GranDGamesBR: Perceptual Analysis of Computer Graphics Characters in Digital Entertainment

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***Abstract*—This paper presents a discussion regarding the area of perceptual analysis in Computer Graphics characters. This discussion is focused on presenting one challenge area in Digital Entertainment. Many issues in the area of perception analysis have been researched in last years, in particular with respect to the theory of Uncanny Valley (UV) proposed by Masahiro Mori in 1970. Indeed, it is known that realistic characters from movies and games can cause strangeness and involuntary feelings in viewers, what can affect the acceptance of audience in games and movies. This paper aims to present concepts and discuss issues in this area.**

***Index Terms*—Computer Graphics, Comfort, Charisma, Perception, Emotion.**

I. Introduction

In recent years, advances in Computer Graphics (CG) have allowed the entertainment industry to create very realistic virtual humans [1] in terms of animation of their bodies and faces [2]. In some movies, real actors have been replaced by CG characters (such as Disney's 2016 Rogue One movie, 2019 Aladdin movie, and 2020 The Mandalorian series), and often this substitution is not even perceived by the public; however, there are still some perceived artifacts, such as the movement of the mouth and eyes [3]. In some cases, those artifacts or other distortions and images characteristics can cause strangeness and negative feelings in viewers, what can affect the acceptance of audience. Knowing how humans perceive and understand virtual characters can be important to help mitigate these oddities to generate a CG character more similar to a human being, making the experience of watching a movie, a game, or interacting with a character more fluid.

Perception comes from the Latin word with the same spelling that means "to apprehend" or "to understand". According to Zell et al. [4], the brain processes information from the senses and interprets its relevance to the organism. The first process of transforming information driven by the senses is called the ascending process. The second process is based on information acquired about the world through learning and provides a context for meaning information to be interpreted, known as the top-down process. Therefore, when looking at a person or a character, for example, a perception is created about what is being seen and represented by the face of the other.

The roboticist Masahiro Mori [5] conducted an analysis of the emotional reaction of humans when exposed to artificial beings. According to his theory, artificial beings (robots, CG characters, etc) with a high degree of realism next to real humans may fall into the Uncanny Valley (UV), causing a strange impression on the viewer. The UV theory analyzes human perception in an emotional context for artificial beings. According to Mori, artificial beings with a high level of realism (high similarity to humans) and without a common characteristic can cause strange sensations to those who watch them. This feeling is intensified when artificial beings give signs of life, as a movement, thereby changing the shape of the valley. Moreover, this feeling can also be caused by lack of familiarity with being artificial or other characteristics that can cause discomfort.

The perception area is essential for CG since many techniques developed in the past were based on knowledge of how the human visual system interprets visual stimuli [4]. Human perception is also a theme present in many pieces of research in CG [4], [6], and it is considered very relevant when discussing the evolution of virtual humans and realistic faces. According to Mori [5], robots made to appear too similar to real humans can fall into the UV, where sometimes a high degree of human realism evokes an eerie feeling in the viewer. According to Tinwell et al. [7], the technological advancements that help developing realistic characters is accompanied over the years by people's discernment about this content. With that, Tinwell and colleagues believed that the UV would never be surpassed since discernment can help people to observe the technical tricks better. The UV hypothesis on CG characters has become increasingly influential in scientific studies [8],

[9], but some questions are still unanswered.

II. Related Work

In this section we present some specific problems that have been discussed in literature with respect to perceptual analysis in CG characters.

Concerning the perception of CG characters, many papers have proposed various ways to evaluate humans perception. For example, the work of Zell et al. [4] was essential to understand the perception process (i.e., how to create a stimulus, how to measure and evaluate perceptual data, etc.). They analyzed two traits of appearance: shape and material, and with the help of artists, they designed stimuli consisting of different stylization levels for both parameters. They analyzed how different combinations affect the perceived realism, appeal, eeriness, and familiarity. Also, the authors investigated how such combinations affect the perceived intensity of different facial expressions, and concluded that the shape of a character is relevant to its realism and expression. Chaminade et al. [10] investigated how the appearance of animated characters can influence the perception of their actions. The authors presented different animated characters with movement data captured from human actors or by interpolation between poses and asked the participants to categorize movement as biological or artificial. The results showed that the more anthropomorphic, the less biological bias the character had.

The effect of the UV theory on human perceptions of 3D models also has been investigated by the CG community. MacDorman and Chattopadhyay [11] aimed to determine whether reducing realism in visual characteristics would increase the uncanny effect. The authors based themselves on the theory of inconsistency in realism, which states that an entity can cause the Valley without some characteristic of an anthropomorphic being. Schwind [12] conducted nine studies that examined the effects of UV on human perception, how it affects interaction with computer systems, what cognitive processes are involved, and the causes that may be responsible for the phenomenon. Hyde et al. [13] conducted two experiments showing how exaggerated facial movement influences the impressions of cartoons and more realistic characters, and stated that an essential factor in diminishing the sensation of strangeness is the attempt to replicate human expressions (body and facial) in CG characters. Ruhland et al. [14] used algorithms to synthesize real-time motion capture of human expressions with animation data created by designers. To validate synthesized animations, they conducted a perceptual study, and results indicated that the animations had an expressive similarity to animations made by hand.

Flach et al. [15] investigated the UV theory to evaluate its effects on the perception of CG characters used in movies, games, and computational simulations. The authors evaluated the human perceptions about these characters through a questionnaire containing images and videos of these characters. Araujo et al. [16] revisited Flach experiment, in 2021, with the same questionnaire tested in 2012, and also the same images and videos of CG characters, in addition to more recent ones. Some of Araujo's findings include: *i)* the perceived comfort increased over time when comparing the characters of 2012 and 2020. However, it did not change significantly for the perceived comfort of 2012 characters. It means that the perceived comfort of people in 2012 and 2020 remain very similar in relation to 2012 characters. In addition, they found a correlation between perceived charisma and familiarity about tested CG characters, and between charisma and comfort. Interestingly, more charisma was perceived in videos than in images, and unrealistic characters were also perceived as more charismatic.

Regarding the perceived charisma, MacDorman [17] has hypothesized that an uncanny robot can cause innate fear of death and create culturally supported defenses to deal with the inevitability of death. Concerning charisma, in one of the experiments, the author showed speeches by two politicians, one charismatic and one relationship-oriented, and asked participants which candidate they would vote. Participants who previously saw uncanny robots preferred more charismatic speeches than participants who previously saw a human being. Rosenthal-von der Pütten and Krämer [18] provided an overview and categorization of explanatory approaches to the UV effect. The authors presented images and videos of humanoid robots and uncanny androids to participants to explore their evaluations of robots, their attitudes about these robots, and their emotional reactions towards these robots. The results showed that the appearance of robots was important for participants since some characteristics matched specific skills. For example, participants described charisma as a human characteristic.

With regard to characters that can generate charisma, according to West and Armstrong [19], one of the ways to study the complexities of charisma is through fiction. Goethals and Allison [20] related charismatic characters to their appearances, citing as examples that Obi-Wan "Ben" Kenobi from Star Wars and Dumbledore from Harry Potter had archetypes of sages, which could increase the emotional impact on viewers. In terms of charismatic leadership, Awamleh and Gardner [21] reported the importance of vocal variety, eye contact, relaxed posture, and lively facial expressions. Riggio [22] already described charismatic individuals as animated, charged with emotion, and full of life.

Specifically concerning CG characters, Araujo et al. [23] recently presented a discussion about following questions: *i)* How does the comfort perceived by people of both tested genders (female and male) relate to the genders of the characters? and *ii)* Is the charisma influenced by the realism of the characters, considering the subjects and genders of the characters? Authors conducted perceptual studies on characters created using CG in images and videos through questionnaires. Their results indicated that the gender of the subjects and characters affected comfort, charisma and perceived realism. In addition, they also revisited the aspect of the UV theory (perception of comfort and human likeness), and found coherent curves compared to many works in the literature.

The Computer Graphics field is also involved in studies with

animated characters, concerning macro and micro expressions. Several authors have already developed methods that sought to imitate and respond to the emotions presented by humans ([24]). The research developed in this work is inspired by the work of Queiroz et al. [25] and based on three psychological studies that deal with the perceptions of micro expressions. The first study is proposed by Bornemann et al. [26], in which micro expressions are displayed briefly enough (between 10 and 20 milliseconds) to ensure that people do not consciously perceive them. In the second study, Shen et al. [27] applied two experiments based on two methodologies, BART (*Brief Affect Recognition Test*) and METT (*Microexpression Training Tool*), also based on Ekman's studies. The BART condition consists of showing the six universal expressions after a fixed point. In the METT paradigm, the universal expressions are displayed between two sequences of neutral faces. This study investigated a possible upper limit of time for the perception of micro expressions, concluding that from 160 milliseconds on, the accuracy of the participants' responses began to stabilize. The third and last study used as the basis for our research is the work of Li et al. [28].

III. Discussion

Based on the few examples presented in the last section, that discuss applications and studies on the referred domain, our goal in this section is to present some challenges, in our opinion, in the area.

Firstly, the assessment of human perceptual data is always a challenge. Opinions and feelings, as perceptual data, can respond to cultural, personality and even emotional state of subjects. So, propose ways to capture and validate such information is very important and certainly a challenge. Secondly, to create experiments where CG characters are controllable is relevant, as mentioned in literature [4], e.g. to change the shape, the movement, the light. However, on the other hand, such experiments do not approach the CG characters as normally presented in digital entertainment, e.g. in a game context, in a virtual environment, interacting with others and etc. It means that maybe the controlled researches present characters very different from how they are presented in real life. It is also a relevant challenge, i.e. how to test hypothesis using games and movies characters, where we can not control them?

Finally, a third and very important challenge concerns with the area of computational aesthetics. The study of aesthetics from a computational angle began with Birkhoff, in work published in 1929 [29] [30] and formalized in his book in 1933 [31]. His work aimed to propose a way to measure the aesthetic value of certain shapes and objects mathematically. According to Birkhoff, aesthetic quality is related to the amount of attention required when observing an object, defined by the complexity and the notion of order of the object, in this case represented by elements mainly related to symmetry and repetition. In 2005, Hoenig [32] created the definition of the discipline of computational aesthetics intending to motivate the continued development of the area. According to Hoenig (2005, p. 16): "Computational Aesthetics is the research of computational methods that can make applicable aesthetic decisions in a similar fashion as humans can". This definition is intended to emphasize two aspects: one is the use of computational methods and the other is the enhancement of applicability. One example of methodology recently proposed in this area is the work of Pinho et al. [33]. In this work, she investigates the relationship between images features and the discomfort that human beings can perceive (UV). The authors extract image features based on Hu Moments (Hum), Histogram Oriented Gradient (Hog), saliency detection, and finally, a model using Support Vector Machine (SVM) to provide binary classification is suggested. The results indicate accuracy of around 80% in the image estimation process comparing with the subjective classification. As a contribution, some areas may benefit from this study for avoiding the creation of characters that may cause strangeness, such as the games, conversational agents and cinema industry, avoiding to develop perceptual studies with subjects.

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