Celebrity Avatars:

A Technical Approach to Creating Digital Avatars for Social Marketing Strategies

by

Ledis Molina

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Ledis Estefania Molina Ortega

This thesis was prepared under the direction of the candidate's thesis advisor, Shane Eason, School of Communication and Multimedia Studies, and has been approved by all members of the supervisory committee. It was submitted to the faculty of the Dorothy F. Schmidt College of Arts and Letters and was accepted in partial fulfillment of the requirements for the degree of Master of Fine Arts.

SUPERVISORY COMMITTEE:

Shane Eason (Nov 24, 2021 06:42 EST)

Shane Eason, MFA, MSc.
Thesis Advisor

Christopher Maraffi, MFA, MSc.

Joey Bargsten, Ph.D.

CBMills (Nov 26, 2021 21:13 EST)

Carol Bishop Mills, Ph.D.
Director, School of Communication &
Multimedia Studies

Michael J. Horswell, Ph.D.
Dean, Dorothy F. Schmidt College of
Arts & Letters

Robert W. Stackman Jr.
Robert W. Stackman Jr. (Nov 27, 2021 20:29 EST)

Robert W. Stackman Jr., Ph.D.
Dean, Graduate College

November 29, 2021
Date

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Abstract

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Avatars are growing in popularity and presented in many computer-mediated communication environments like social media, virtual 3D worlds, and augmented reality applications. With its incredible success in the Asian market, followed by the latest rapid increase in popularity for digital avatars in the Western market, it is necessary to look at the avatars' roots and their newfound use as celebrities. Virtual celebrities or influencers are digital characters consumed in digital mediums, with a given personality, background story, and the first-person point of view of the world, accessible to different social media platforms. These virtual celebrities are now being used for various entertainment industries, with game companies currently leading the way in building their metaverse by attracting audiences to virtual experiences, fueled by the need to sell live content during the Covid-19 pandemic.

This paper traces the complex history of the Hindu *avatara* to a digital representation. It will explain how it has been affected by the context of literature,

virtual gaming worlds, films, and new trends, moving away from a God-centered culture to one centered on humans. This effect is caused by the need for people to create a virtual presence and express themselves in virtual environments. Since its early beginning, avatars have filtered into the mainstream, and different brands have taken advantage by adopting them to represent their values to attract more customers and appear more reliable. This adoption led them to partner up with the entertainment industry creating virtual avatars, virtual concerts, and merchandise all tied in the metaverse.

I also demonstrate how ten digital characters were created from concept art to final output, explaining the process I followed to integrate emerging tools to create an efficient pipeline for real-time animation, rendering, and production for various digital characters for use in social communication and marketing strategies. After following this pipeline, I ended up with a set of virtual avatars that can be used for virtual production purposes focusing on a real-time final output for any digital live event. However, this pipeline still requires development to solve real-time self- body collisions, higher fidelity, cost-effective overall performance capture, and ways to save on performance while simulating and rendering realistic-looking clothes and hair. Nonetheless, that is not stopping industries like digital marketing online entertainment to begin to take advantage of the fast content production workflows and consumers' enthusiasm for live events and celebrities to create a marketing strategy. The pipeline review in this project is only the beginning of this journey into reaching the core concept of the metaverse.

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Introduction

When I think about computer-mediated communication (CMC) for an online representation, the avatar usually comes up as a video game character or pictorial representation on a social media network to help users navigate virtual environments. Computer-mediated communication environments can range from social networks, video conferencing, virtual 3D worlds, augmented reality applications, and non-Fungible Token (NFT) Games. However, recent technological improvements have allowed for new marketing strategies to emerge. With a growing number of games and online platforms now relying on people's need to broadcast their digital representation to capitalize on this expanding market area, the metaverse is becoming a reality. The combination of the prefix *meta* meaning "transcending" and the suffix *universe* that describes a hypothetical synthetic environment liked the physical world [1]. The metaverse is a term that has been coined to facilitate the digital transformation of our physical lives, and it stands the division of an immersive Internet as a unified, persistent, and shared world. Users can now customize, manipulate, control, and embody avatars to interact in different media contexts, affecting how digital avatars are perceived. Some current uses of this expanded control have manifested with the growth of *VTubers*, and tools like *VRChat*, *Vroid*, and other off-the-shelf character design tools. Mark Zuckerberg, creator of Facebook says "we're basically mediating our lives and our communication through these small, glowing rectangles. I think that that's not really how people are made to interact [1]." He

shows his support by investing $10 billion in 2021 on their part of the metaverse, promising to invest more for the next several years [2].

Industries like music, fashion, and Hollywood are also starting to contribute to the creation of these metaverses. These industries have created partnerships with video games like Roblox and Fortnite to add limited edition items and create virtual concerts that users can attend using their virtual avatar and purchasing in-game items. David Kleinman, Managing Director of *Giantstep*, a creative technology company, mentions that most of their work in the metaverse is dedicated to *SM Entertainment*, the largest entertainment company in Korea. This company represents several high-profile K-pop artists, and their goal is to create virtual avatars, virtual concerts, and merchandise all tied in the metaverse. Kleinman also said, "The design, storytelling, and real-time technology can come together to create the quintessential metaverse. No matter what the "brand" is, the intent is clear: instill brand loyalty through real-world and virtual engagement" [3].

This paper explores tools and pipelines to illustrate a contemporary use of digital avatars adopting different marketing strategies in the metaverse, focusing on the process and technical challenges of creating three-dimensional avatars for real-time interaction and production. It will break down every decision made for the stylization of the characters, considering the social impact, the design of the character, and their adaptation into the metaverse. These challenges include reviewing the findings on avatars' social categorization when it applies categories of sex, gender, race, and ethnicity to a digital representation, in which such alterations can have real implications in consumer behavioral decisions. These alterations will also explain the cultural, social reaction, and

technical complications of applying anthropomorphic characteristics on real-time animated avatars.

The user's communication outcome needs will determine the character's design and characteristics, setting the appropriate pipeline implementation. These criteria include selecting the avatar design, skills, personality traits, and other factors that affect how the avatar is perceived and determines its social development, creating potential effects that encourage persuasion, communication, and social engagement. Finally, the research outlined in this paper and the adaptation of ten digital avatars will demonstrate how I took advantage of emerging tools to create an efficient pipeline for real-time interaction, animation, rendering, and production. This process represents the idea of digital puppeteering through the manipulation and performance of ten digitally animated avatars in real-time using a performance capture system, focusing on social communication and marketing strategies in a virtual environment.

History of Avatars

When the 2009 epic science fiction film *Avatar* was released and received positive reviews and a record-breaking box office, not many people who watched it were aware of the kaleidoscopic Hindu doctrine that had its fundamentals in the concept of avatara [4]. To truly understand how modern applications derived the term avatar, it is essential to break down the complex history of the Hindu and Buddhist concept of *avatara*.

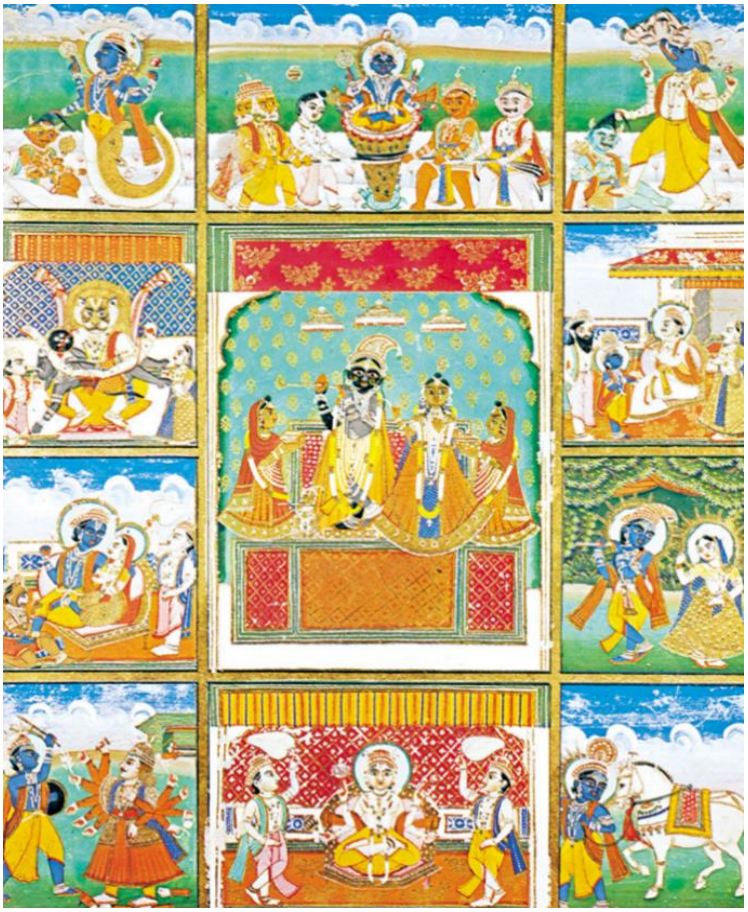


Figure 1 Vishnu with his 10 avataras (Incarnations) Courtesy of the Victoria and Albert Museum, London

The concept of the avatara dates to the oldest religious text in an Indo-European language, written around 400 BCE [5]. The etymology of the term avatar enters in the conjoining of the prefix *ava*, meaning "away, down or below." The suffix *tar* means "to pass or cross over," forming the word avatar, which generally translates as "(re-)incarnation," an often

cyclical "making flesh" (carn-) of a deity, signifying the descent or condescension of God to lower terrestrial regions [6] [7]. In Hinduism. the concept of an avatar is most often associated with different deities like *Lord Vishnu, Lord Shiva, Lord Brahma,* and *Goddess Parvati or Adi Shakti*, which also have avatars or incarnations. From innumerable incarnations of *Vishnu, Rishis,* or *Sages,* ten avatars were selected to represent the rest, and the list of ten first recurring figures is known as "dashavatara" [4]. In the Indian and Chinese subcontinents, in which Hinduism and Buddhism are practiced, they focus their beliefs on the cyclical nature of their deities. Avatars can recycle through the ages, often taking the form of animals with anthropomorphic characteristics. According to the Hindu religion, a god requires a vessel or vehicle to embody his holy being when interacting with humans. In this form, the deity appears before humans in either human or animal form [8].

Early appropriations of the avatar's idea in literature enter the Western worldview with the philosophical approach of the *alter-ego*. The term's first appearance was in the book *Laelius on Friendship,* written by the Roman philosopher Marcus Tullius Cicero in the year 44B.C. The etymology of alter is the Latin *altero,* whose meaning is "to change something and transform it into something different." In other words, alter-ego is "another-I" as well as "something which I can interchange with myself" and "another way of self-being" [9]. The first novel to make a remarkable stand through history in the realm of alter-egos is the ingenious novel by Miguel de Cervantes and his alter ego *Don Quixote of la Mancha,* published in 1605. *Quixote* becomes the alter ego of an old, deluded man named Alonso Quijano, a man who goes in a number of crazy self-constructed adventures [10]. Alter ego has been present in popular culture and fiction,

romanticized in the novel The *Count of Monte Cristo*, written by Alexandre Dumas in 1844, in which protagonist Edmond Dantes assumes three alter egos [11].

Another example is the Gothic novella: *Strange Case of Dr. Jekyll and Mr. Hyde* by Robert Louis Stevenson in 1886, which explores the concept that good, and evil exist within one person, constantly at war [12]. *The Scarlet Pimpernel* novel, written by Baroness Orczy and published in 1905, was the prototype hero with a secret identity, and a hero who leads a double life as a wealthy fop. However, in reality, he is a formidable swordsman, a quick-thinking master of disguise, and an escape artist, in the style of the famous comic books hero, *Bruce Wayne (Batman)* [13]. This set example to other modern forms of literature, like comic books, superheroes, and their secret identities, to also be considered a form of alter-egos. For example, *Superman* assumes the identity of a newspaper reporter Clark Kent. *The Incredible Hulk*, whose secret identity is Bruce Banner, an American theoretical physicist, who loses control as he becomes angry, letting his alter ego Hulk takes over with incredible superpowers. Each alter-ego representing a superhero, or a supervillain holds some superhuman ability that enables them to complete tasks mortal humans would not be able to do. This concept has been moving towards the digital version of superheroes in digital media communication environments portraying a custom semi-customizable character that can be driven in real-time inside the metaverse.

In the late 19th century, various French literature works also experimented with the avatar theme but this time in a more direct approach, starting with a short story written by Theophile Gautier titled *Avatar* in 1856, listing all ten of the dashavatara of Vishnu in his book. By 1906, Charles Marion wrote *Les Avataries* (The Avatarized One), providing a comedy of errors involving the transference of souls, in which people get

"avatarized" into the wrong bodies. Another work that experimented with the avatar theme in 1919 was the novel written by Omar Chevalier titled *L'Avatar d'Yvan Orel*, which talks about the avatar as transcending time and space that inhabited superterrestrial planets [4].

In the twentieth century, the avatara term came to the Western World with a growing tradition of spiritual guides that were important in introducing Hindu ideas. Nevertheless, with the dawn of the information age[1], avatars became the digital representation of users in virtual gaming environments, films, or online forums [14]. In the late 1090s' and early 2000s' Hollywood started to play with CGI and the avatar theme creating movies like *The Nutty Professor (1996)* and *Freaky Friday* (2003) in which the actors embodied someone else, completely transforming their personality and behavior based on their look. In fact, in the latest edition of the *Oxford English Dictionary*, avatar now has a range of meanings in the English language, from "incarnation" to "manifestation or presentation to the world" to simply "manifestation, display, or phase." [15].

The avatar concept communicates the unique role of incarnation in the world, along with questions of identity. Although, avatars still have a great deal of meaning in religion and cultural importance to a significant portion of the world's population. Scholars have noted that video game avatars tend to contradict the notion of the Hindu term avatar, converting the meaning from the divine made flesh in Hinduism, to a figure made in virtual world. While no longer a divinity made of flesh, avatars in video games mark a crossing over into the virtual world, and if allowed for complete control over

objects and the virtual space, avatars can enrich the notion of the player beyond the screen, creating the sense of embodiment and inhabitation [7].

Avatars now represent players in the digital worlds of gaming and online forums that can sometimes be in a three-dimensional or a two-dimensional form. This new ideology of digital representation grew progressively in western culture, taking influence from Asian cultures with their successful use of mascots, shaping the meaning of the avatar over the last two hundred years. It has affected context of literature representations, virtual gaming worlds, and blockbuster films, moving away from a God-centered culture to one centered on humans. The following section will explain the journey of avatars into the digital world with a view of the postmodern world, exploring how the global culture, human bonds, and the market have appropriated the term avatar, transforming its meaning and purpose in the process.

Avatars in the Digital World

Inspired by the early images and metaphors from cyberpunk[2] literature, western culture adapted to new digital environments. A few sources of inspiration were the science fiction novel *True Names* by Vernor Vinge in 1984 with his lyrical development of new full-immersion virtual technology called "Other Plane[3]." Another example came from the book *Mirror Worlds* by David Gelernter in 1991, which explains the revolutionary high-tech of voodoo dolls in Mirror Worlds[4], explaining how the user can interact with reality by interacting with the images. However, one particular novel came with the explosion of digital technology. A newly emerging virtual embodiment, and identity possibilities that contributed to the popularization of avatars in the late twentieth century [8].

> The people are pieces of software called avatars. They are the audiovisual bodies that people use to communicate with each other in the Metaverse. If you're ugly, you can make your avatar beautiful. If you've just gotten out of bed, your avatar can still be wearing beautiful clothes and professionally applied makeup. You can look like a gorilla or a dragon or a giant talking penis in the Metaverse [16].

With his science fiction novel *Snow Crash* (1992), Neal Stephenson is often attributed to the popularization of the word avatar in the Western world to refer to human

representations in digital environments. In his book, he imagined a world where virtual reality-based internet-connected people across the globe could cohabitate in a virtual world called the "Metaverse." Inside this metaverse, users would interact through digital forms of themselves he called avatars. In his novel, the fictional avatars of the metaverse are technologically advanced and signal a potential future where human activity is augmented and enabled by avatar technology [7] [16].

Although Stephenson did an excellent job in popularizing the term, the series of role-playing video games *Ultima* (1981) takes early appropriation of the word avatar in the digital culture with the creation of *Ultima IV: Warriors of Destiny* (1985) by Richard Garriott. Famous tabletop games influenced the franchise to make character customization fundamental to adding more attributes and details, with each game iteration culminating in *Ultima Forever: Quest for the Avatar* in 2013 [17]. In the 2010 documentary series *Critical Path,* Garriott explained that he wanted the player to respond to "moral dilemmas and ethical challenges" as they would, unlike alter-egos. Looking for ethical parables or moral philosophy, he claims to see the concept of the word avatar repeatedly in many Hindu texts. "In that case, the avatar was the physical manifestation of a god when it came down to earth. That's perfect because really I'm trying to test your spirit within my fictional realm." Garriott said in the



Figure 2 Sample character creation screen from Ultima Online.

interview [18]. Another essential digital experience was Lucasfilm's online virtual world called *Habitat* in 1986, created by Randy Farmer and Chip Morningstar. Farmer expressed to the New York Times in 2008 that Chip came up with the word avatar as an informal reference to in-game characters. Farmer also mentioned that "the avatar was the incarnation of a deity, the player, in the online world. We liked the idea of the puppet master controlling his puppet, but instead of using string, he was using a telephone line" [19]. It was primarily through the ambiguous use of the word avatar in the game *Habitat* that the Oxford English Dictionary collected the expression as the first use of the term. Stephenson acknowledged taking inspiration from *Habitat* after the first publication of his novel. The adoption of the word avatar substantially changed how game designers understood the quality of the player experience. By calling it avatars, adding linguistics and a conceptual nuance and depth, the gaming industry found a new way of detaching the player from the ordinary world. Expanding the limits of merely being a vessel or navigational tool in a virtual world adds the potential to create a new incarnation of self. Although the technology was not new, the representation of the user in a digital environment enabled the user to experience and interact within the spaces of digital mediated worlds [7].

Second Life was one of the earliest simulation games that allowed users to create a virtual representation of themselves that users could modify to their likeness. *Second Life* was released in 1999 by the former Linder Lab CEO Philip Rosedale. He envisioned continuous landscapes distributed across multiple servers that were interconnected to create his virtual dream world. In this Three-Dimensional world with user-generated content, *Second Life* contains a mechanism that allows for real-time interaction between

users due to a system design that automatically responds to the utterances of other avatars by turning their heads towards them like real-human interaction. Stephenson included that the novel Snow Crash has the closest practical resemblance to *Second Life* as it exists now [7]. A player's presence in a virtual world is not only "being there" but "being there together [20]."

With the term avatar growing in popularity, countless versions of online representations for users' identities have appeared. From online social media platforms with their "profile picture" idea to some of the top-selling home consoles like *Nintendo* and *Microsoft* to the propagation of personal avatars like the Miis [21] and Xbox avatars [22] paved the way to mass adoption of virtual incarnations by the social market. Mainstream adoption of these virtual personas helped the wide adoption of the newest human-computer interface device, the virtual reality headset. Companies like *Oculus* and *HTC* (*High Tech Computer Corporation*) revitalized the early technology and took it out of the lab and into consumers' hands around 2014 [23]. Virtual Reality applications that, just like *Roblox*, *SideQuest, Facebook Horizon*, and *VRChat*, allow players to create an account, upload their custom avatar, and move around custom-built worlds, have popularized virtual reality hardware, which parallels the real-world implementation of Stephenson's metaverse in his



Figure 3 VRChat – Create, Share, Play – YouTube (Promo Video)

novel. Having a virtual avatar can allow many people to express their multiple personalities, sometimes having multiple avatars in a virtual world to be sloppy, timid, erratic, confused, sarcastic, sexy, and or sneaky.

Digital avatars have become the primary form of media access to virtual environments, and communication scholars have universally recognized the description of the avatar as a digital representation [24]. In a metaverse environment, the avatar is the sometimes-customizable digital character controlled by the user with a two- or three-dimensional visual representation attached to the user's online name or pseudonym in online forums and social media.

With the advancement of technology, avatars are becoming more customizable, increasing the potential for the player to identify with the avatar on the screen. Cutting-edge tools allow for more control over the avatar body, personality, aesthetics, and functions, evolving to be more robust, transitioning from the real world and into the metaverse [17]. When the avatar is well designed, it can contribute to a sense of being there as a *presence* and a sense of being there with others, as a *co-presence* in digital space [25]. However, understanding how to create a well-designed character is vital to make sense of the relationship between humans and their avatars. Avatars are a form of embodiment, incarnation, or personification that facilitates more complex actions like nonverbal communication through common gestures and body postures [26]. The psychological effects of the relationship between avatars and users have been studied using role-play, listing possible benefits and drawbacks of self-immersion. The following section of this paper will explore the psychological aspects and the human-avatar relationship through role-playing games.

Role-Playing Avatars

Children often pretend to be someone else, playing the role of adults, going grocery shopping at home, imagining being pirates, astronauts, or superheroes. This behavior aids in the development of identity as adolescents seek to deviate from their parents and find their place in the world either through reading, watching movies, taking drama classes, or imagining themselves in the shoes of someone they idolize. Even adulting consists of taking on the role of a manager, teacher, or doctor. Modern-day practices like cosplays, renaissance fairs, theme parties, theme parks staff members, and immersive theater all involve the fundamentals of role-playing [27].

The term role-playing game has roots in the history of psychology. The Austrian American psychologist Jacob Moreno, the founder of psychodrama and group psychotherapy, coined the term role-playing in 1934 [27]. Psychodrama consists of a therapist helping patients to explore issues through role-playing. Psychodrama motivated each patient to participate in re-staging past events or imagined scenarios in the future to look for alternative solutions to problems, just as leisure role-playing often does, allowing for patients to develop new social skills. Some games are designed to explore psychological scenarios such as infidelity or taboo topics for society such as sexuality, racism, murder, slavery, or gender, with topics overlapping in most cases [27]. However, for any of these previous scenarios to be successfully explored, the player has to immerse themselves in another life for extended periods, sometimes multiple times to consistently develop a point of view from a different perspective.

Studying the concept of immersion and the relationship between avatars and players can be very complex. Immersion is not limited to gameplay but rather a pivotal condition of human consciousness involving different cognitive and emotional processes. The relationship between humans and avatars lies in the system designed to control avatars. The lower levels of system control on this scale are primarily hands-off, in which the digital character is semi-autonomous and creates automatic responses triggered based on a series of codes created by the developer; The higher levels include precise control in which the user is a full-time puppeteer, controlling every motion and action in the virtual world. The user can achieve this level of control through motion capture technology, which allows the transfer of human actor movements to a three-dimensional animated digital avatar model, in some cases accompanied with natural speech movements to show the avatar's emotions and expressions [28].

The involvement of each player can turn emotionally engaging, in which the players create a deeper connection with the character by immersing in the narrative, environment, or community. Sub-component of immersion exists in role-playing, which includes the sense of character catharsis, embodiment, and education. These sub-components refer to experiencing emotions through the character, decision-making based upon the character, and acquiring knowledge and understanding of the virtual world through avatars, which may affect user's decision-making process. Some scholars emphasize that character immersion can be a primary form of identity exploration by enacting alternate personalities or avatars in RPGs. However, moments exist where the player feels semi or complete detachment with the character where the character is simply a thin façade performing expected functions rather than pushing the boundaries of

identity. However, there are moments where the player experiences the character as a complex and distinct individual with clear goals, feelings, and psychological complexes that flow between the player and the character identity, constantly entering a state of overlap [29].

Another level of character immersion is described as the phenomenon of using theatrical metaphors. In this case, the player will act as a puppeteer, directing all actions with slightly more immersion and a stronger sense of control. The player may experience the character as a possessing force that takes control entirely over the experience, but the actor still lies beneath the character as the primary action [29].

A deeper connection creates the potential of avatars to influence their user's behavior and attitudes, which has increased the media attention on this phenomenon, creating a *Proteus effect*. Scholars have suggested that the Proteus effect, which affects users' decisions based on how their avatars look, can motivate the user's behavior inside and outside the virtual world. An experiment conducted to prove this effect over participants provided results explaining that participants assigned taller and more attractive avatars demonstrated a smaller social distance and showed greater confidence and intimacy in the virtual world accompanying face-to-face interaction. Studies also reported an increase in the effect based on the user-avatar similarity, for example, more user control over the avatar and degree of avatar customizations [30]. It is sometimes at the hand of the designers to define the phenomenon's potential of affecting the users' behavior by implementing conditions and mechanisms that help to increase the effects. For example, enabling the ability to customize avatars to the user's likeness, and providing them with more freedom over virtual spaces and interaction with other avatar.

The relationship between the player and their avatar is one of the most fascinating and complex subjects in role-playing studies, partially due to the distinction that is unique to social experiences of non-professionals in gaming and Live Action Role-Playing games. The distinction between player and avatar extends to which the user relates to and identifies with their characters in categories such as gender, sex, race, age, religion, and culture allowing for a deeper connection. The acting president and CEO, Stanley Pierre-Louis with the *Entertainment Software Association* ESA, expressed his thoughts that video games enhance our interconnected experiences and relationships and redefine the interaction between humans and technology [31].

The emergence of social platforms created an intense human interaction, along with virtual worlds. These tools have users worldwide, creating substantial economies of their own, creating complex social relationships, and allowing for the formation of virtual communities. By encouraging the player's creativity as an example of recent online collaborative environments, virtual worlds emerge as a medium for creation, allowing users to undertake a digital avatar and become artists, creators, and authors making big brands interested in these new medium's business model and adapting marketing strategies to modern technology. With this information in mind, the following section will cover the complexity behind creating virtual avatars. It will dig deeper into why several individuals, big corporations, producers, actors, sports players, singers, and other organizations are developing the application of virtual avatars as a celebrity endorsement model. It will also discuss how the player-avatar identification theory in which celebrities' and avatars' identification influences consumer behavioral decisions adds value to the different marketing strategies [32].

Avatars and Marketing Strategies

Avatars are crucial for visual communication between players and have become elaborate tools for self-representation through customization [33]. Avatars are increasingly accepted by users and continue to grow in quality with improving hardware. This phenomenon is motivated by enhancing social appeal for various virtual platforms, cost-effectiveness, and increased flexibility in avatar appearances [34]. The digital era has also acknowledged the potential of creating virtual avatars to represent users through the web and their benefits to sponsoring brands. The increasing understanding of the importance of the avatar for establishing emotional connections through games consequently became a site of technical innovations and commercial intensification within the industry. With its incredible success in the Asian market, followed by the latest rapid increase in popularity for digital avatars in the Western market, it is necessary to look at its roots and newfound use of avatars as celebrities. A celebrity endorsement model is a promotional tool that boosts brands awareness by performing different advertising exercises that may drive consumers to purchase various products [35].

For example, in the late 1990s, an English virtual band named Gorillaz introduced the concept of digital avatars to the public after making their first debut in the music video titled *Tomorrow Comes Today*, released on November 27th, 2000. They appeared as a digital music band of four two-Dimensional animated characters named 2-D, Murdoc, Noodle, and Russel [36]. In 2002 the band innovated their performance during the Brit Awards held in London in which the virtual members Gorillaz decided to

perform as three-dimensional characters using four large screens accompanied by the rapper Phi Life Cypher, a production reportedly to cost £300,000 to create at the time [37]. This digital group of individuals represented the mastery of virtual avatars in a unique case for the world of music. Each character from the band has a full bibliography with detailed information of town of birth, childhood to adulthood description that explains how each character got their unique appearances, their way of behaving, and how they joined the band Gorilla [38].

The band was well-received in different parts of the world, including the United States, joining their mixed media market strategies by interviewing the cartoon characters rather than the actual musicians. Their website www.gorillaz.com continued to be a big success since 2001 when they received more than 500,000 hits a month, contributing to their principal publicity medium taking the role of more conventional celebrity appearances. They also had lucrative contracts for video game sales and other merchandise, including PlayStation, Cartoon Network, featured-length animated films, and band's promotional videos [39]. Since then, the members have been transitioning to



Figure 4 NME's First Live Interview with Gorillaz

an entire three-dimensional appearance with their first live on-camera interview in 2017 with BBC radio 1 [40]. Damon Albarn, the primary songwriter for the band, whose voice plays the animated lead singer on the band named "2D", said that he created the characters as a reaction to what was happening on the media charts at the time. He expressed his dissatisfaction with the manufactured media content, arguing that Gorillaz was different. "They may only appear in cartoon form, but, believe me, they are larger than life," Albarn said [41] [39].

The popularization of Japanese anime' and manga across a technologically advanced world was significant to the avatar adoption in global marketing strategies. This influence has partly been attributed to the prevalence of gaming culture like *Nintendo, PlayStation,* and *Xbox,* to rapidly influence Europe and North American with Japanese cartoon series such as the *Power Rangers, Sailor Moon,* and *Dragon Ball* to feature-length animated movies produced for adult consumption like *Akira, Ghost in the Shell, Paprika,* and *Grave of the*



Figure 5 Idle Idol Book: The Japanese Mascot

Fireflies. However, the most significant influence comes from using brand mascots as marketing strategies to attract consumers and build brand loyalty [42]. In Japan, characters can be seen everywhere, from store to store to pharmacies, police, restaurants, business, institutions, and appear in posters and signs to lure customers into shops, promote products, and provide a friendly face when communicating to the public. Mascots made their appearance in Japan in early 1600 when a small town started to create large ceramic sculptures of the Japanese raccoon dog tanuki as a sign of good luck. By the late 19th century, these figures began to represent shops that served tanuki soba noodles [42]. In modern Japanese establishments, mascots add a traditional quality, charm, personality to make businesses more accessible and appealing.

In the 1960s in Japan, the mascots made their way to three-dimensional forms when small vinyl figures became significantly popular, particularly with banks that would give away money boxes in the shape of their mascots. These figures gained their popularity through animated TV advertisements that further developed their personalities. In 1963, a Japanese snack company called Meiji saw an increase in sales after creating a campaign that gave away Astro Boy's sticker with a chocolate bar. During the rest of the decade and following years, various companies started to use more storefront mascots for advertising their products and services. In 2017 a report from CBS News indicated that character business generated nearly $16 billion a year, posting mascots as a significant source of profit due to their popularity [43]. Mascots have made their way to other areas worldwide, with Taiwan currently holding one of the most extensive collections of mascots that have ever existed. Lin Cheng-i, a mascot specialist in Taiwan, said, “mascots, first of all, they are cute. Second of all, they are unique, and they can build up

some awareness in the public, including in the lead-up to the event. Then you have a powerful tool with greater longevity [44]."

The adoption of mascots in America has been an important market strategy. In the Western world, characters used to advertise products appeared in the 17th century with the "cigar store Indian." This representation is because Native Americans were associated with the introduction of tobacco. So, it became a common symbol of tobacco stores, with store shops adding wooden figures made with uncultured representations of how they thought Native Americans looked to show their (sometimes illiterate) customers what they sold [42]. Some of the most popular mascots are the US Forest Service's Smokey Bear and Woodsy Owl, Mr. Peanut for Planters Peanuts, Miss Chiquita for Chiquita Bananas, or the famous Micky Mouse for Walt Disney Company. It is important to note that most US mascots have anthropomorphic features that help them access the consumer interest of children and adults. Anthropomorphic avatars allow customers to have a better interaction or relationship with brands [45]. More long-established institutions have also started to adopt an anthropomorphic digital character as their mascot, for example, the insurance company GEICO with gecko and Aflac Duck with Aflac. In

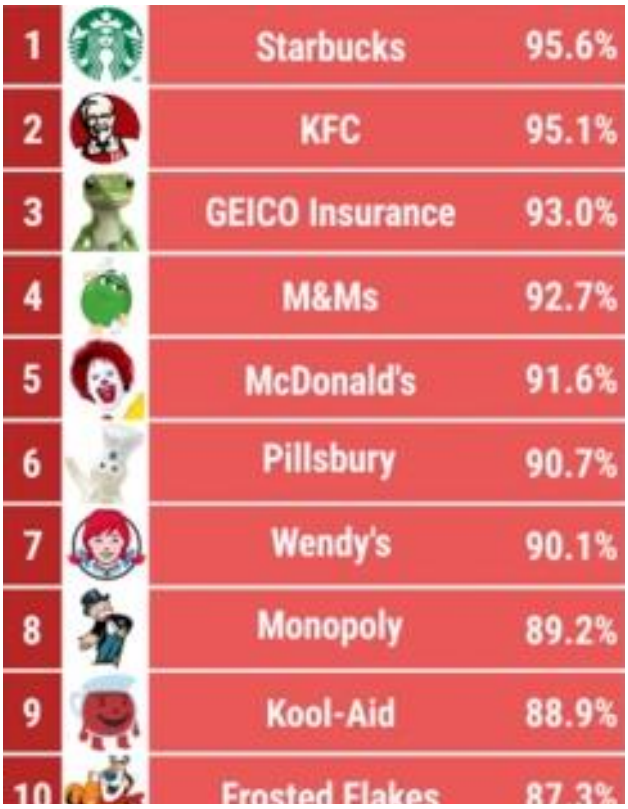


Figure 6 Crestline: Top 10 - Mascot Recognition Challenge 2021

the 2021 *Mascot Recognition Challenge,* GEICO gecko was in the top 5 most memorable brand mascots with ninety-three percent recognition. Its brand was classified as likable, trustworthy, and persuasive among Colonel Sanders (KFC), Starbucks mermaid, M&M spokes candies, and Ronald McDonald [46]. Digital avatars have transformed in the recent decades with more sounds, facial and body expressions, and an enormous improvement on the avatars' aesthetics that can range from realistic avatars being an actual representation of a user to abstract avatars like cartoons or anime [34]. Research has demonstrated the benefits of using an avatar as an online sales agent, spokesperson, or customer representative to create positive evaluations of the product, increase purchases, and higher overall satisfaction [34].

Online video games purchased items valued at more than $15 billion in 2016 due to flexible business models engaging strategies to bring highly engaged players to create custom content [47]. For example, in May 2009, Valve[5] introduced the capability for player avatars to wear hats in *Team Fortress 2* [48]. While this item served no tactical use during playtime, these items allowed players to display something about their personality by choosing a hat they felt was appropriate for them and their avatar. Developing the mechanisms for gaining hats illustrates a shift in the relations between players and their avatars and the economics of video game production, distribution, and play. In the beginning, hats were gifted to players as random items during the game. Every 25 minutes of online gaming on Steam[6], each player had a 25% chance of acquiring a hat. The possibility of earning in-game items motivates the players to maximize the time they play while connected to the Steam community website [49]. Valve took advantage of their avatar management system, providing incentives to gamers who purchase games on

their platform. For example, players who purchased *BioShock Infinite* on Steam were gifted various items to customize Team Fortress 2 avatars. This move became a tool for Steam and other companies to adopt new business strategies [49].

In video games, the acquisition of in-game items promoted by three-dimensional avatars plays a similar role the celebrity model discussed in this paper. Players purchasing in-game items demonstrate a great status or insignia for game developers to further introduce new games or features to profit the companies. Gaming companies invest in promoting their games in a similar way clothing, make-up, and other big corporations invest in endorsing their brand's identity. These entities feature celebrities in their advertising campaigns, creating an association with the brand attracting consumers' attention [50] [32]. Game companies use different strategies designed for the players to entice the consumer to buy in-game features repeatedly. Most of the time, they allow players to play the free-base game levels and provide the opportunity to purchase additional game content for their avatars in the form of virtual items like attires, level-ups, and currencies. Top brands are particularly interested in understanding celebrity associations related to digital avatars unifying the avatars with the famous public image's role to explore the effects on consumer behavioral intentions. Research shows that players are eager to polish their avatars according to their self-image and improve their connection with their digital avatar [51], feeling that the better the avatar's look, the greater the bond with their avatar and enhance game performance. This effect entices players to spend money on their avatar and its in-game features to make their in-game life better [52]. Other marketing strategies to achieve the same results while increasing the

player's relationships with brands is by providing the user with the ability to play as their favorite celebrity [32].

Fortnite: Battle Royal is the ideal example of a game that successfully adapted the new model of celebrity-avatar as a new marketing strategy based on its target audience. *Fortnite,* produced by Epic Games and released in July 2017, has an online game community of more than 350 million registered users, with 62.7 % of its users being *Gen Z* and future generation players [53],generations born in a truly digital environment. These generations with people born since 1996 has three main implications in their view of consumption and their relationship with brands. Their view of consumption refers to access rather than possessions, expression of individual identity, and matter of ethical concerns [54]. Recent research argues that millennials and Gen Z are virtual influencers' most effective target audience [55]. *Fortnite: Battle Royal* is a free-to-play game, that since its launch, has managed to bring hundreds of millions of dollars in revenue every month, earning them the ability to bring big brand, comic books, movies, singers, and other celebrities in their avatar form, better known in the game as



Figure 7 Fortnite Twitter account - Published May 7, 2018

crossovers [56]. Fortnite crossovers are unique since they adapt their distinguishable character and asset design to every integration making it recognizable and emblematic to their brand. In May 2018, the first sponsored integration was announced via Twitter, promoting the release of Marvel's Avengers: Infinity War movie. They decided to integrate an original hero and villain from the movie in the game, promising a "limited time mashup[7]" between Fortnite and Marvel characters [57]. The idea of fighting or portraying a celebrity avatar was so enticing that it attracted many new players and revenue to the platform. After that, it became a trend to create more crossover with other massive brands, famous TV series, films, games, such as *Star Wars, John Wick, Birds of Prey, The Walking Dead, Deadpool, Ghostbusters, The Mandalorian, Batman, Predator, Ferrari, Shang-Chi*, and more. They also created partnerships with individual content creators and celebrities like Ariana Grande, Marshmallow, Major Lazer, Neymar Jr, J Balvin, and Tyler "Ninja" Blevins [58]. They all have added bundles as limited-edition items, live concerts, or special outfits associated with each celebrity that can be either free or in-game paid items. However, an exceptional category of celebrities and influencers have recently made their way to the *Fortnite: Battle Royal* crossover and have attained great recognition in the online community. These "virtual celebrities" are Guggimon and Janky. Guggimon is a bizarre-looking rabbit who is a three-dimensional animated virtual influencer and the Superplastic mascot with over 3.4 million followers on *TikTok* [59] and 1.3 million followers on *Instagram* [60]. This virtual celebrity came to *Fortnite*: *Battle Royal* in 2021 [58] alongside the pop culture icons Superman and Rick Sanchez. Guggimon and Janky characters are properties of Superplastic, a company creator of animated synthetic celebrities, designer toys, and apparel [61], which has

previously created figures and other merchandise with the likeness of the Gorillaz and collaborations with human celebrities such as Steve Aoki, and J. Balvin [62] [63].

Virtual Celebrities

Virtual celebrities or influencers are digital characters consumed in digital mediums, generated using various three-dimensional software, then given a personality, background story, and the first-person point of view of the world to be accessible to different social media platforms. Because these characters are animated avatars, their flexibility and integration with different brands and existing digital spaces are seamless. Virtual Influencers have become popular in social media platforms, integrating human networks, and interacting with users due to their popularity, cost-effective strategies, and their small risk of "human errors" in marketing campaigns. Luxury brands increasingly collaborate with virtual influencers, sometimes creating their own digital influencers to promote their product. For example, LilMiquela has created partnerships with various luxury brands like Prada, Balenciaga, UGG, and Calvin Klein [55].

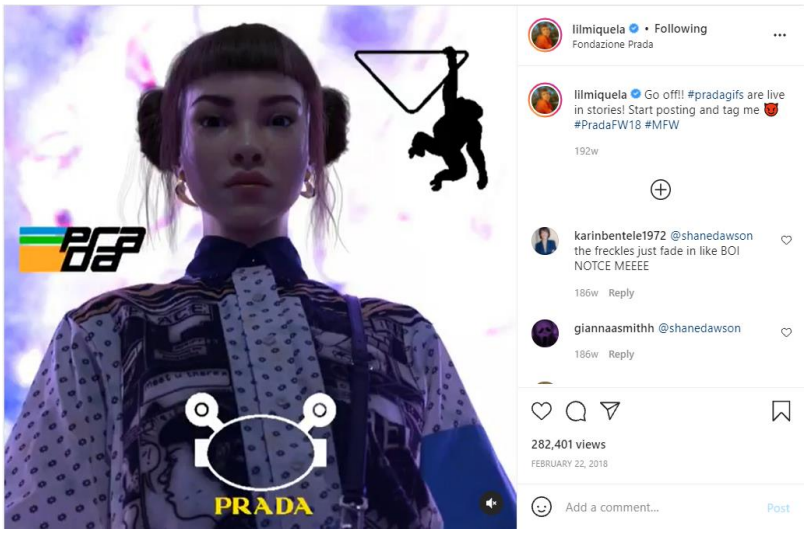


Figure 8 @lilmiquela Instagram account. Promotional post - Prada

Before the COVID-19 pandemic, increasing negative perceptions of influencers were fueled by concerns about the sustainability of the influencer lifestyle. Virtual

influencers presented a unique opportunity in the intensification of the current pandemic economic crisis many brands and consumers face. As they are not affected by anxiety, isolation, depression, or physical contact obstacles caused by the health measurements of the pandemic, virtual influencers were able to continue creating regular content. Human influencers are tied to human constraints like time, budget, and availability, and those limits do not exist for most virtual influencers. For example, LilMiquela "visited" a deli during the pandemic for an advertised performance. Her virtual attributes allow her to avoid any physical or legal restrictions and take advantage of the fictional nature of her existence [64].

A comparison study about the posting behavior and reaction to one human (Marta Cygan), a human-like avatar (LilMiquela), and an anime-like (Noonoouri) virtual influencers, revealed that between the two virtual influencers the most human-like avatar (LilMiquela) caused less positive influence with a nuance of skepticism and disliked towards her "robotic" quality. Despite replicating the human appearance and posting behavior in content, photo, and video, sometimes leaving the audience guessing her real nature, the human-like avatar still received more criticism towards her appearance and behavior. In contrast, the human (Marta Cygan) and anime-like (Noonoouri) influencers

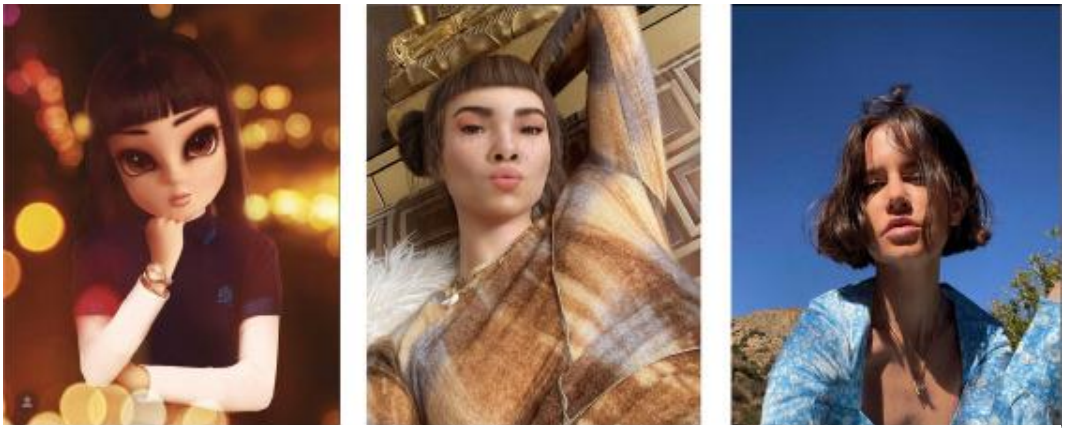


Figure 9 Noonoouri (anime-like,) LilMiquela (human-like,) Marta Cygan (human)

showed very few differences in reactions. As a whole, it stood out that human-like avatars appear too similar to humans, attempting to create human-like experiences for her followers' created reactions of creepiness and adverse emotional reactions falling into the effect of the *uncanny valley*[8] [64].

Interestingly this effect is offset by the presence of anthropomorphic elements in the anime-like virtual influencer. An essential characteristic of anthropomorphism regarding virtual influencers is the attempts to pass for humans in videos, including speaking or signing. Many social cues that attract people to interact with virtual agents are clothing style, correct use of backgrounds, facial expressions, attractiveness, use of emojis, and photorealism. By adding human emotional experiences with human-like avatars, the risk of triggering the feeling of uncanniness increases, perceiving the virtual avatar to be trespassing on what makes humans unique [64]. However, another research comparing human-like vs. anime-like avatars concluded that participants could not agree whether humanized virtual influencers were more appealing to customers than characters with anthropomorphic elements. Instead, it turned their response to focus towards a "well-executed character design" regardless of whether it is humanized or not [55].

Other subsets of digital avatars that are also adapting the celebrity endorsement model are *Vtubers*. These social media personalities can publish content as a two- or three-dimensional character that can be entirely puppeteer and voiced by humans. Vtubers take roots in Japanese culture with the success of Kizuna AI, a Japanese Vtuber who started posting videos in 2016. This character is the largest Vtuber with almost 3 million subscribers on her YouTube channel [65] and 1 million subscribers on the Chinese video platform Bilibili. Kizuna has performed at various anime conventions and

worked for many game companies. Kizuna became such a popular virtual entity that the original company that managed this character Activ8 decided to move Kizuna AI to a newly created company—dedicated exclusively to this character, calling the company Kizuna AI Inc., with Japanese voice actress Nozomi Kasuga as the new company's primary voice model for Kizuna AI and advisor [66]. Vtubers create content similar to human YouTubers, such as vlogging, game streams, music videos, educational content, and even unboxing videos and product reviews. Like Kizuna AI, another Japanese avatar named Hatsune Miku, a virtual Japanese singer with long blue hair, has revolutionized VTubers' functions. Hatsune has over 2.5 million followers, but this character's unique celebrity-avatar role plays with increased demand for concerts in Indonesia, Los Angeles, New York, and Shanghai. She has generated billions of dollars in revenue across all her avatar and merchandise by implementing a celebrity endorsement model [67].



Figure 10 PlayStation.Store Hatsune Miku VR Live 1st Stage features 6 songs

The virtual site *VirtualHumans.org* decided to ask VTubers creators across the globe, What made VTubers attractive to them. Their responses developed into four main categories: convenience, anonymity, brand strategy, and fun [68]. The interview revealed

that creators in these platforms enjoy having some freedom and getting away from the real world, allowing them to explore genres and content formats they might not typically pursue or even consider as their human selves [68]. An example of this could be singers who do not feel confident showing their real selves and prefer using a virtual avatar to show their many talents. A unique factor to Vtubers is their audience since they usually suspend their disbelief to participate in a narrative in which the virtual character also exists [68]. As their audience suspend disbelief, VTubers always try stay on character to maintain the illusion and act consistently. It is crucial to follow the narrative and history the creator gave to their character to successfully immerse and maintain the audience submerged in the character world.

Virtual influencers can be found almost everywhere within the context of computed environments, and the quality and quantity of content they produce have increased significantly. Just like *Gorillaz*, various major South Korean singers represented by SM Entertainment have embraced the idea of having a virtual avatar to represent each of the singers, such as *K/DA* and *Aespa* [3]. Epic Records singer-

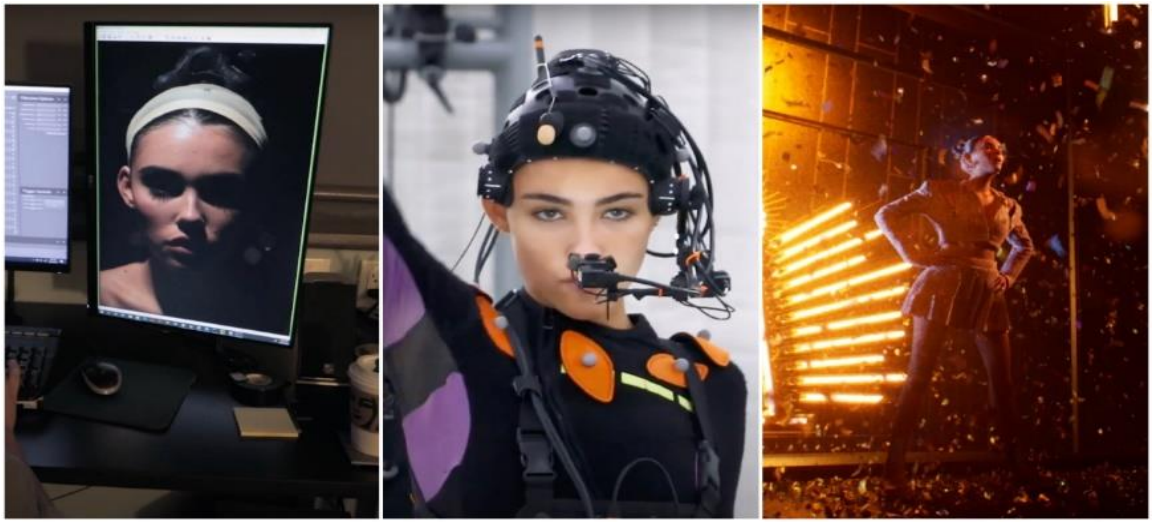


Figure 11 Boundless by Sony - Madison Beer Defines the Immersive Reality Concert Experience

songwriter Madison Beer debuted in an immersive reality music experience on TikTok LIVE. The ultra-realistic digital avatar of Madison was created by Sony Music Entertainment, TikTok, and Verizon in partnership with Sony Immersive Music Studio in an entire digital recreation of the Sony Hall concert venue in New York. In an interview with Madison, she expressed that experimenting with a virtual production technology for her performance was like nothing she had ever done before. She also mentioned that exploring new ways of bringing music to fans created a fulfilling experience for her, especially when physical contact is not possible. Sylvia Rhone, Chairwoman, and CEO of Epic Records said that supporting the development of cutting-edge immersive experiences like the one created for Madison's is one of the many ways the company Epic Records can help create differentiated opportunities for their artists to expand their creative options and delight fans [69]. A similar idea created by Fox Alternative Entertainment and premiered on September 22, 2021, is the new show *AlterEgo*. The shows are about music competitions, much like *American Idol* or *The Voice*; however, the singers perform backstage using a motion capture system to create a unique digital representing of their "dream avatar" for each singer on the stage [70].

With a great deal of meaning in religion and cultural importance, the avatar has become a significant way for people to interface with technology. From crossing over from spiritual to a virtual incarnation, avatars have become more than just vessels or navigational tools in games. Furthermore, users now are eager to polish their avatars to their self-image to improve their connection with their avatars. This leads to greater confidence and intimacy in the virtual world. The ability to customize, manipulate, control, and embody avatars in different media contexts is helping to make the metaverse

a reality. The increase of powerful graphic cards and accessible character creation tools are helping to produce effective pipelines for real-time animation, rendering, and production for various digital avatars. These pipelines have helped boost content creation while maintaining production fidelity. Leading brands and companies to focus on digital characters as virtual celebrities due to their proven effectiveness to attract consumers and build brand loyalty with their friendly appearance. These changes have made businesses more accessible and driven consumers to purchase various products, presenting a unique marketing opportunity for brands and consumers facing the current pandemic economic crisis. The following section of this paper will discuss how a variety of real-time emerging technologies have been used to create various digital avatars for content production use in social media communication and marketing strategies.

Production Overview

The previous context facilitates understanding the growing market and the push on content creators to look for real-time production pipelines to produce content faster with higher fidelity than previously used methods. Today, the line between the different classifications of virtual entities like virtual influencers, digital humans, CGI characters, and VTubers is blurring thanks to the enhancements of real-time computer graphics and network technologies. Combining traditional and emerging tools and pipelines allows for the creation of more customizable characters for real-time performance capture with the fidelity of a studio production pipeline. Barbie is an example of the transition from toy to virtual influencer with high fidelity for virtual production setups. Besides posting on her Instagram account and making appearances in different magazines, and toy advertisement videos Barbie also has a YouTube channel in which she creates video content in a similar format as discussed for VTubers. This virtual character does not stop there; she also creates music with a Spotify account producing content similar to human celebrities [71].

The focus is now on the technical challenges of creating virtual avatars for modern marketing strategies and applications used for real-time interaction and production. The virtual characters created for this project combines traditional methods and emerging tools and pipelines with different animations layers created for real-time motion capture clean-up. Some technical constraints faced during the development of this project include the physical characteristics assigned for each character. For example, facial expressions, motion capture preparation, real-time hair and clothing simulation,

skin textures, muscles, and wrinkles deformation, as well as modular animations for anthropomorphic character traits (e.g., tails, whiskers, animal fur, and others.) By utilizing real-time technology, the different components of the production can be communicated faster and quickly propagate changes with more straightforward and more elegant solutions.

Simulating complex behaviors of virtual humans inside their environments has been one of the most significant obstacles to overcome during the development of this project. Essential human communication takes place in various forms; one of the problems is that virtual humans do not display the subtle gestures and mannerisms that characterize a real human being, such as body language and facial expressions. Characters with rigid postures in any human interaction, whether through complete virtual environments or mixed media, affect communication and, consequently, affect immersion for both the user and the viewer. Mapping real-world motions to virtual avatars have facilitated peoples' interactions with virtual characters [72]. Through this project, the combination of real-time technology such as inertial body capture and facial capture is essential to create virtual avatars that can communicate with the audience as if they were real entities separated from their human puppeteer.

Lastly, the user can experience the body movements of their character from two different perspectives depending on the use of the character. One of them is the first-person perspective, such as VR platforms like VRChat, primarily used as personal communication and navigational tool in a virtual environment. The second option is a third-person point of view with a mirror image of themselves from a computer monitor or TV screen to deliver a form of entertainment through the use of online streaming

platforms, such as YouTube, Steam, Instagram, and TikTok. Since this project aims to make the character move as natural as possible, a first-person perspective will obstruct any facial capture setup due to the use of the head mount display required for VR platforms. This method also allows the interaction with the viewers to be smoother since the user can see the character moving in real-time and adjust accordingly to deliver the best performance possible.

Some of the limitations stated in this section are becoming a thing of the past with the creation of accessible next generations rendering software, and high-fidelity character creation tools such as *MetaHuman Creator, Unreal Engine 5, WrnchAI*, and the *Omniverse*. As covered earlier in this paper, such differences can influence beliefs, attributes, and immersive levels that influence users' behavior and consumption habits. The following production book will outline the process used to create early prototypes and the road map used to create the ten virtual avatars. The last part of this paper will deliver a cohesive discussion, and reflection of the project outcomes, and a brief interpretation of what the future might bring to virtual avatars.

Character Design

The earliest development of these virtual characters focused on finding a suitable pipeline to maximize time and quality for each virtual character, slowly adding layers to improve aesthetics, movements, and expressions to enhance marketing campaigns. During the development of this project, the exploration of different character creation tools and software was essential to understand what is currently available in the market and put together an accessible and efficient pipeline to adapt characters for a real-time production set-up. The first steps to creating a character start from concept art or design that helps to give an idea of what the end product would look like. A quick turnaround is necessary in the business world since any production always comes with time constraints significant to the client. Building characters from scratch is often not the quickest way and requires a larger team such as a concept artist and character designers that are often needed for more custom characters depending on the user's needs.

Platforms like *Artbreeder* and *Generated Photos* have successfully provided the general public access to image generations tools powered by Artificial Intelligence (AI). Artbreeder is an online tool that allows the users' collaboration and creativity to *breed* images by selecting the generated offspring of parent images in addition to direct *gene* editing. The user can select categories like human portraits, anime portraits, landscapes, buildings, characters, and *furries* to start their "breeding" process to generate a unique image [73]. On the other hand, *Generated Photos* is a website that generates images based on machine learning (ML) systems containing data from model-released images

captured in their studio. Both websites allow further modifications in sex, skin tone, hair color, age, emotions for more control over the final design. I used Generated Photos since it only generates human faces ensuring realistic face features and accurate skin tones essential when recreating a human look. It also allowed me to select a neutral face, mouth closed, eyes open, and relaxed pose, making it faster to get the desired image. Artbreeder is a fantastic tool for generating specific art designs or even reconstructing and coloring photos by *crossbreeding* images, but it can take longer to generate the desired result. Both tools can provide strong concept art to start the modeling process for humanoid avatars allowing the creator to avoid problems like acquiring expensive legal likeness or royalties' issues [74].

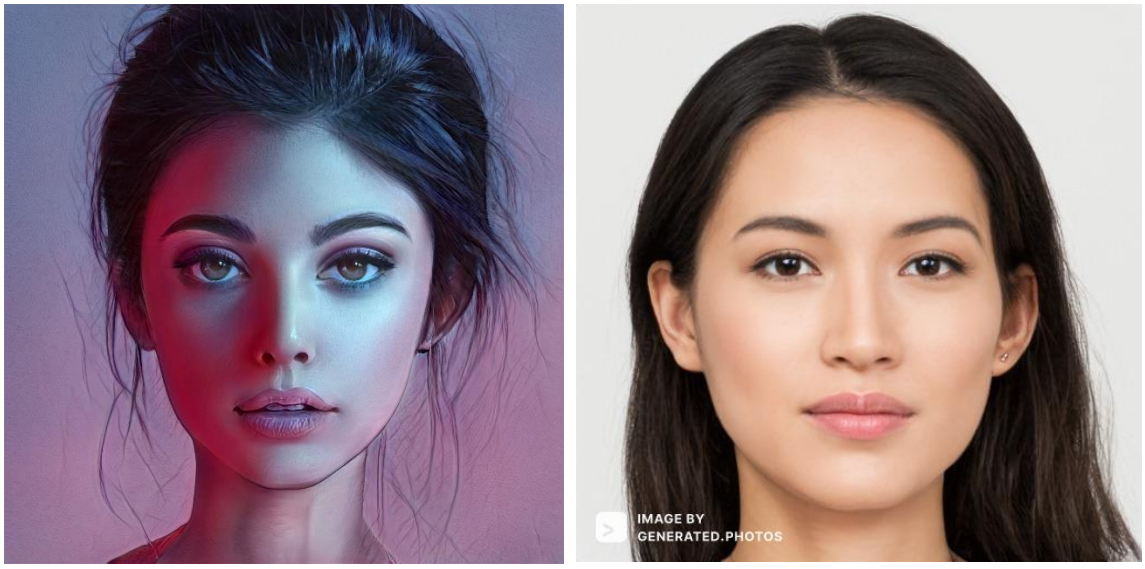


Figure 12 Artbreeder vs Generated Photos

With the combinations of these AI tools and the launch of Headshot, a plugin by *Character Creator 3*, artists are now one step closer to creating affordable, original, and realistic human characters. Headshot is another AI-powered tool that facilitates the creation of three-dimensional real-time digital human characters from one photo. Character Creator is a complete character creation software that allows any artist to easily

create and customize stylized or realistic characters compatible with multiple 3D software such as *iClone, Maya, Blender, Unity,* and *Unreal Engine 4*. Besides having intelligent texturing blending plugins like *SkinGen* and head mesh creation, the characters generated using these tools come out fully rigged with body and facial capture compatibility with motion capture technology and Apple ARKit. The iPhone ARKit is a face tracking solution that uses the "TrueDepth" camera available on iPhone X or higher with their 52 facial blend shape system to drive their character facial expressions in real-time [75]. Tools like Character Creator already have a predetermined pipeline between their character creator tools and real-time engines that facilitate virtual avatars' creation.

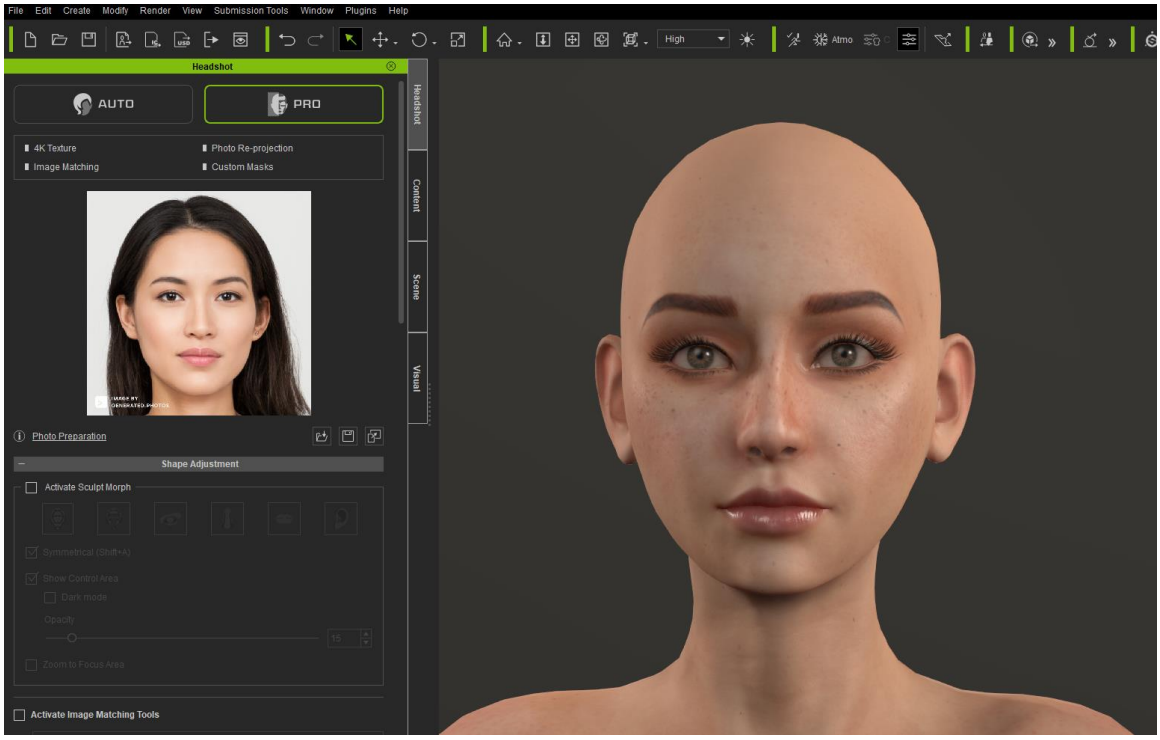


Figure 13 Character Creator 3 - Headshot plugin. LuLemon Character Development

A similar tool launched its early access at the beginning of the year called MetaHuman Creator. *Epic Games* raised $1 billion to help develop the Metaverse. With that investment, they were also able to include enhancements to their MetaHuman

Creator tool, a cloud-streamed tool created by Epic Games with the help of companies like *3Latral*, and *Cubic Motion*. This powerful website is designed to create realistic three-dimensional virtual humans with minimal effort and software knowledge required, without the trouble of jumping between multiple three-dimensional platforms [57]. I used these innovative tools with access to a diverse range of human scan faces to blend between them and refined the character using sculpting tools and controller guides that took high-fidelity human character creation from weeks to a few hours. Just like Character Creator, this tool allows the user to create fully rigged characters with a pre-built pipeline ready for real-time animation inside Unreal Engine 4.26 or higher using RTX graphic cards with the highest quality, strand-based hair and ray tracing enabled,

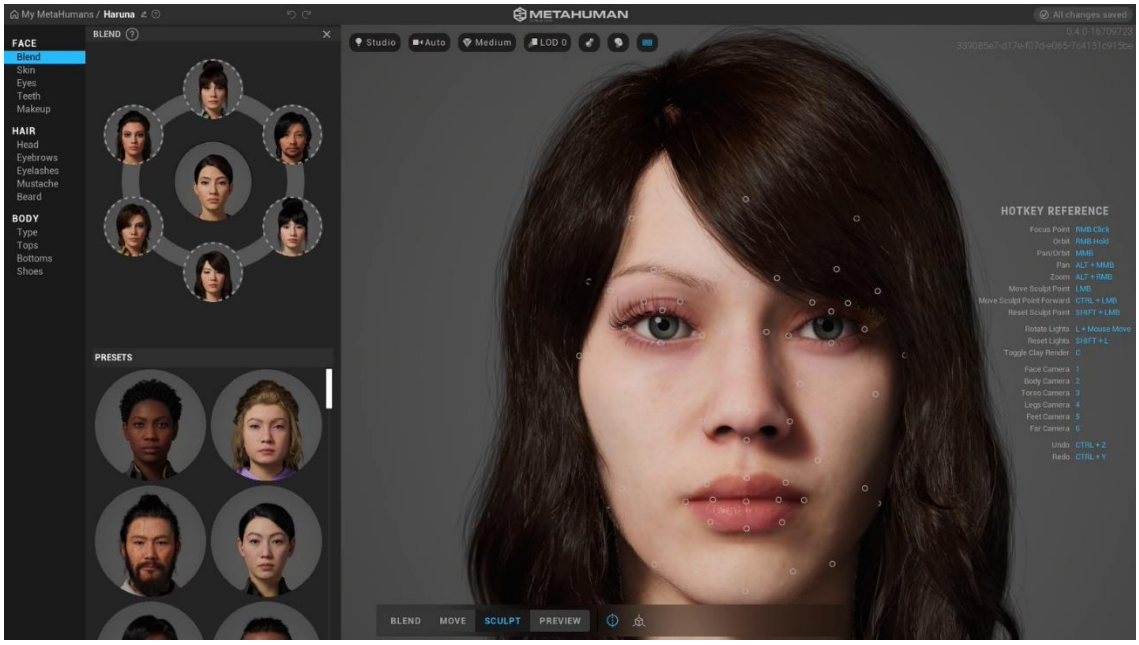


Figure 14 MetaHuman website - Haruna Avatar development

compatible with any motion capture system and Apple ARKit integration.

Other applications that offer easy and semi-customizable character creation tools are Ready Player Me, Vroid Studio, VTuber Maker, VUP, FaceRig, and other off-the-shelf applications that offer some level of character customization. These applications

specialize in outputting only anime-like avatars, most of them inspired by Japanese anime. However, most of these platforms require essential basic hardware for a whole puppeteering rig. Accessible applications like those mentioned above usually have a cost-effective motion capture pipeline already integrated within the platform. Body motion capture is usually a straightforward connection enabled inside the software and supports Leap Motion, Kinect V2, Noitom PN, Xsens, and Intel Realsense. The software often uses an ordinary camera to synchronize the user's eyes, eyebrows, and mouth expressions in real-time for facial capture. Although these pipelines require a simple setup, the expressions are limited based on the software capability and are only synchronized with characters created inside their own platform, limiting the designs of the avatar. These companies are not focusing on outputting game or production-ready characters but rather provide access to the metaverse to the general public. Other applications such as the Vtuber software are looking to facilitate character creation for live broadcasting design for video content creators that wants to develop a virtual presence. They are designed for

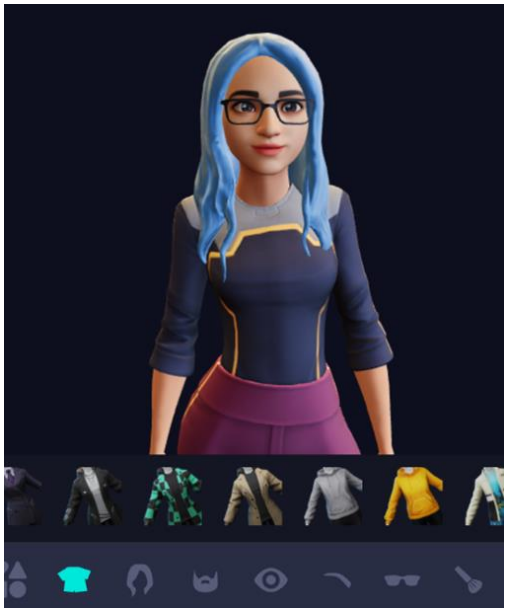


Figure 16 Ready Player Me website - MomoChan Character Development



Figure 15 Vroid Software - Lechuga-Chan Character Development

public entertainment to generate profit from user engagement, partnerships with brands, and commercial licensing.

These development tools also contain their real-time character pipeline like the previous two applications. However, exclusively customizable characters within their system tend to fall into a recognizable pattern and design. In some cases, the desired results are not achievable within the boundaries of these creation tools, and it is necessary to look for dedicated character modelers that use a combination of 3D sculpting and texturing tools such as *Zbrush, Maya, Blender*, *Mudbox, Substance Painter*, and *Photoshop* to generate custom characters. Even high-end tools that can generate 3D-looking humans like MetaHuman Creator and Character Creator have limits in the aesthetics user can achieve. Any production pipeline will require further customization on these characters, such as custom clothing, hair designs, and accessories to break the current aesthetic and add authenticity and believability. For this project, I used Maya as my base 3D software to assemble all characters due to its robust nature and ability to create, modify, texture, rig characters and assets to prepare them for real-time animation.

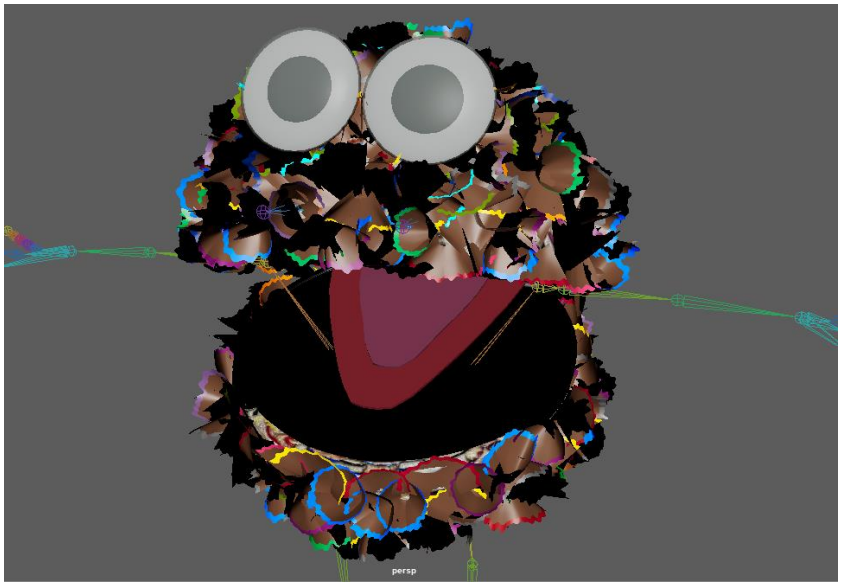


Figure 17 Maya - Figgi Character Development in Maya - Concept Art developed by Rafi Nizam

As discussed earlier, the standardization of Apple ARKit for facial capture is already part of these applications' pipelines, but the solution is only available to characters built within their software and sometimes is not expressive or natural enough. Facial expressions are essential for any virtual character and can often be complicated and time-consuming. In some cases, they require expensive equipment and software necessary for high-end film productions or video games. However, technology is gradually evolving to be feasible for smaller companies that cannot afford high-priced equipment and large workforce. The development of hardware and software is turning more accessible to the general public as well as experts. There are services like *Polywink* that offers automatic generated facial blendshapes compatible with iPhone with an advertised turnaround of 24 hours, but the results were not expressive enough for this project. After researching alternative solutions, I found that the *Blender* plugin *Faceit* was the missing component to this project. Faceit is a tool dedicated to professionals to create shape keys beyond the 52 ARKit expressions. It allowed me to export and import custom facial expressions and modify to my desire the current ARKit

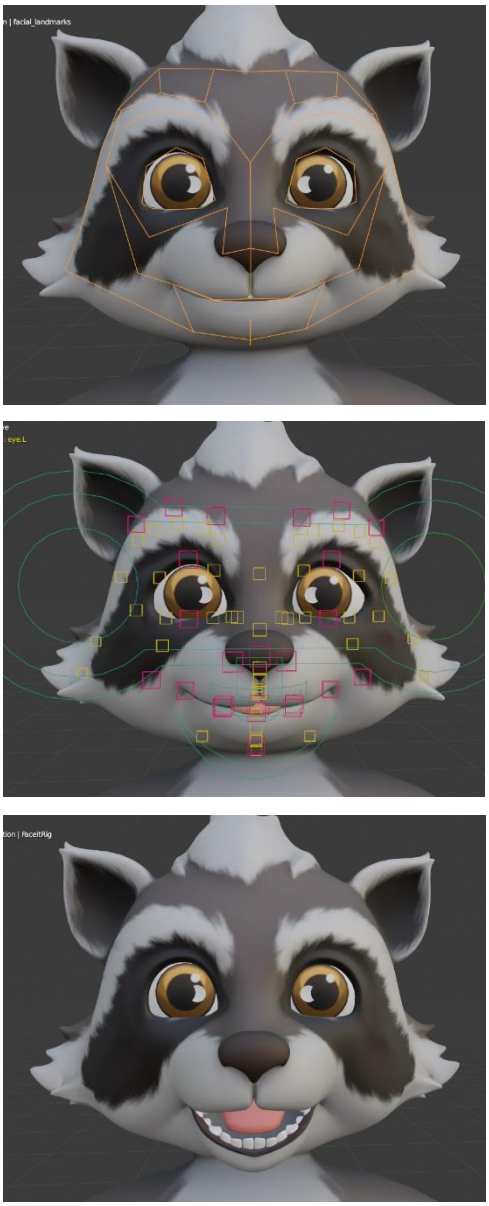


Figure 18 Blender 3D software using the plugin Faceit. Character model provided by Noitom

blendshapes that are generated semi-automatically for any humanoid character with a step-by-step guide that explains the setup process. The ability to customize the 52 facial expressions provided the necessary level of control needed to increase the natural movements required on human and non-human characters without the cost of high-end solutions used by companies like *Marvel Entertainment* films or software like *Faceware*.

After completing the required facial blendshapes, the characters are then exported back to Maya to complete the rigging process. For most anthropomorphic characters, their design journey ends, but for most human/anime-like avatars, extra layer customization will offer a more appealing aesthetics to the audience, increasing their believability and acceptance. Tools like *Marvelous Designer* offers solutions to generate,

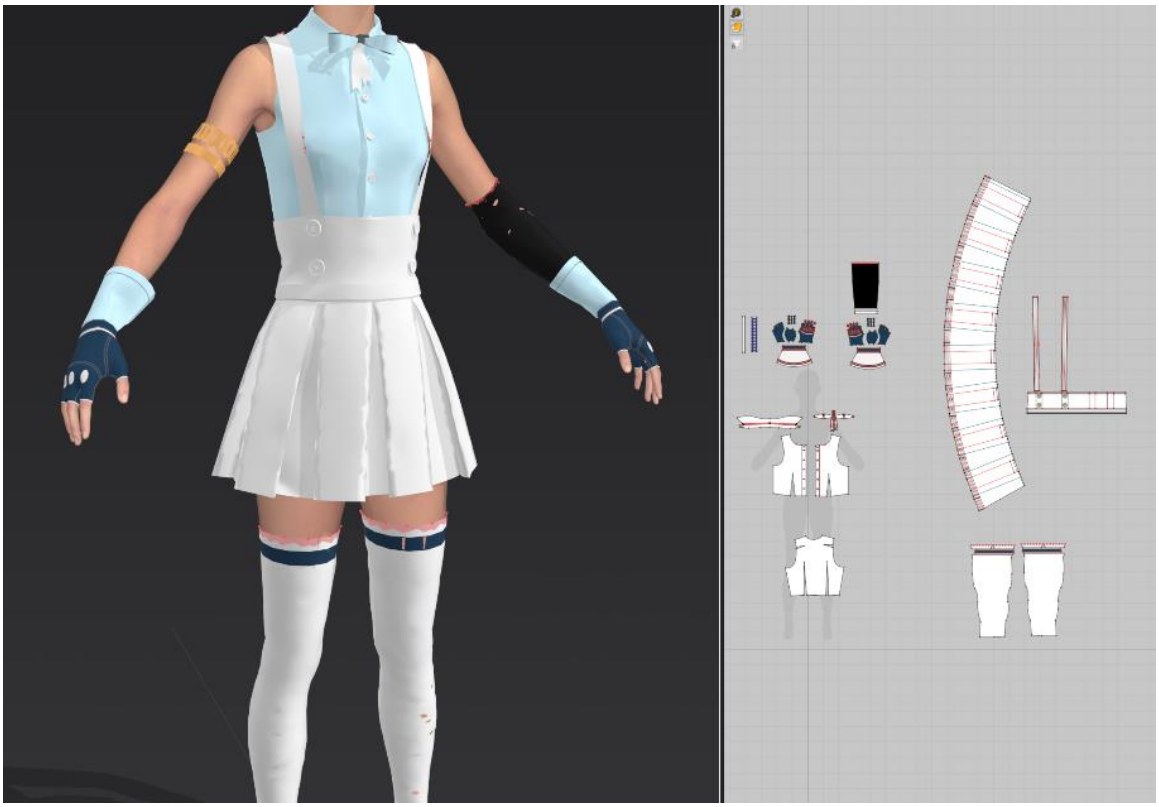


Figure 19 Marvelous Designer 3D Original 3D Garment - 2D pattern (Haruna Character Outfit)

edit, and reuse 3D clothing fitted to individual characters. This application adopts actual traditional cloth production methods into 3D cloth modeling with standardized, high-

quality results. It provided accurate and fast cloth simulation creating natural wrinkles in my 3D garments in real-time. It also offers a remesh and retopologizing functions to optimize the mesh conveniently for real-time pipelines.

Following the creation of the 3D garments using Marvelous Designer, an FBX file is imported into Maya the rigging process for each new garment. The last step would be to generate realistic hair using *XGen,* a Maya tool designed to procedurally create and style hair, fur, and even feathers for characters using hair guides and curves. This Maya tool allowed me to add parameters that mimic real-life styling options like trim, curl, frizz. Combining multiple references from different sources to determine the directional changes to help create a groom that is unique yet based on reality. To prepare this groom for further customization and optimization is always good practice to attach the groom to a separate piece of geometry, often called a *growth mesh* that exists for the sole purpose of emitting the hair or fur. For most humanoid characters, this growth mesh is usually called the scalp. Having a growth mesh helped make it easier to focus on the groom for each area and prevent having fur or hair in areas not needed, such as eyeballs, eye sockets, inside the mouth, or hidden areas.



Figure 20 Sketches of directional changes - image by Unreal Engine Hair and Fur Whitepaper

The idea to generate hair using tools like XGen, *Yeti*, *Ornatrix*, and *Houdini* is to allow game engines to instantly recognize the specific characteristics of human hair, such

as its unique translucent and reflective properties, including their tendency to clump and curl together, reacting to forces like gravity and wind to recognize it as natural instinctively. Epic Games explains how previously, the challenge of creating computer-generated (CG) hair and fur lay in fooling the human eye. Until recently, the game engine company decided to introduce the ability to optimize, render, simulate and generate LODs for the real-time performance of hair and fur in Unreal Engine, Epic's engine. The game Engine uses the Alembic file format to facilitate the import of static grooms from applications like XGen. The density of the groom and the number of curve vertices on each strand are factors that affect performance, rendering, and simulation, so it was essential to optimize the hair without affecting the visual effect before importing it into the game engine [76].

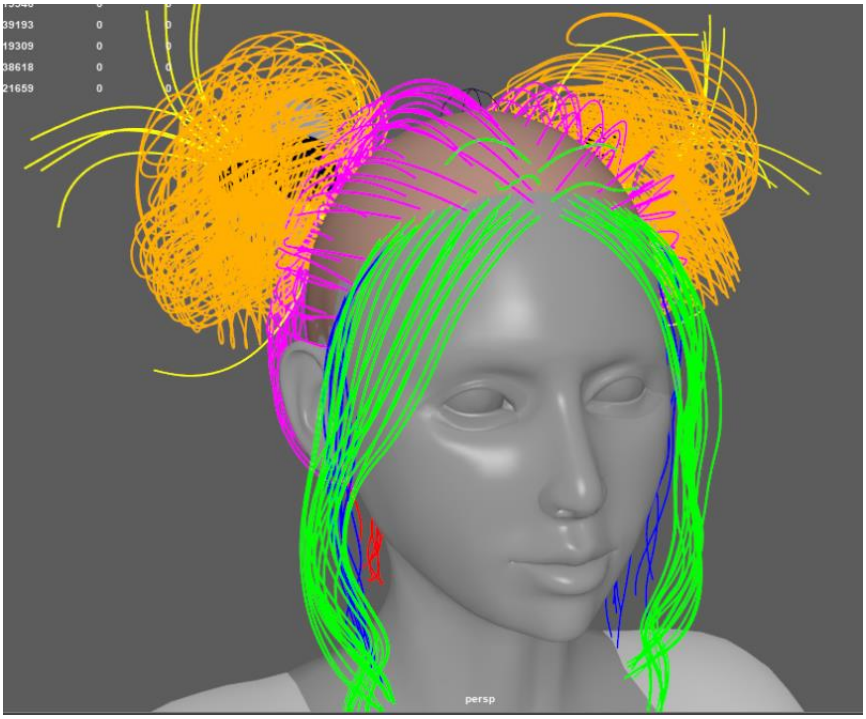


Figure 21 Maya XGen Hair Guides - Hair Development

Now that each character has reached their final stage of development, the last step is to ensure that they can undertake any further changes by breaking them into modular pieces. These characters should be ready to have different sets of clothing, hairstyle, or accessories to make them efficient and customizable. A high frame rate is needed to

ensure the quality of the video in real-time, so this process also helps optimize each character for the game engine not to render unseen polygons. It also enables better character performance by not having the skin poking through the clothes when the character contours into a particular posture. For this method, the characters are divided into key mesh variables. For example, for human-like avatars, the first variation would be head, arms, and legs; The secondary is top, bottom; shoes; and scalp; The following subdivision composes things like rings, necklaces, gloves, hats, or any other accessory. Each character has its process, with each subdivision sharing the same skeleton, making the retargeting process more manageable and cleaner inside the game engine. This modular process is standard in the game industry since they always have to deal with in-game customization and quick add-ons with a structured and efficient system.

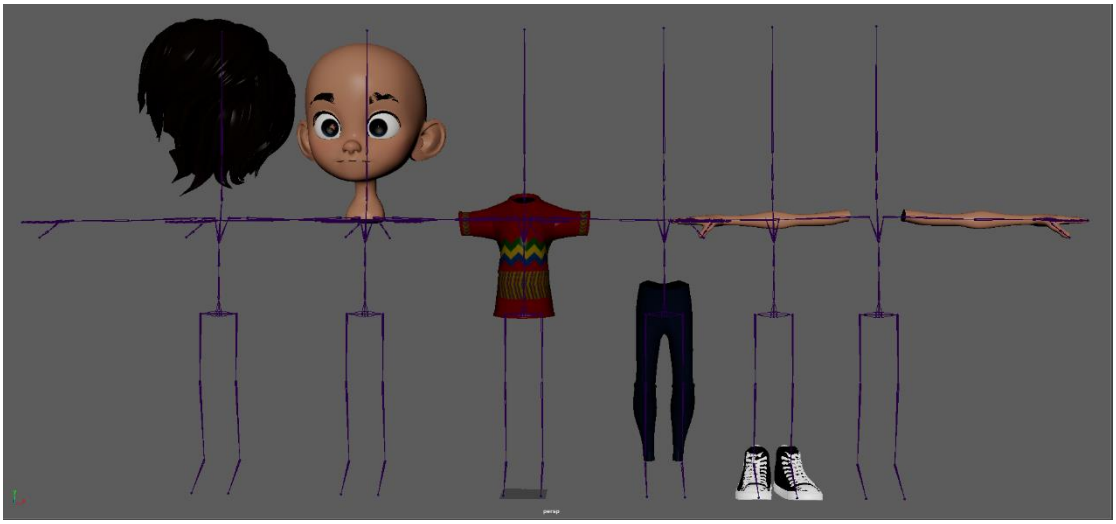


Figure 22 Pedro Modular Set-Up. Character Base 3D Model provided by Noitom

Each character used different tools and software to create the design and 3D model of the character, most of them with their internal pipeline for a real-time rendering solution limiting character customization. Most characters built using digital content creation (DCC) tools with standardized process, lacked either design, uniqueness, or expressive movement necessary to make them feel natural and appealing. Based on the

previous research discussed earlier on this paper, I decided to add another level of customization and optimization process suitable for real-time production pipeline in order to maintain an appealing design while considering time constraints found in regular production industries. The following section will discuss the integration with Unreal Engine 4 and the different layers of animation added to output the most natural movement for real-time avatars.

Real-Time Integration

Animation pipelines continue to evolve by embracing real-time technology and linear content development pipelines. Now it is possible to capture the motion of the human body and puppeteer skeleton-based virtual characters in real-time. There are companies like *Unity, Houdini, Cinema 4D, Lumion* that can output real-time rendering data; however, Epic Games has stood out in recent years with their free-to-develop game engine Unreal Engine 4 (UE4.) They have been able to create one of the friendliest ecosystems for developers working with real-time technology. They have integrated pipelines for industries like broadcasting, live events, game development, film, television, simulation, VR/AR applications development, and architectural visualization to help deliver cutting-edge entertainment, compelling visualizations, and immersive virtual worlds.

I chose UE4 because of its real-time rendering capabilities to output creative interactive characters that would take advantage of their physical base lighting, materials, and global illumination for more realistic results. This process is accomplished by using some built in tools like live link, which allows real team data from external applications to stream into Unreal Engine. Blueprints are Unreal's native visual scripting language that allows incoming mocap data and character assets to be combined into a single, programable asset [77]. The Actor is a blueprint Class that lets me create the main set-up for my digital avatars and place or spawn them on the level. This Actor contains a collection of Actor Components, which controls how the actor moves, renders, interacts,

etc., in the level. The number of components varies depending on the complexity of the character. However, the primary component that all my actors share is the Skeletal Mesh, which allows me to select the desired character to control with an Animation Class blueprint. The Skeletal Mesh comprises two parts: The polygon mesh that contains all the character's materials and textures and a hierarchical set of bones known as the character skeleton. The Animation Class of the Actor Blueprint is defined by the Animation Blueprint created from the character Skeletal Mesh. The Animation Blueprint allows me to connect all the incoming motion data to manipulate the character performance in real-time. This level of connection is achieved by directly controlling the skeleton's bones through logic that will ultimately define the final animation pose for a Skeletal Mesh per frame.

For this project, I have decided to use a commercially available motion capture suit (Perception Neuron Studio Suit and Gloves) to capture the body motion for my digital avatars. In a traditional pipeline, the motion capture data is recorded using internal software provided by the motion capture company. For example, Perception Neuron Studio equipment uses Axis Studio software to capture motion data. Later, that data is exported out using the software's internal skeleton or standard skeleton formats such as Mixamo, 3DsMax, or Maya human IK. This export can be in the format of FBX or BVH with custom FPS (frames per second) that is used to target the animation to the proper avatar skeleton using external 3D software such as Maya, Blender, Unreal Engine, and Unity.

However, the objective of this project is to transfer the motion data such as joint rotation and translation from a source skeleton (Axis) to a target skeleton (characters in the game engine) in real-time. The joint values can be directly copied over from skeletons with aligned initial T-poses. However, in most cases, a skeleton provided by other DCC tools tends to have a different default pose and naming convention from the source skeleton. Therefore, the first action course is to align the default pose between the target skeleton (A) and the source skeleton (B). This action is performed through two steps:

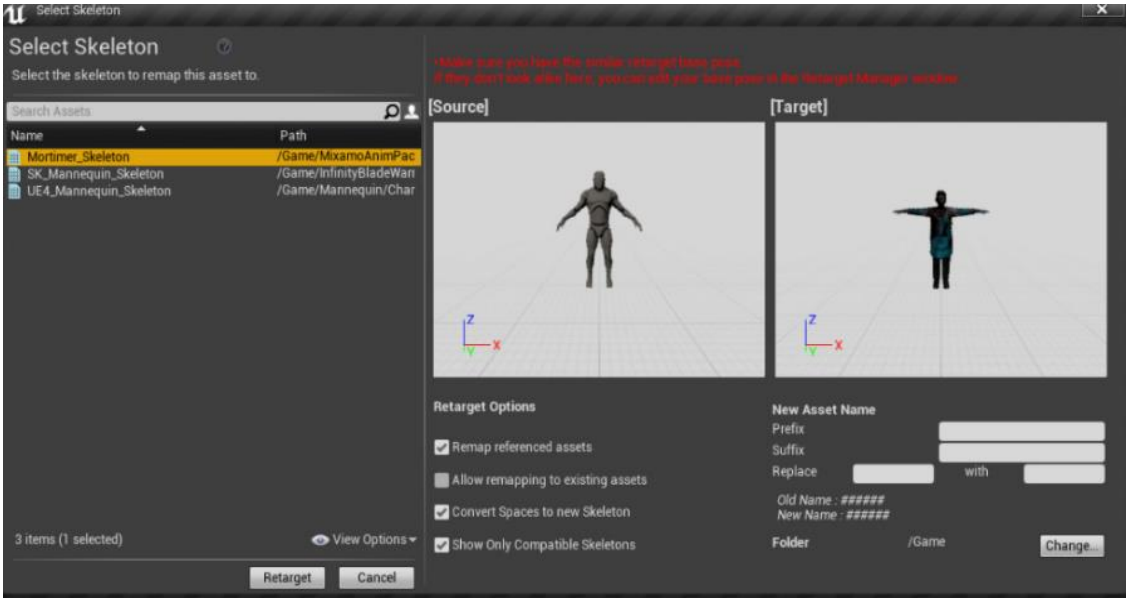


Figure 23 Unreal Engine 4.27 Documentation - Retarget Manager

First, rename the character skeleton bones in an external 3D software like Maya or Blender to match the source target skeleton. This step is avoided by rigging the character with the target source skeleton, ensuring 100 percent compatibility; Second, if the character is not in a default T-pose, it is necessary to repetitively rotate each bone in the target skeleton in a hierarchical order to match the world rotation of the source skeleton at the default pose. The target skeleton is then adjusted to have the same default pose as

the source skeleton. After achieving the desired pose, I created an animation asset from the current pose in the Animation Blueprint as a retarget asset.

In collaboration with the research in this paper Noitoms' Axis software launched a new version in early 2021 that included several streaming skeleton retargeting assets to facilitate the time-consuming process of retargeting various skeletons. By modifying the base pose inside the mocap software, Axis studio can export or broadcast predefined skeletons that more closely match the target skeleton pose. This process allows me to skip creating an Animation Asset for each character and select the desired skeleton directly from Axis Studio, simultaneously streaming the corresponding skeleton with that of the target character.



Figure 25 Ready Player Me character before creating animation asset



Figure 24 Ready Player Me character after adding an animation asset as a retargeting pose

Since the early stages of development, I planned on standardizing my own process by selecting two skeletons to share across characters. However, a retarget asset was required for the character made using the Ready Player Me website. Although it was compatible with the Axis Thumb-Open skeleton by sharing the same name and hierarchical order, the default pose was similar to the UE mannequin.

Animation Blueprint node that controls face and body movements based on real-time incoming data from Axis Studio Software and iPhone Live Link Face App The set-up starts with two essential blueprint nodes, the Live Link Pose, and the Output pose. From there, more nodes are added depending on the complexity and requirements of each character. The image below demonstrates the basic blueprint set-up required to start controlling an avatar in real-time. Two Live Link Pose nodes are needed to control the

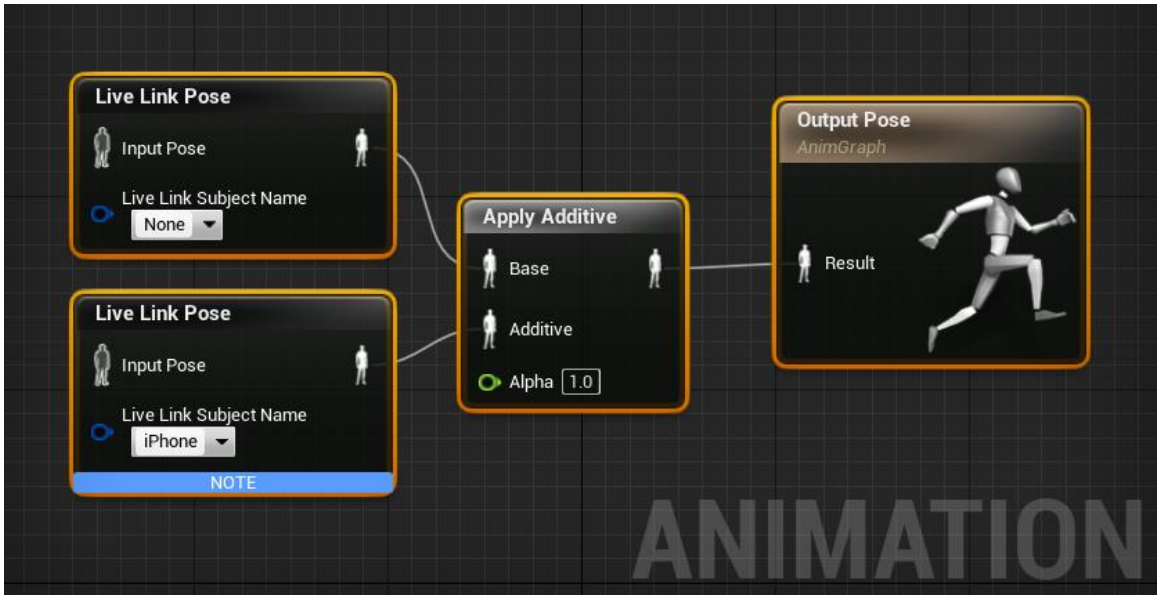


Figure 26 Animation Blueprint node that controls face and body movements based on real-time incoming data from Axis Studio Software and iPhone Live Link Face App

body and facial animation data of the avatars. The 52 Apple ARKit blendshapes embedded to the character will automatically activate after Unreal detects the incoming data from the Live Link Face application installed on an iPhone X or higher. The performer can now adjust the avatar's face for more accurate performance by quickly following a calibration process in the Live Link Face app. At this point, most characters are ready for facial capture without requiring any further adjustment. However, blendshapes are adjustable through the use of clamps or limits. These blendshapes can also behave differently using a Remap Assets or Blueprints logic to modify the morph

target curve data or drive facial bones such as the eyes, head, and jaw. For example, most three-dimensional characters have a standard set-up with 52 facial morphs created using any external sculpting 3D program, in this case using the Blender Faceit plugin, in which the character now has the embedded morph targets in the character base model allowing Unreal Engine to automatically import the blendshapes when importing the character.

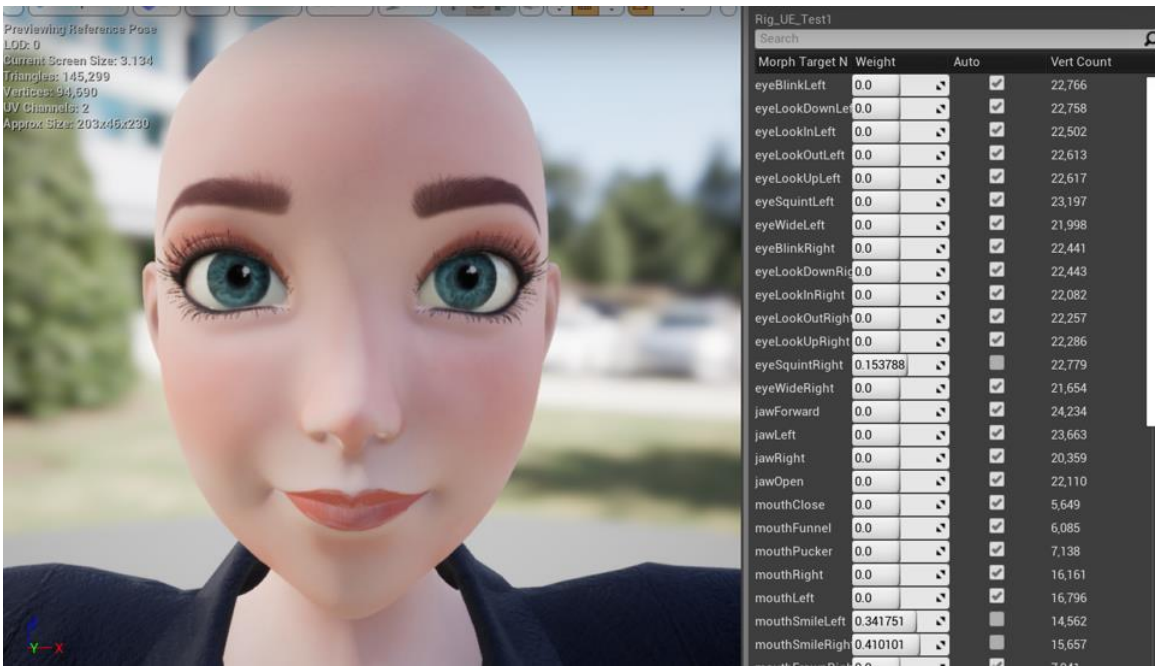


Figure 27 Facial Blendshape test and set-up in Unreal Engine

Furthermore, one of the avatars in my project had to combine traditional 2D animation using phonemes and using the 52 Apple blendshape list to create real-time animation using two-dimensional images. The facial expressions were divided into quarters, making the Apple required neutral blendshape the 000 point and the highest expression a 100%. The expression between 0 and 1 are the in-between frames that help output smoother animation following traditional two-dimensional animation techniques. However, using four images to create one facial expression was sufficient for a smooth and stylized animation. More data tends to require more processing power from the game engine, this needs to be considered when implementing custom facial setups to avoid

frame drops in the engine. Blueprint logic is then used inside the Actor Blueprint to give the appearance of facial animation by quickly flipping between the images designed to the corresponding blendshape combination.

Beyond receiving raw animation data into the game engine, it quickly becomes apparent that the mocap data needs some cleanup. Unreal Engine added a layered animation system that allows the implementation of procedural animation in real time Control rig is a node-based rigging system designed to provide users with tools to create flexible, dynamic, and procedural characters. After the retargeting process is complete, additional nodes can be added to set constraints and adjust individual bones to improve the overall appearance of the animation [78]. In this project I used control rig to correct three major problems with real time motion capture. The first, involved using layered procedural animation on the ears and tails of animals to support secondary animation in real-time. Having ears and tails respond to the actor's movements helps sell the overall performance. Second, I created a ground recognition system using control rig to constantly ground the character's hips to the ground level, allowing for characters that are shorter than the performer to properly

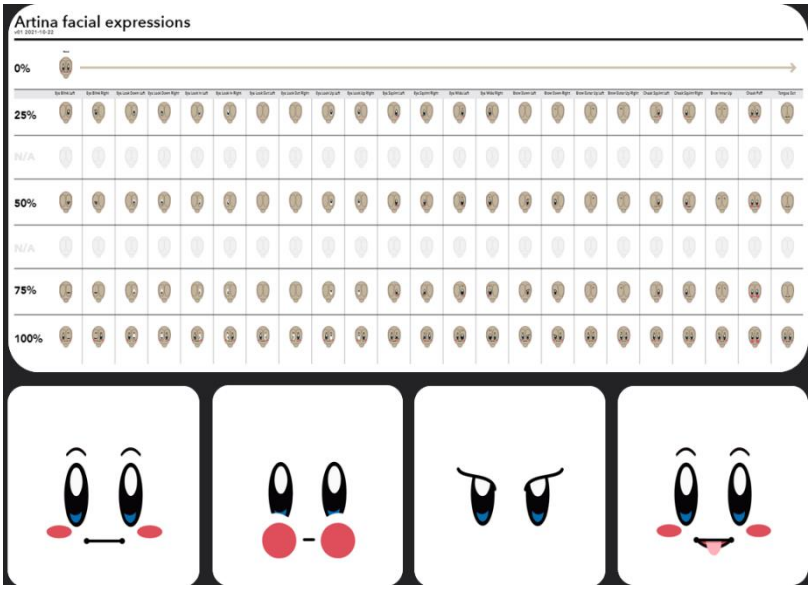


Figure 28 Artina's 2D Facial Blendshape. 2D Drawings by Rafi Nizam

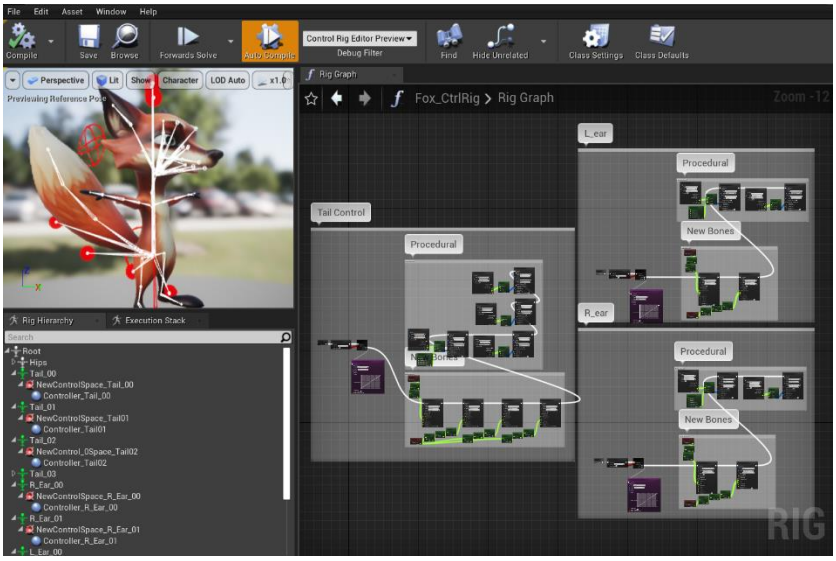


Figure 29 Control Rig, UE Asset - Rig Unit that controls character's legs and ears through a modular animation set-up

maintain a believe height. Lastly, I used control rig to add an IK system to the arms and legs to allow for additional constraints in the case accurate hand position is needed an optional tracking system.

Control Rig is later added to the Animation Blueprint as a regular adjustment node filtering the animation before connecting it to the final Output Pose. Characters that share the same skeletons hierarchy and global rotation can also share most of the blueprint nodes between them, which speeds up the preparation process for multiple characters. The Control Rig Units are also shared between characters by copying and pasting the blueprints from one Control Rig to the other. Other blueprints used for these characters are

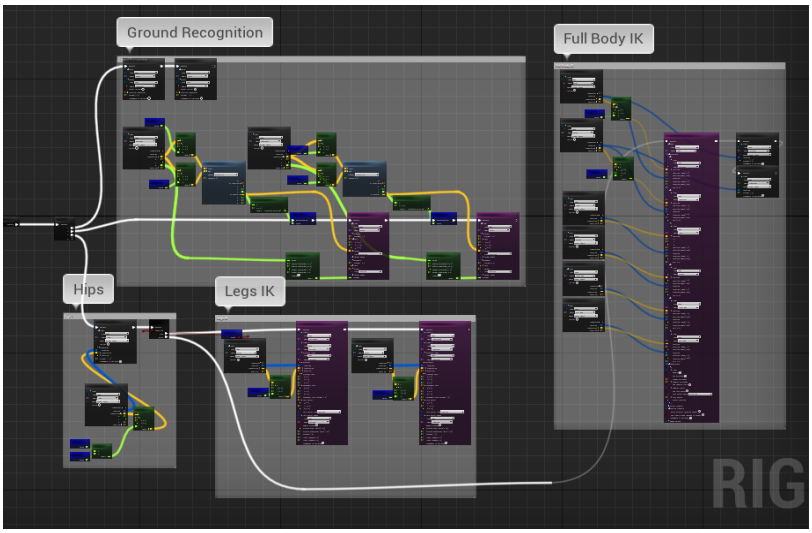


Figure 30 Control Rig, UE Asset - Rig Unit that controls motion warping in UE4

Transform (Modify) Bone, in case minor adjustments like bone translation, rotation, or scale are needed. For example, the characters need to be slighting scaled up or down to match the motion capture performer height and volume to avoid mesh clipping. This process depends on the digital avatar design and the body proportions of the performer.

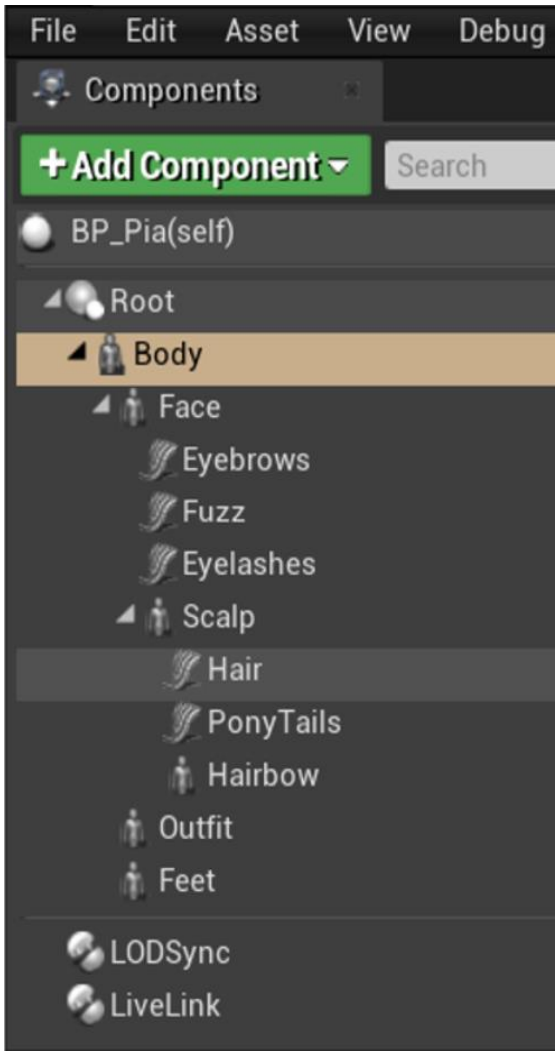


Figure 31 Haruna character final Actor Blueprint set-up

Matching the scale of the puppeteer to the characters helps to improve accuracy in the character performance. However, I decided not to focus on this area since the performer can be replaced during production, and the characters should continue functioning with similar quality performance regardless of the performer.

Character skeletons like the UE mannequin and MetaHuman have a larger number of bones in their hierarchy that can be manipulated to increase the quality of real-time performance. For example, these skeletons, by default, have bones called Twist bones that have more control and allow for natural limb deformation in areas like the wrist, elbow, arms, hips, legs, or ankles. Using blueprints like *Apply Limits* and apply a *percentage of rotation* drastically improve how natural humanoid characters look without the expense of simulating muscles deformation. More advanced applications

of this technique can be achieved, as demonstrated by Mold3D studio and their version of the Unreal character Eco. Instead of adding complicated and expensive muscle physics, they decided to use body, and muscle deformation blendshape layers to create the illusion of muscle deformation as the arm or leg bends in real-time. Now that the character has all its adjustment layers, I can start the assembly of the Actor Blueprint. The first component is the Skeletal Mesh that will define the base of the hierarchy. Depending on the complexity of the model and the number of modular pieces it can contain many or a few. Skeletal Meshes. Since they all share the same skeleton, only the base Skeletal Mesh needs to define the Animation Class by adding the Animation Blueprint created for this specific character. The body is usually the base since it contains the Hips, Pelvis or Root, following the skeleton's hierarchy. The Head, Top, Bottom, and Shoes will be assigned as a child of the body, with the rest of the accessories parented to its corresponding Skeletal Mesh. For example, the scalp will be under the Face/Head, and the groom will be assigned to the scalp. I also have hair bows in the image example, which I attached under the scalp as an accessory for the hair.

The grooming setup starts with an Alembic File exported from Maya. This file has a .abc extension that contains the information UE4 needs to simulate and render hundreds of thousands of photorealistic hairs for more convincing human characters and animals in real-time. Once the file is imported to Unreal, I added the proper Levels of Detail (LODs) and an advanced hair shader, which determines the approximate light reflection from the surface of the hair with anisotropic specularity, as well as refraction through it and it scatters throughout multiple strands that improves visual fidelity of simulated hair in real-time.

Further customization exists within the game engine, such as simulating clothing and other fabrics with PhysX or the Chaos physics solver. These two systems allow setting clothing parameters within the Engine and seeing the results in real-time by letting the 3D artist determine which areas of the clothing need simulated physics. Tools like Marvelous Designer offers animation functions with interactive cloth simulation; however, the tool is not ready for real-time clothing simulation outside their software.



Figure 32 Haruna Character Grooming - UE4.27



Figure 33 LuLemon Character Grooming - UE4.27

Many of the tools described in this section are either in open beta or under heavy development. Many of these workflows are not established nor widely accepted by various production industries, which is why it is important to continue to develop characters utilizing these powerful pipelines. The future of real-time character development has yet to be written and the next section will look to the future of the avatar and what to expect in the coming years.

Conclusions, Outcomes, and Reflections

The pipeline described in this paper presents one way of achieving the goal of creating characters for real-time interaction. Although there are many use cases for this technology, for example to create characters that can be used for previsualization of films, live shows, games, or any project that involves representing people as digital avatars. A lot of those cases have post-production components that lets you fix many problems encountered in the performance. Various entertainment industries are now implementing virtual production pipelines such as broadcasting, television, production studios, and gaming, to mention a few that see virtual production as a new method of fast content production. The recent pandemic has helped accelerate the adaptation of virtual production pipelines in the industry with real-time tools.

The purpose of this project was to build characters that are intended to be used for real-time final output for any digital live event or performance. Industries like digital marketing online entertainment are beginning to take advantage of the fast content production workflows and consumer's enthusiasm for virtual concerts and celebrities to create a marketing strategy. Unlike the dystopian world presented in literature, companies today are trying to make an augmented world in which real-life and digital content coexists.

The development of these pipelines has led other companies to start producing virtual live events and support the introduction of the metaverse. An example of these strategies includes virtual concerts like the one produced by *Riot Games* in September

2021 using characters from the *League of Legends* franchise. The event took inspiration from the concerts done by the virtual group *K/DA.* These mixed media events are changing the nature of live entertainment and inspiring others to embrace the augmentation of the real world [79]. In contrast to *Gorillaz*, these new bands are now performing in entirely virtual spaces, helping the rise of the metaverse, bring the audience into the virtual world.

Game companies are leading the way in building the metaverse by attracting audiences to virtual experiences, fueled by the need to sell live content during the Covid-19 pandemic. Travis Scott's Fortnite concert event drew 12 million players to a live shared experience in 2020, and Ariana Grande's *Rift Tour* only continued to grow the platform [80]. Like traditional concerts, these virtual events can sell tickets and merchandise that their virtual avatars can wear. One of the most significant advantages for the producers of these concerts is that they will not have to pay for the expensive physical location, leading to new financial avenues for producers and promoters to pursue. A similar situation applies to virtual celebrities or influencers that are not attached to any physical or time constraints, producing countless hours of content. Other professional practices for virtual avatars have been collaborating with single live shows and educational projects. The application of this could range from kids TV show to corporate training videos, customer service, instructional videos, and more. The pipeline review in this project is only the beginning to this journey into the metaverse.

Virtual entertainment is a growing practice alongside the metaverse. Games like Fortnite and Roblox will continue hosting virtual concerts and selling in-game merchandise related to their virtual celebrities. Virtual avatars do not age; bands like

ABBA are now launching a virtual concert next year in London with a ten new songs album [81]. HTC vice announced that they will be developing a metaverse platform for virtual concerts called *Beatday*, [82] and Fox's reality show *Alter Ego* are just a few to mention. The growth of virtual avatars in the areas of entertainment and marketing will only keep growing. Brands are more interested than ever in these possibilities that enables them to advertise their line of products in ways never imaged before, producing content faster without the cost of high-end industry practices. There are still issues to be fixed with the current pipeline presented on this project. This project's development needs more research for problems like self-body collision to avoid characters clipping through the body, more accuracy with the overall performance capture, and looking for ways to save on performance while simulating and rendering realistic clothes and hair for real-time performance. This is only the first step to reaching the proposed metaverse.

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[1] Historical period that began in the mid-20th century, characterized by the rapid shift from traditional industry to an economy primarily based upon the information technology.
[2] Subgenre of science fiction in a dystopian futuristic setting that focuses on a combination of lowlife and high tech featuring advanced technology and scientific achievements.

[3] Fictional description used in the book *True Names* to depict a new-full immersive virtual reality technology.
[4] Fictional description used in the book *Mirror Worlds* to describe dolls as a high technology communication system.
[5] American corporation. A video game developer, publisher and digital distribution
[6] Video game digital distribution service
[7] An event that allowed players to convert into Thanos after finding the hidden *Infinity Gauntlet*. This made players' avatar transform into Thanos with new character abilities for a limited time.
[8] Effect that describes the relationship between the human-like appearance of a robotic and the emotional response it evokes. Usually leaves a sense of unease or revulsion towards humanoid robots that are highly realistic.