Advanced Virtual Human Modeling with Metahumans: Focus on Genderless Characters

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***Abstract*—Virtual Humans (VHs) with high levels of anthropomorphism in visual appearance and behavior can enhance user experience in movies, games, and other interactive media. Users often seek human-like representations that include realistic movement, emotion, and gender, fostering a stronger sense of identification with VHs. Studies from Psychology have shown that people tend to evaluate characteristics of others within their own group differently, known as the in-group advantage. For example, women may be better at recognizing emotions in other women than in men. Researchers have also noted differences in feature recognition based on both the gender of the person and the gender of the perceiver, a phenomenon that also extends to VHs. Understanding how humans perceive VHs is crucial for improving user experience and representation in virtual environments. Gender is a key anthropomorphic characteristic in VHs, essential for representativeness, human identification, and user comfort. Typically, VHs assigned a specific gender exhibit stereotyped features such as movements, clothing, hairstyles, and colors, designed to be easily recognized by users. Insights into gender representation in VHs can guide the industry in modeling and animating VHs to achieve the desired impact. This tutorial introduces a methodology for modeling gender in VHs, from genderless virtual babies to genderless virtual adults, focusing on visual and behavioral aspects. Participants will learn how to create genderless VHs, enhancing gender representation and making virtual environments more inclusive for a diverse audience.**

***Index Terms*—virtual human, modeling, gender, perception.**

I. Introduction

Computer Graphics (CG) are increasingly used in games, movies, and real-time simulations to create realistic characters by capturing actors' facial and body expressions. Virtual Humans (VHs) created with CG are becoming sophisticated in representing human behaviors and appearances, enhancing user engagement and comfort (Chaminade et al. [1]; Mori et al. [2]; Katsyri et al [3]; Ho et al. [4]). Studying human perception of VHs is crucial as it affects user experience and representation in virtual environments (Zell et al. [5]). A key anthropomorphic characteristic in CG is the gender of VHs (Dodik et al. [6]; Araujo et al. [7], [8]; Bailey et al. [9]; Nag and Yalçın [10]; Ghosh et al. [11]). Gender, crucial for representativeness and comfort, is a social construct, while sex refers to biological traits (Wallach [12]). This study uses "gender" as recommended by APA Norms 7th Edition.

In the gaming industry, where can we measure gender differences between VHs, although the representation of female protagonists is increasing, male VH protagonists are still the majority[1]. From 2016 to 2020, female protagonists in games grew by 16%. Additionally, the number of non-binary VHs remains low, between 3% and 5%. Although the number of diverse VHs in games is increasing, their modeling and design often perpetuate real-world stereotypes. For example, female VHs often have sexualized appearances in games [13], various social standards regarding gender roles and other gender stereotypes are reinforced in games [14], [15] and movies[2] [16].

[1]https://www.statista.com/statistics/871912/character-gender-share-video-games/

[2]https://thedissolve.com/news/655-disney-animator-says-women-are-hard-to-draw-becaus/

According to Condry and Condry [17], gender stereotypes are less likely to be observed in young children compared to adults, as babies up to a certain age are considered naturally "genderless." This reduces interference when measuring human bias. Araujo et al. [7] explored this concept by presenting animations of a genderless Virtual Baby (VB) to three groups of users, each group receiving different gender cues (female name, male name, and no name). The study found that users' perceptions were influenced by the gender cues: for example, women perceived more emotional intensity in the VB's actions when it was given a female name compared to a male name.

In terms of virtual adults, this is more complex, in 2021[3], 73% of Brazilian women and nonbinary players encountered gender stereotypes in mobile games. Draude [18] notes that VHs' human-like appearance and behavior enhance usability and comfort. Abbruzzese et al. [19] discuss the in-group advantage, where people better recognize attributes in their own groups, extending to gender. Studies by Zibrek et al. [20] and Hess et al. [21] indicate easier gender identification of opposite-sex actors in non-stereotypical models. Guadagno et al. [22] found in-group advantages in evaluating persuasive VHs, with biases detected by out-group members.

This tutorial aims to present methods for modeling genderless VHs. First, it introduces the VB 3D model and virtual environment from Araujo et al.'s work, which demonstrated a genderless VH methodology based on participants' gender-biased behaviors towards the VB. Second, it outlines a methodology for creating a genderless adult VH, based on a continuum from male to female, with the extremes representing binary genders and the midpoint representing nonbinary gender. This approach, inspired by Armando et al. [23], focuses on modeling genderless VHs rather than investigating VH gender identity. The resulting 3D models are designed to avoid clear identification as binary genders, offering a broader representation.

II. Related Work

This section presents the importance of gender for the perception of VHs. Johansson [24] established that humans can identify behavioral movements with minimal information. Research indicates that facial expressions influence gender recognition/perception [19], [25], [26], and this extends to VHs, where female VHs often convey emotions more convincingly than male ones [27]. Zibrek et al. [20] investigated how participants perceived the gender of VHs based on their movements, using real actors' and actresses' movements to represent different emotions. The study found that participants could attribute gender based on the VH's movements. Similarly, McDonnell et al. [28], [29] explored gender perception and attribution in VHs based on movement and appearance, using male, female, and gender-neutral (androgynous and skeleton) models. In a follow-up experiment, they also altered the shapes of the male and female models to assess changes in gender perception. Their results showed that gendered features in the appearance of a VH could influence gender attribution.

Draude [18] noted that humans attribute gender to objects and VHs even without clear gender cues. Social Identity Theory [30] and studies by McDuff et al. [31] and Abbruzzese et al. [19] suggested that in-group members recognize emotions better in each other, while out-group members may face dehumanization [32], [33]. Araujo et al. [7] replicated Condry and Condry's experiment [17], showing gender bias in emotional evaluation and gender attribution of VBs. Studies by Nag and Yalçın [10], Ghosh et al. [11], and Hess et al. [21] found that visual features like hair and facial characteristics lead to gender bias in gender attribution and emotion recognition of binary and nonbinary VHs. Furthermore, like the present tutorial, Nag and Yalçın's work [10] also presented a methodology for creating genderless adult VHs, which will also be used in this present tutorial for comparisons. Zhao et al. [34] further showed that participants more accurately identified masculinity in male VHs and femininity in female VHs.

III. Methodology

This section aims to present the methodologies for modeling/designing genderless VHs, and is divided into: *i)* Design for the use of scenes involving genderless VBs; and *ii)* Modeling of genderless adult VHs.

A. Design for Genderless Virtual Babies

As mentioned previously, according to Condry and Condry [17], babies/children up to a certain age can be considered genderless. The work of Araujo et al. [7] has shown that VBs can also be considered genderless. So, in this tutorial, we use the work of Araujo and his colleagues as an example, showing how to model a virtual scenario in which there is a genderless VB. In this first part of the tutorial, we use Unity to model scenarios involving VB.

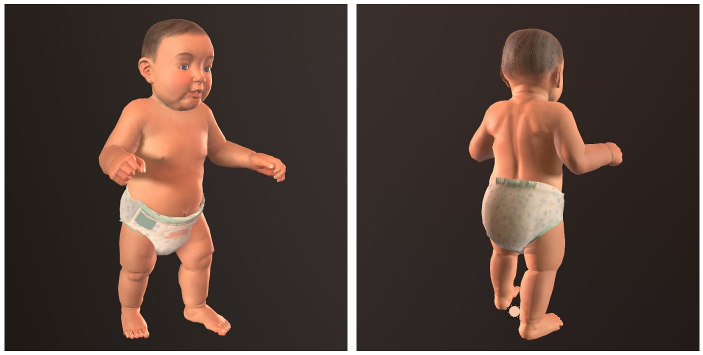
We use the same 3D VB model, virtual environment, and configuration scenario as in the work of Araujo et al. The 3D VB model, purchased online, originally featured a white diaper with details that could imply a gender bias. To neutralize this, we change the diaper texture to a plain white color (gender neutral). The VB also has animations depicting realistic baby behaviors such as crawling, walking, and playing with a ball. Therefore, additional animations were created for the VB interacting with a unicorn[4] and a Jack-in-the-box[5]. Figure 1 shows the VB model, while Figure 2 illustrates the VB interacting with these three objects, where in Figure 2(a) the VB played with a ball, in (b) the VB reacted to the unicorn, and in (c) reacted to a jack-in-the-box.

Araujo et al. aimed to ensure the VB exhibited genderless behavior and a gender-neutral appearance to replicate Condry and Condry's perceptual study of real babies. In Condry and Condry's study, one group of participants was told the baby was a girl, while another group was told the baby was a boy.

[3]https://www.statista.com/statistics/1301348/perception-gender-stereotypes-mobile-gaming-worldwide/

[4]https://free3d.com/3d-model/unicorn-doll-772526.html

[5]https://www.blendswap.com/blend/27680



(a) (b)

Fig. 1. VB model used in the work of Araujo et al. In both (a) and (b) it is possible to see that VB's diaper had details that could generate possible confusion about VB's gender.

Similarly, Araujo et al. informed participants differently about the VB's gender. Both studies found in-group preference, where women emotionally evaluated the girl VB differently than men evaluated the boy VB. In these cases, people cared more about the VB's name than its appearance. This occurred because the VB's appearance was genderless.

Furthermore, a virtual room devoid of gender-biased objects was designed to provide context for the VB scenes. In total, three scenes were created for the three objects. Although the ball and unicorn could suggest gender biases, the authors aimed to ensure the VB did not exhibit visual stereotypes.

B. Design for Genderless Virtual Adults

This section presents methodology for modeling nonbinary and binary VHs. In addition, we also carried out perceptual studies with a focus group of gender experts to validate the VHs models.

1) Modeling a Nonbinary Adult VH: This section outlines the methodology used to model a genderless/nonbinary adult VH that does not simultaneously possess male and female features. The key step in this tutorial is to utilize features between male and female characteristics to minimize binary gender biases. To create the genderless adult VH, we employed Metahuman Creator [6], which offers a broad range of photo-realistic 3D models and allows for manipulation of facial and body features. Additionally, the software enables the merging of facial features from different models. Using this tool, we selected two standard Metahuman models—Ada (female) and Bryan (male)—and generated intermediate models between them using the provided slider interface. We tested facial feature transformations in both directions (from Ada to Bryan and vice versa) and found similar results. Consequently, we focused on the transformation from Ada to Bryan.

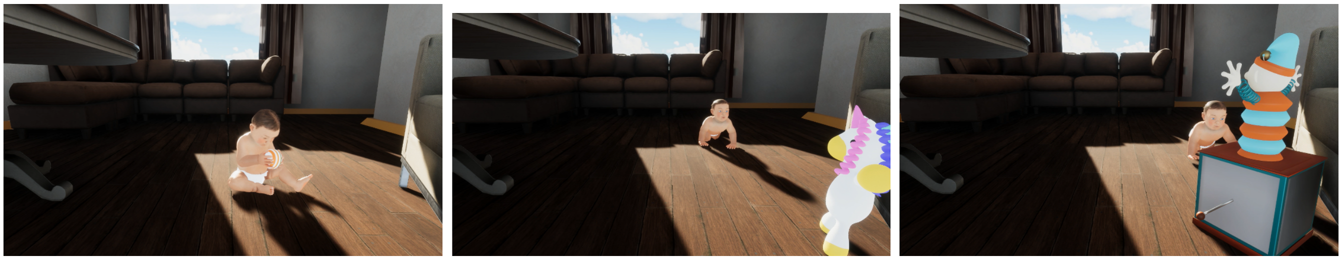
We created seven variations by merging the two models, with the 50%-50% blend serving as the intermediate variation. Our initial hypothesis was that this intermediate model would represent the nonbinary VH. To explore all possibilities, we also created three variations with more prominent characteristics of one model (i.e., 100%-0%, 85%-15%, 60%-40%) and repeated these variations with more features from the other model. To ensure consistency and reduce potential biases, we removed the hair from all VHs, as hair and hairstyle can be strong gender cues and introduce significant biases (as noted in studies by Hess et al. [21] and Ghosh et al. [11]). All variations are illustrated in Figure 3.

2) Modeling Binary Adult VHs: We also utilized the Metahuman Creator tools to model male and female VHs based on gender stereotypes for binary VHs. Starting with the nonbinary VH model as the base, we merged it with the binary models (Ada and Bryan) without hair to ensure comparability. With a free design, we added features based on femininity and masculinity traits, such as adjusting the mouth shape, to model the two binaries. The models are depicted in Figure 4.

3) Results: In relation to the nonbinary adult VH, we conducted a focus group study with 27 participants (12 women, 14 men, and one nonbinary individual) to validate the most nonbinary model from the seven variations. Participants, including gender specialists from the PVPP group, rated each variation's femininity and masculinity using 5-point Likert scales. The 50%-50% model was deemed the most nonbinary, as it had neutral response values of femininity and masculinity, indicating participants found it challenging to categorize as either feminine or masculine. This confirmed our hypothesis that the intermediate model would be the most nonbinary.

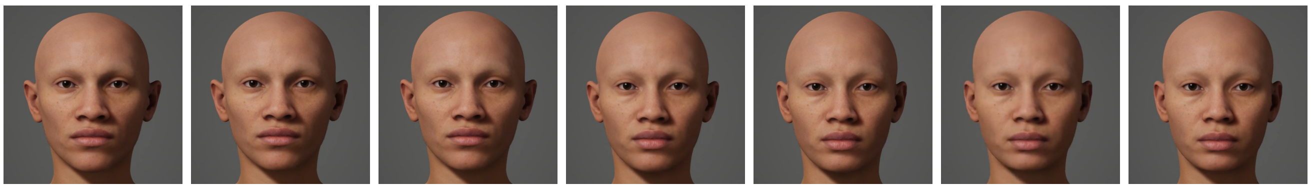
In relation to the binary models, to evaluate the femininity and masculinity of the female and male models, we asked a focus group of 25 participants (15 women and 10 men) to rate them using a 5-point Likert scale. The results showed that the female model was rated as more feminine (Avg = 3.44, SD = 0.94) and less masculine (Avg = 2.4, SD = 0.89), while the male model was rated as more masculine (Avg = 4.24, SD = 0.7) and less feminine (Avg = 1.64, SD = 0.74), as expected. Notably, the ratings for the female model were more central on the Likert scale compared to the male model. These findings are consistent with Nag and Yalçın's work [10], where participants also rated a female model with short hair as less feminine. We chose to continue studying this female model

[6]https://metahuman.unrealengine.com/



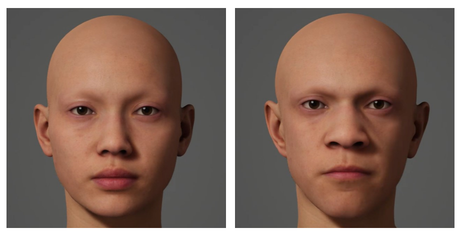
(a) Ball (b) Unicorn (c) Jack-in-the-box

Fig. 2. The environment and the three objects used in the work of Araujo et al. [7], and the VB interacts with are as follows: (a) the baby plays with a ball; (b) the baby crawls away from the unicorn; (c) the baby reacts with a negative emotion when Jack pops out of the Jack-in-the-box.



(a) 100M/0F (b) 85M/15F (c) 65M/35F (d) **50M/50F** (e) 35M/65F (f) 15M/85F (g) 0M/100F

Fig. 3. All variations between Female (Ada) and Male (Bryan) characters. In addition, the model considered the most nonbinary gender (50M/50F), as evaluated by the focal group, the one highlighted in bold (d).



(a) Female (b) Male

Fig. 4. The binary models used in our work: female (a) and male (f) characters presented using the motion stimuli. From (b) to (e), the happiness of the female model expressed by, respectively, female style, male style, actress, and actor, while (g) to (j) shows happiness applied to the male model.

because participants cited the absence of hair and accessories as factors leading to more neutral evaluations. However, as studies by Hess et al [21]. and Ghosh et al. [11] have shown, hair can introduce significant bias.

IV. Final Considerations

The goal of this tutorial was to present a methodology for modeling nonbinary VHs from infancy to adulthood. For VBs, the tutorial focused on the methodology used by Araujo et al., who employed a genderless VB in a perceptual study to measure emotions and gender attribution. For adult VHs, we introduced a methodology for modeling both nonbinary and binary VHs by blending femininity and masculinity traits. By attending this tutorial, participants will learn how to model a nonbinary VH using Metahuman Creator, a state-of-the-art platform for creating highly realistic VHs, as well as how to create a genderless VB. The motivation behind creating nonbinary VHs is to enhance gender representation in virtual humans and to increase the comfort and inclusivity of a diverse audience.

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