that aren't visible up close are can be of poor quality. Figures 64, and 65 depict a high-quality high-memory character with a disc size of 144MB and Figures 66, and 67 depict an optimized model of the same character with the lowest LOD and a disc size of 15MB, resulting in a significant size reduction while maintaining acceptable quality.



Figure 64: Extra character- High Quality- Body



Figure 65: Extra character- High Quality- Face



Figure 66: Extra character- Low Quality- Body



Figure 67: Extra character- Low Quality- Face

In addition to polygon reduction techniques, there are a few more things that can be considered when optimizing the models.

- Hide inner mesh – The body mesh of the regions inside the clothes can be hidden to reduce size. When exporting FBX, CC3 offers this option.

- Embed texture and merge material – Use these options to bake textures into a single material and save time on the processor.
- Low-quality eyes and jaw- Low-quality eyes and jaws can be applied for characters after converting to Game Base for the ones who will not be positioned near the camera. CC3 enables you to use these assets for free.
- Avoid smooth mesh- This option makes the characters high quality but adds significant strain on the processor. Hence, should be avoided.

6 WORKFLOW

A variety of tools were utilized to construct full-fledged character models for this project. The workflow diagram shown in Figure 68 depicts the overall workflow that was followed. This isn't the only option, though. In iClone, lip-sync animations can be made, negating the need for Crazy Talk entirely, like in the example of Dr. Parker. An alternate method (shown in Figure 69) was utilized to solve the challenges with lip-sync animations (discussed in detail in Chapter 8).

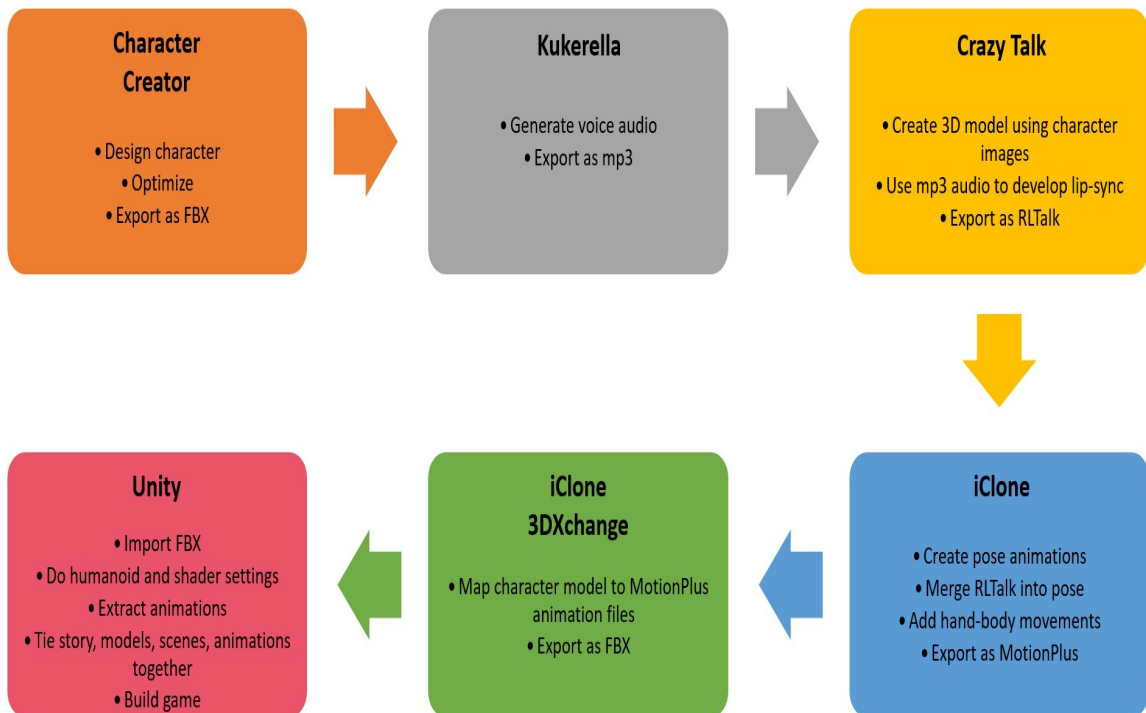


Figure 68: Workflow

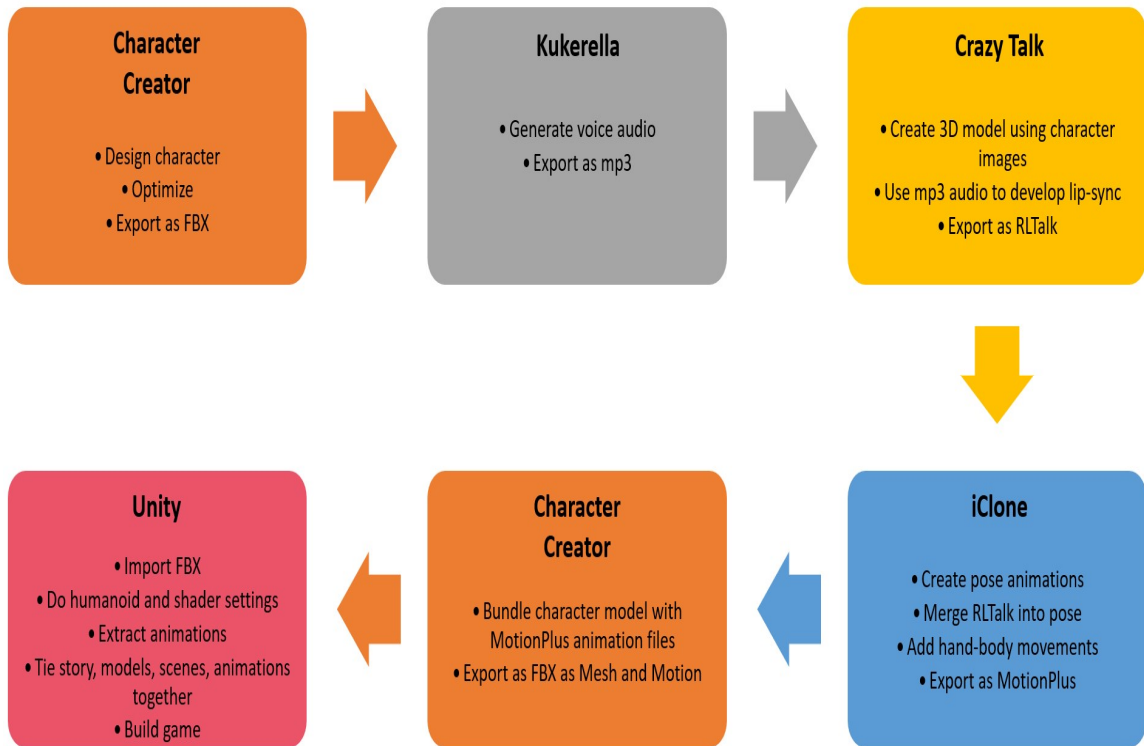


Figure 69: Alternate Workflow

7 CHALLENGES

Developing an application using such a diverse set of technologies presents a slew of difficulties. Some challenges arise as a result of technological shortcomings, others as a result of lack of diversity and yet others as a result of a lack of expertise. The obstacles that were experienced will be discussed in this section.

- **Limitations of Character Creator-** Although CC3 is a great tool by itself, the issues that were encountered were related to assets.
 - **Charles Shoe Fitting Issue-** Clothing assets in CC3 normally scale to match the body of the character model, however when character models represent big individuals, difficulties arise. Charles' feet were extremely tough to put into shoes. His legs bulge from his shoes (see Figure 70) and his workout attire makes it highly apparent. Reducing the size of the character's feet is one solution, but it messes off the character's body proportions. Another workaround offered by CC3 is to alter collision (see Figure 71), but this does not appear to be a smooth solution. Option 2 is used to repair Charles' shoe problem, although it compromises the avatar's authenticity.



Figure 70: Charles- Shoe fitting issue



Figure 71: Charles- Shoe fitting issue - fixed

- **Backpack Issue-** Ashley's avatar was supposed to carry a backpack because she is a college student, however, no free or paid asset would apply to her existing clothes. The majority of backpack items were only available as a shirt, which meant they could only be used on characters wearing short-sleeved

clothes. Ashley couldn't use backpack assets because she was already wearing a long-sleeved shirt. As a result, this idea was dropped.

- **Scarcity of Diverse Models and Assets-** The project needed the development of three African American models: Charles, Dani, and Andy. Many free models and accessories are included in CC3; however, they are mostly tailored for white characters. Diverse head morphs are available in the Reallusion marketplace, albeit they usually cost \$100 or more. The desired characters were eventually constructed (See Figures 3, 11, 19) by modifying the available morphs, but it was a difficult task. Another challenge was finding suitable hairstyles for this group of people. Thus, representing a diverse group of people authentically is a challenge.
- **Mapping Crazy Talk Animations on CC3 Models to Unity-**
 - **Weak Lip-Sync Issue-** The crazy talk was used to construct lip-syncs for this project. These used to play completely well in iClone and even 3DXchange, but after exporting to Unity, seemed very weak, with lip movements diminished to the point that they looked like mumbling. Reallusion recommended altering the workflow to export the animations using CC3 because of difficulties with mapping facial muscle movements in Crazy Talk-generated animations. This method fixed the lip-sync problem, but it also generated a new one, which is discussed next.
 - **Eyeblink Issue-** The lip-sync motions were rendered correctly in models exported to Unity via CC, but the eye blinks were not. CC3 appears to transfer Crazy Talk animations' lip movements accurately in Unity, but not their eye

movements. Eye muscles are well-mapped by 3DXchange, but lip motions are not. The final solution is to use 3DXchange to export the models and their corresponding eye blinks, as well as CC3 to export all other animations. This workaround with Crazy Talk animations works, but it doesn't appear to be the best option. Also, since the Reallusion team has discontinued supporting Crazy Talk 8, they no longer provide product support.

- **Voice-** Although Kukeralla has solved the need for unique voices for each character, the computer-generated audios sound very synthetic. There are also concerns with odd words, which cause emphasis to be placed in the incorrect areas. A question, for example, does not sound like a query. If a dramatic and emotional act is desired, the challenge is compounded. It hurts the simulation's seriousness and realism, as well as the user experience.
- **Hair Rendering-** In Unity and iClone, there are also concerns with hair rendering. As shown in Figure 72, it does not move and lacks a realistic-looking hair effect. There are solutions, but they take more expertise and effort.

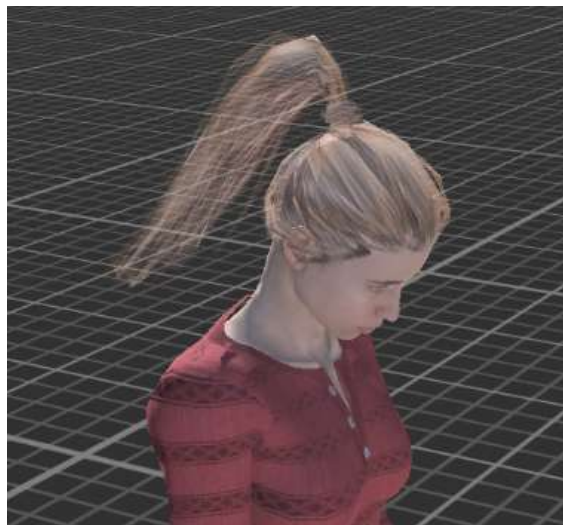


Figure 72: Ashley- Hair Issue

8 CONCLUSION

To improve the patient care experience and outcome, it is critical to cultivate awareness regarding SDoH as well as long-term compassion and empathy in health care employees for their patients. Serious Role-Playing Games (RPGs) are among the most engrossing forms of games because they immerse players in a variety of settings, and they are widely recognized as a valuable and effective tool for teaching, training, and behavioral change. Wright LIFE (Lifelike Immersion for Equity) is a simulation-based SDoH training program designed specifically for mobile platforms such as smartphones. Considering game characters are so important for player engagement and enhancing their play experience, it's critical to develop better human character models that appear and feel more realistic and closer to the users.

From a complete beginner's viewpoint, this thesis has illustrated the strategy and experience of designing and building realistic human character models and animations for enhanced human-game interaction (HGI), an important part of human computer interaction (HCI). Some of the market tools were examined, and the decision to use Reallusion Pipeline was supported. The thesis has discussed the iterative process of developing characters with an interdisciplinary team. This project resulted in a portfolio of high-quality, low-memory multi-modal avatars resembling a broad range of people of various ethnicities, ages, body types, and genders for supporting the Wright Life app, in addition to its contribution to efficient design approaches.

While the benefits of simulation-based training appear to be working in healthcare, it's easy to see how they could be used in other areas of business, such as human resources (HR). For example, in future work, simulations can be designed to train recruiters to

understand being compassionate with job seekers and not make judgments before learning about their past. Learning to develop customized assets, such as hair, may be helpful to deal with character asset difficulties. Avatar models made in this simulation can be distributed through the Reallusion or Unity asset stores, allowing others to utilize them in their own apps or simulations. Motion capture tools such as iPhone Facial Mocap can be explored to capture motion data and create more realistic animations. Hiring genuine voice actors to record audio for the simulation to replace the synthetic audio can help make this more realistic. Additionally, alternative methods for improving the present process of interacting with the interdisciplinary team can also be explored. Working jointly to accessorize the characters, for instance, can reduce feedback workaround time.

REFERENCES

- [1] "Social Determinants of Health," US Department of Health and Human Services, [Online]. Available: <https://health.gov/healthypeople/priority-areas/social-determinants-health>. [Accessed 16 04 2022].
- [2] E. H. Samantha Artiga, "Beyond Health Care: The Role of Social Determinants in Promoting Health and Health Equity," KFF, 10 May 2018. [Online]. Available: <https://www.kff.org/racial-equity-and-health-policy/issue-brief/beyond-health-care-the-role-of-social-determinants-in-promoting-health-and-health-equity/>. [Accessed 16 04 2022].
- [3] "Achieving Health Equity in the United States," American Public Health Association, 13 11 2018. [Online]. Available: <https://apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2019/01/29/achieving-health-equity>. [Accessed 16 4 2022].
- [4] R. Rudowitz, R. Garfield and E. Hinton, "10 Things to Know about Medicaid: Setting the Facts Straight," FF, 6 3 2019. [Online]. Available: <https://www.kff.org/medicaid/issue-brief/10-things-to-know-about-medicaid-setting-the-facts-straight/>. [Accessed 16 4 2022].
- [5] C. Sufrin MD PhD, A. Davidson MD MS and G. Markenson MD, "Importance of Social Determinants of Health and Cultural Awareness in the Delivery of Reproductive Health Care," The American College of Obstetricians and Gynecologists, 2018. [Online]. Available: <https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2018/01/importance-of-social-determinants-of-health-and-cultural-awareness-in-the-delivery-of-reproductive-health-care>. [Accessed 16 4 2022].
- [6] M. C. E. S. Project, "Medicaid Care Experience Simulation Project," Ohio Department of Medicaid, [Online]. Available: <https://grc.osu.edu/projects/MEDTAPP/MedicaidSimulations>. [Accessed 17 5 2022].
- [7] L. Baily, "How Role Playing Games are Improving Simulated Learning in Healthcare," Healthy Simulation, 5 12 2019. [Online]. Available: <https://www.healthysimulation.com/20539/role-playing-games-medical-simulation/>. [Accessed 17 5 2022].

- [8] F. Ricciardi and L. T. De Paolis, "A Comprehensive Review of Serious Games in Health Professions," *International Journal of Computer Games Technology*, vol. 2014, no. Article ID 787968, p. 11, 2014.
- [9] O. S. University, "Virtual patient: Avatar shows emotions as he talks to med students," *Science Daily*, 25 2 2015. [Online]. Available: <https://www.sciencedaily.com/releases/2015/02/150225151639.htm>. [Accessed 16 4 2022].
- [10] S. Aseeri, S. Marin, R. N. Landers, V. Interrante and E. S. Rosenberg, "Embodied Realistic Avatar System with Body Motions and Facial Expressions for Communication in Virtual Reality Applications," *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, no. doi: 10.1109/VRW50115.2020.00141, pp. 580-581, 2020.
- [11] iMeshup, "Maya: pros, cons, quirks, and links," *Medium*, 5 9 2018. [Online]. Available: <https://medium.com/imeshup/maya-pros-cons-quirks-and-links-4ee1c4eecc2>. [Accessed 16 4 2022].
- [12] Capterra, "Maya Reviews," Capterra, [Online]. Available: <https://www.capterra.com/p/146825/Maya/reviews/>. [Accessed 16 4 2022].
- [13] I. M. Hub, "Blender," *Influencer Marketing Hub*, [Online]. Available: <https://influencermarketinghub.com/video-editing-software/blender/>. [Accessed 16 4 2022].
- [14] Autodesk, "3ds Max: Create massive worlds and high-quality designs," Autodesk, [Online]. Available: <https://www.autodesk.com/products/3ds-max/overview?term=1-YEAR&tab=subscription>. [Accessed 16 4 2022].
- [15] S. W. JAGWE, "Creating a 3D Sci-Fi Short in 30 Days," *CGSociety*, [Online]. Available: <https://cgsociety.org/news/article/4330/creating-a-3d-sci-fi-short-in-30-days>. [Accessed 16 4 2022].
- [16] Reallusion, "Products," Reallusion, [Online]. Available: <https://www.reallusion.com/products.aspx>. [Accessed 16 4 2022].
- [17] C. Bloq, "Bringing Brands to Life with Real-time Mascots in just 2 Months," *Reallusion*, 4 2 2021. [Online]. Available: <https://magazine.reallusion.com/2021/02/04/bringing-brands-to-life-with-real-time-mascots-in-just-2-months/>. [Accessed 16 4 2022].
- [18] Reallusion, "Character Creator 3," Reallusion, [Online]. Available: <https://www.reallusion.com/character-creator/>. [Accessed 16 4 2022].

- [19] Reallusion, "Create 3D Talking Heads with Crazy Talk 8," Reallusion, [Online]. Available: <https://www.reallusion.com/crazytalk/>. [Accessed 16 4 2022].
- [20] Reallusion, "iClone7- Real-time 3D Animation Software," Reallusion, [Online]. Available: <https://www.reallusion.com/iclone/>. [Accessed 16 4 2022].
- [21] Reallusion, "3D Animation Pipeline," Reallusion, [Online]. Available: <https://www.reallusion.com/iclone/pipeline.html>. [Accessed 16 4 2022].
- [22] J. Petty, "What is Unity 3D & What is it Used For?," Concept Art Empire, [Online]. Available: <https://conceptartempire.com/what-is-unity/>. [Accessed 16 4 2022].
- [23] SaaSwothy, "What is Kukarella ?," SaaSwothy, [Online]. Available: <https://www.saaswothy.com/product/kukarella>. [Accessed 16 4 2022].
- [24] S. O'Sullivan, "REALISM VS ANIMATION," Open Library Publishing Platform - Pressbooks for Ontario's Postsecondary Educators, 2021. [Online]. Available: <https://ecampusontario.pressbooks.pub/gamedesigndevelopmenttextbook/chapter/realism-vs-animation/>. [Accessed 16 4 2022].
- [25] E. GAROFALO, "Pose-to-Pose Animation: A Step-by-Step Guide for Beginners," Make Use Of, 2 9 2021. [Online]. Available: <https://www.makeuseof.com/posetopose-animation-for-beginners/>. [Accessed 16 4 2022].
- [26] CBC, "The Seven Universal Emotions We Wear On Our Face," CBC, [Online]. Available: <https://www.cbc.ca/natureofthings/features/the-seven-universal-emotions-we-wear-on-our-face>. [Accessed 16 4 2022].
- [27] InstaLOD, "Remeshing," InstaLOD, [Online]. Available: <https://instalod.zendesk.com/hc/en-us/articles/360016273779-Remeshing>. [Accessed 16 4 2022].
- [28] Reallusion, "Creating LOD with Remesher (New for v3)," Reallusion, [Online]. Available: https://manual.reallusion.com/Character_Creator_3/ENU/3/Content/Character_Creator_3/3/17_Export/Creating_LOD_with_Remesher.htm. [Accessed 16 4 2022].
- [29] S. Shukla, "Development of a Human-AI Teaming Based Mobile Language Learning Solution for Dual Language Learners in Early and Special Educations," Wright State University, Dayton, 2018.
- [30] PCT Inc., "Supported Versions," 2021. [Online]. Available: <https://library.vuforia.com/platform-support/supported-versions.html>.

- [31] Google, "Fundamental Concepts," 08 01 2021. [Online]. Available: <https://developers.google.com/ar/discover/concepts>.
- [32] Google, "ARCore Supported Devices," [Online]. Available: <https://developers.google.com/ar/devices>.
- [33] Google, "About ARCore," [Online]. Available: <https://arvr.google.com/arcore/>.
- [34] Google, "ARCore Overview," 06 11 2020. [Online]. Available: <https://developers.google.com/ar/discover>.
- [35] PTC, Inc., "Vuforia Engine: Developer Portal," 15 03 2021. [Online]. Available: <https://developer.vuforia.com/>.
- [36] PTC, Inc., "Vuforia Engine Pricing," [Online]. Available: <https://www.ptc.com/en/products/vuforia/vuforia-engine/pricing>.
- [37] Google, "Cloud Text-to-Speech," [Online]. Available: <https://cloud.google.com/text-to-speech/>.
- [38] A. v. d. Oord, S. Dieleman, H. Zen, K. Simonyan, O. Vinyals, A. Graves, N. Kalchbrenner, A. Senior and K. Kavukcuoglu, "WaveNet: A Generative Model for Raw Audio," arXiv:1609.03499 [cs], 2016.
- [39] H. Aronowitz and W. Zhu, "New Advances in Speaker Diarization," IBM, 10 28 2020. [Online]. Available: <https://www.ibm.com/blogs/research/2020/10/new-advances-in-speaker-diarization/>.
- [40] Google, "Separating Different Speakers in an Audio Recording," 23 04 2021. [Online]. Available: <https://cloud.google.com/speech-to-text/docs/multiple-voices>.
- [41] Z. Kons, S. Shechtman, A. Sorin, C. Rabinovitz and R. Hoory, "High Quality, Lightweight and Adaptable TTS Using LPCNet," arXiv:1905.00590 [eess.AS], 2019.
- [42] Google, "Cloud Text-to-Speech: Pricing," 24 04 2021. [Online]. Available: <https://cloud.google.com/text-to-speech/pricing>.
- [43] IBM, "Text to Speech: Pricing Plans," 04 22 2021. [Online]. Available: <https://cloud.ibm.com/catalog/services/text-to-speech>.
- [44] IBM, "Watson Speech to Text," [Online]. Available: <https://www.ibm.com/cloud/watson-speech-to-text>.
- [45] IBM, "Unity SDK," 04 07 2021. [Online]. Available: <https://github.com/watson-developer-cloud/unity-sdk>.

- [46] Unity Technologies, "Creating and Using Scripts," 19 03 2018. [Online]. Available: <https://docs.unity3d.com/Manual/CreatingAndUsingScripts.html>.
- [47] Perelman School of Medicine, "What is a Standardized Patient," University of Pennsylvania, [Online]. Available: <https://www.med.upenn.edu/spprogram/what-is-a-standardized-patient.html>.
- [48] X. Ogletree, I. Hartzell, K. Ryan and R. Zink, "Friday Project Cracking - CEG 4410 Mobile Computing," Wright State University, 07 05 2019. [Online]. Available: https://www.youtube.com/watch?v=3fdTn-7h7_I.
- [49] Google, "UI Elements," 09 04 2021. [Online]. Available: <https://developers.google.com/ar/design/interaction/ui>.
- [50] R. D. Caballar, "What is the Uncanny Valley?," IEEE Spectrum, 06 11 2019. [Online]. Available: <https://spectrum.ieee.org/automaton/robotics/humanoids/what-is-the-uncanny-valley>.
- [51] M. M. Vasoya, A. Shivakumar, S. Pappu, C. P. Murphy, Y. Pei, D. A. Bricker, J. F. Wilson, A. Castle and P. J. Hershberger, "ReadMI: An Innovative App to Support Training in Motivational Interviewing," *The Journal of Graduate Medical Education*, vol. 11, no. 3, p. 344–346, 2019.