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Expressive Virtual Human: Impact of expressive wrinkles and pupillary size on emotion recognition

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ABSTRACT

Improving the expressiveness of virtual humans is essential for qualitative interactions and development of an emotional bond. It is certainly indicated for all applications using the user's cognitive processes, such as applications dedicated to training or health. Our study aims to contribute to the design of an expressive virtual human, by identifying and adapting visual factors promoting transcription of emotions. In this paper, we investigate the effect of expressive wrinkles and variation of pupil size. We propose to compare the recognition of basic emotions on a real human and on an expressive virtual human. The virtual human was subject to two different factors: expressive wrinkles and/or pupil size. Our results indicate that emotion recognition rates on the virtual agent are high. Moreover, expressive wrinkles affect emotion recognition. The effect of pupillary size is less significant. However, both are recommended to design an expressive virtual human.

CCS CONCEPTS

• **Human-Centered Computing → Human Computer Interaction (HCI)**.

KEYWORDS

Emotions, expressiveness, facial animation, dynamic wrinkles, pupil dilation, affective computing, virtual human

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1 INTRODUCTION

Designing an expressive virtual human requires understanding the representation of emotions in humans. Nonverbal communication and especially facial expressions provide essential information about the emotional state of the user. Researchers made recommendations about transcribing of emotions on a virtual human [16]. In expressive virtual human design, expressiveness and realism are essential. Expressiveness depends on the animations related to expressions and body movement transcription. A lack in animation usually results in what is called the Uncanny Valley [14]. The user and his experience are affected by the realism of the virtual agents and the emotions they convey [1]. Users may feel a form of attachment to these characters, depending in particular on their level of realism and their behavior. This paper presents the effect of expressive wrinkles and pupillary size to enhance the recognition of emotion on a virtual human. The purpose of this study is to contribute to the improvement of recommendations for the design of an expressive virtual human.

2 RELATED WORK

2.1 Recognition of emotions

In order to evaluate and compare the recognition of emotions between a photorealistic virtual human and a real human, multiple studies have been conducted on the representation of emotions, notably in static or dynamic rendering. Dynamic representation of expression on a virtual face increases accuracy during recognition and reduces confusion [10].

Dyck demonstrates a similarity in recognizing basic emotions of virtual and real human [3]. The recognition of negative emotion on a virtual agent was also studied [9]. The chosen emotions were fear, anger, disgust and pain. Disgust is confused with fear and anger. For all the other emotions, a positive correlation between expression stimuli and participant evaluation has been observed.

2.2 Expressive wrinkles for the expression of emotions

Before transcribing it to virtual humans, the functioning and usefulness of wrinkles on humans needs to be understood. There are two kinds of wrinkles. Static wrinkles are related to age. They don't

change according to movement or emotional state. Dynamics wrinkles, such as the expressive wrinkles, are a deformation of the skin due to the contraction of a muscle [11]. They can be related to emotional reactions.

The integration of expressive wrinkles on virtual humans is recommended as dynamic wrinkles increase realism [15]. Their representation, with wrinkle maps, is complicated because they appear and evolve according to emotional state. A wrinkle map is a texture including topography information related to expressive wrinkles and is applied to the mesh of the virtual face.

2.3 Variation of pupil size for the expression of emotions

The orientation of the gaze and the variation of the pupil diameter are expressiveness factors in humans. The pupil size of a human can vary from 1.5 to 9mm. It reacts to a change in brightness (to optimize vision) but also to cognitive processes [18]. The variation of pupil size has an important role for interactions between humans, for the perception of others and their emotional state [8]. The diameter of the pupils varies depending on the emotions. They contract for the emotion of disgust, anger and sadness [7, 8, 12]. In opposition, they dilate for joy, surprise and fear [8, 12]. Gaze: eye contact, blinking, dilation of the pupils are beneficial and necessary to design a virtual agent and must be taken into consideration [13].

3 EXPERIMENT SETUP AND DATA COLLECTION

We have 82 participants including 56 male and 26 female subjects (aged 20 to 52 years, M=28.23, SD=0.87). During the study, the user watches 24 videos, in which the six basic emotions are expressed in four conditions: real human R, virtual human V, virtual human without pupil size V-P, virtual human without expressive wrinkles V-W. The user chooses an emotion and indicates his certainty level, using a Likert scale (1=not sure, 5=very sure).

3.1 Designing of the expressive virtual human

To design the expressive virtual human, we bought a photogrammetry 3D scan of a face. We adapted it to be compatible with real-time constraints and we improved textures. For the transcription of emotions, we have designed part of the Action Unit on our character [5]. In order to set up and adapt pupil size depending on the emotion, we have created two blendshapes to dilate or contract them (Figure 1). To design the expressive wrinkles, we have recovered topography information from the 3D scans. Then, we have activated expressive wrinkles maps depending on the activated AU (Figure 2).

In order to evaluate emotions dynamically on the virtual human, we needed to opposite it to a real human. We have chosen the video library MMI (ID100) including videos of a woman expressing basic emotions [17, 19].

3.2 Hypothesis

H1: The expressive virtual human allows basic emotion recognition as effective as on a real human.
H2: Expressive wrinkles combined with pupil dilation promote the recognition of emotion on an expressive virtual human by the user.

Figure 1: Contraction and dilation of pupils

Figure 2: With or without expressive wrinkles

4 RESULTS

Following the experiment, a statistical analysis of the data was carried out.

4.1 Recognition of emotions on virtual and real humans

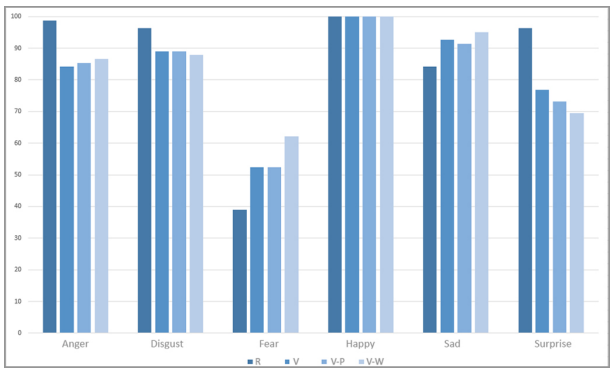

Figure 3: Summary of participants answers (in %) for the recognition of emotions on real and virtual humans.

The McNemar test was used to analyze the recognition of emotions by comparing two different conditions. There are two significant differences on the six emotions between the real human R and the virtual human V. These differences are anger (p=0.002) and surprise (p<.001), better results for R than V (See Figure 3).

4.2 Impact of the lack of pupil size variations and the lack of expressive wrinkles

To analyze the impact of the absence of pupil variations and expressive wrinkles on the recognition, we used McNemar test to compare

results between the different conditions of the virtual human. There is no significant difference between the virtual human V and the virtual human without pupil size V-P, and no difference between the virtual human V and the virtual human without expressive wrinkles V-W.

4.2.1 Impact of expressive wrinkles and pupillary size on emotion recognition between virtual and real humans. Although there are no difference between the virtual humans, and in order to obtain more details about differences in recognition, we compared with the real human R. There are significant differences for anger (p=0.003) and surprise (p<0.001) between the real human R and the virtual human who that does not dilate or contract its pupils according to emotions V-P (see Figure 3).

Finally, we have compared results between R and the virtual human who does not have expressive wrinkles V-W. There are significant differences for anger (p=0.002) and surprise (p<0.001), better results for R than V-W. Contrary to our ideas, participants recognize better fear (p=0.006) and sadness (p=0.049) on V-W than on R.

5 DISCUSSION

One of the aims of this study is to determine if recognition of basic emotions is as effective on an expressive virtual human as on a real human. Consistent with previous research [3], it appears that emotional facial expressions are valued at high rates by participants. This is certainly related to expressiveness and a high level of realism due to photogrammetry. Some negative emotions with low intensities can be confused especially when they have Action Units in common [9, 10]. Our study allows to see only the face, whereas emotions generally involve body reactions that could facilitate the perception of this emotion [4]. Moreover and in line with our results, Courgeon recommend a higher intensity to facilitate recognition of certain emotions [2].

5.1 Effect of the absence of pupillary variation

Our result concerning the impact of the absence of pupillary variation related to emotional state does not enable to identify a real consequence for recognition of emotions. We recommend its presence for realism, but further research is needed to confirm their impact on emotions recognition, including researches on intensity.

5.2 Effect of the absence of expressive wrinkles

Results show that the evaluation of some basic emotions is affected by the absence of expressive wrinkles. Furthermore, we analyzed the level of user's certainty during the recognition (using a Likert scale), partipants are more self-confident for the recognition of anger, disgust, joy and surprise on R than on V-W. To conclude, we observe a slight tendency to a lesser recognition of anger and surprise, and an inconvenience in the perception of joy and disgust in the absence of expressive wrinkles. Finally, fear and sadness are better recognized on the virtual human without expressive wrinkles. According to researchers, wrinkles can complicate the recognition of emotions on older real faces, such as our virtual human [6].

6 CONCLUSION

This study contributes to the exploration and understanding of emotion transcription in the aim to create emotionally realistic characters. It is complex to make general recommendations because each emotion has its own specificity, but it seems that presence of expressive wrinkles and pupillary size according to emotional state, have an effect on the evaluation of emotional facial expressions. The improvement of virtual human expressiveness, by mixing new techniques such as photogrammetry and respecting basic concepts such as the FACS, promotes more qualitative interactions and contributes to a more complete user experience, ideal for learning, inducing a feeling of presence and a better user's engagement.

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