Investigation of the Human-Robot Interaction in Affective Robotics Using HRI with apparent differences in VR/AR

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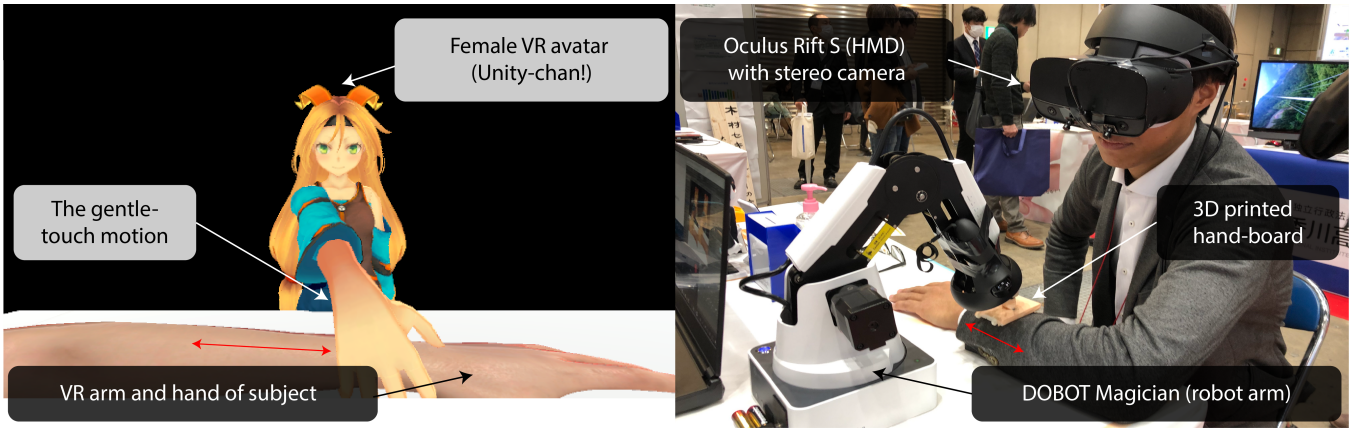

Figure 1: The gentle-touch from female VR avatar through HMD (right), and the actual gentle-touch from the robot arm (left).

ABSTRACT

This research focuses on the relationship between human comfort and the gentle touch from robots with an apparent difference with VR/AR avatar to realize multimodal interaction, and thus explore the importance of this interaction in the field of affective robotics, releasing anxieties and providing profound comfort to humans. 20 participants were used for this investigation after a gentle touch by a robot, firstly, to determine the apparent differences in the effect of a gentle-touch robot with VR/AR avatar and that of a non-avatar robot, and secondly, to determine the effect of gender difference with VR avatar on human comfort. The results show that gentle-touch robot of an opposite gender, and with VR/AR avatar, was more preferable and more comfortable than the robot itself and robotics of the same gender.

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CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**.

KEYWORDS

Gentle-touch robot, human comfort, apparent difference, VR/AR avatar, gender difference

1 INTRODUCTION

Humanitude is a philosophy of "what human care has to be" and "what applications are necessary for human-centered care", is focused on a variety of fields, especially in the nursing and medical fields [17]. Humanitude is therefore known as a multimodal interaction care method which includes perception, emotion, and linguistic that needs a practical application of seeing, touching, and speaking [7]. The touch-care which mainly focuses on touch motion to reduce stress and pain is a well known effective care method for relaxation. It also creates trust by the gentle-touch therapy to hands, arms, legs or back [1]. These kinds of care techniques

are effective in practical situations, but it is, however, difficult to provide such gentle-touch therapy to all patients due to a lack of human resources [12], and therefore in the quest to address this problem, the use of gentle-touch robots have been proposed by researchers, to automatically provide these services to humans to make them feel comfortable [8].

Conventional research on touch-care robots are mainly targeted at the movement of the gentle touch [9]. Tiffany et al [15], evaluated users' impression on humans been touched by a speaking robot. However, they only considered the impression of speech contents but not the prosodic information that is necessary for the perspective of human care. Therefore, our research team focuses more on the relationship between human comfort and gentle-touch with speech. Honda et al, investigated the relationship of the speed of the gentle-touch, and the speech rate, using a robot arm [13]. Results from the list of the questionnaire suggest a correlation between stroke pace and speech rate that provides enough comfort. Previous studies however focus only on touch and speech, but, however, in the perspective of multimodal interaction, visual is also important since humans have more than 90% of sensations perceived by human impressions [10]. Therefore it is necessary to investigate the human comfort relationship with the gentle-touch, speech, and visual information.

This study, therefore, focuses on the relationship between human comfort and gentle-touch robot with the apparent differences with VR/AR avatar. Investigations were made on how the apparent differences with VR/AR avatar of gentle-touch robot affected human comfort, and how gender difference with VR avatar also affected human comfort.

2 THE GENTLE-TOUCH ROBOT AND THE APPARENT DIFFERENCE WITH VR/AR AVATAR

In this section, the experiment to investigate the effect of apparent differences with VR/AR avatar of gentle-touch robot on human comfort was made.

2.1 The system configuration of the gentle-touch robot

Figure 1 on the right image shows the system configuration of a gentle-touch robot that was used in the experiment. A robot arm "DOBOT Magician [2]" with a 3D printed hand-board performs the gentle-touch movement [16], and The HMD "Oculus Rift S [5]" with a stereo camera "ELP 720P dual-lens was [4]" attached to perform VR/AR avatar with voice effect to subjects. ELP 720P dual-lens has a maximum resolution of 2560(H)X960(V) and 60 fps of frame rate. The Oculus Touch (Oculus Rift S controller) was attached on the top of the arm of DOBOT Magician to adjust with the hand of VR/AR avatar that will give the gentle-touch to the subject's arm. The laptop computer of "MSI (MSI Gaming Note GE65 Core i7 RTX2070 15.6 144hz FHD 16GB SSD512GB GE65-9SF-023JP) [11]" was used to control robot arm and motion of VR/AR avatar with voice effect that was created with Unity software [14].

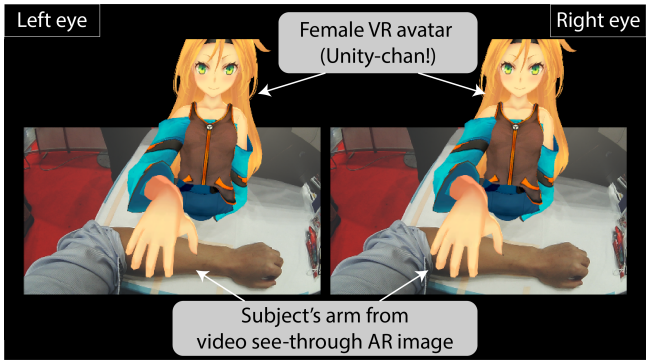

Figure 2: The video see-through AR image of the female avatar that gives the gentle-touch to the subject's real arm.

2.2 Experimental Environment of VR/AR avatar with the gentle-touch

In this experiment, the apparent differences with VR/AR avatar were investigated to determine its effect on human comfort. Two different comparisons were made, firstly, with VR avatar and non-avatar (robot arm itself), and AR avatar and non-avatar (robot arm itself). In the VR/AR avatar, 3D model data of Unity-chan! was used as the female character [6], and the voice of the avatar was generated with VoiceText [3].

Figure 1 on the left image shows the VR avatar's ability to give gentle touch to the subject in the VR environment, while figure 2 shows both right and left eye images inside HMD with AR avatar to give the gentle touch to the subject. In the case of a non-avatar, the video see-through images of the actual robot arm from the stereo camera that is attached with HMD was shown. The experimental procedure is such that the subjects were asked to sit on the chair and wear the HMD attached with a stereo camera, and were then asked to put their arm on the table for touch by a gentle-touch robot. The position of the arm and the gentle-touch robot to adjust the area the gentle touch, and finally, to start the gentle touch with VR/AR avatar and non-avatar to subjects, the subjects were asked to answer a list of questions below:

- Which is better, with the avatar or non-avatar (robot itself) or are both fine?
- On the scale of 1 - 7, 1 being not comfortable and 7, being very comfortable, how will you rate the gentle-touch with robot on the Likert-scale
- On the scale of 1 - 7, 1 being not comfortable and 7, being very comfortable, how will you rate the gentle-touch with the avatar robot on the Likert-scale
- If you have any additional comments or questions, please write your comments.

2.3 Result of apparent difference with VR/AR Avatar

The result of each 20 subjects in a total of 40 subjects (34 males and 6 females) with the age of around 20 to 60 years old were evaluated in each VR/AR experiment, and the most preferable and the level of

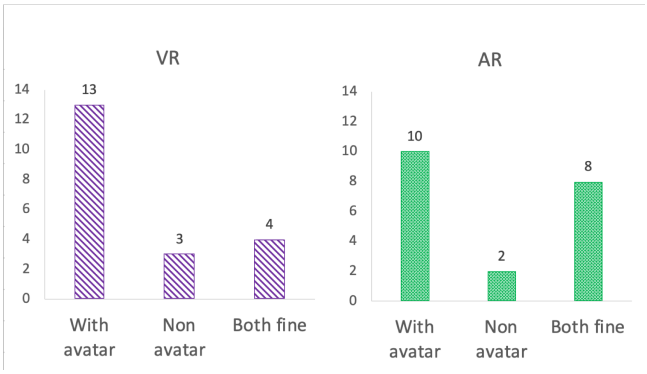

Figure 3: Result of preferable in VR avatar and AR avatar.

comfort by gentle-touch from the robot with the apparent difference with VR/AR avatar was compared.

Figure 3 shows the result of VR avatar and non-avatar on the left with the purple stripe texture graph, and the result of AR avatar and non-avatar on the right with the green texture graph. The horizontal axis show the list of preferable answer, if whether with the avatar, non-avatar, or both were fine, while the vertical axis shows the choices of the subjects out of who choose in a total of 20 subjects.

For the comparison in results, 13 subjects chose a VR avatar, 3 chose a non-avatar and 4 chose both. In the answer to determine the comfort, with the avatar had about 5.1 and the non-avatar had 4.4 on average. However, the result of the comparison between AR avatar and non-avatar, 10 subjects chose AR avatar, 2 subjects chose non-avatar, and 8 subjects chose both to be fine. Results for comfort, with the avatar was about 5.0 and non-avatar was about 4.1 on the average.

2.4 Discussion

Results for the comparison between VR avatar and non-avatar, and that between AR avatar and non-avatar, suggests that with the gentle touch from the robot, the VR/AR avatar was better than the non-avatar, and however the level of comfort with the avatar increased compared with non-avatar, even with the same robot arm. In the VR/AR avatar and non-avatar experiments, subjects said in the comments area that the VR/AR avatar with a face and human-like visual gave relief and seemed more friendly than non-avatar (robot itself). Subjects who chose that the non-avatar robot was better in the result said that VR avatar was less real since the face of the avatar was animation and her mouth did not move while speaking. Subjects who choose both were fine said that whichever the appearance was, it does not matter for a feeling of comfort since the robot arm was the same material. Reasons for subjects to have chosen that both of the robots were fine in the AR avatar experiment was as a result of the position alignment problem of AR avatar and the real robot arm, and quality of AR avatar cause less immersion.

3 THE GENTLE-TOUCH ROBOT WITH DIFFERENT GENDER WITH VR AVATAR

In this section, second experiment to investigate find how different gender appearance with VR avatar of gentle-touch robot effect on human comfort. Since the previous experiment of VR/AR avatar, quality and immersion of AR is less than VR. Therefore, in this gender difference experiment, we use VR avatar.

3.1 Experimental Environment of Different Gender with VR avatar while the gentle-touch

In this experiment, gender appearance with VR avatar was conducted to determine its effect on human comfort. Three different comparisons were made, which includes the same gender with VR avatar, opposite gender with VR avatar, and non-avatar. The male VR avatar "Yuji-Kun" [6] and for the female VR avatar "Unity-chan!" was used in this experiment. The voice of the avatars was generated with VoiceText for each male and female voice. In the non-avatar, the video see-through image of the robot arm from the stereo camera that is attached with HMD is shown. The system configuration of the gentle-touch robot is the same as subsection 2.1.

The experimental procedure as follows. Firstly, the subjects were asked to sit on the chair and wear the HMD with stereo-camera. Secondly, the subjects were asked to put their arm on the table for the gentle-touch from the robot, and thirdly, the position of the subjects' arm was calibrated and that of a the gentle-touch robot also, to fix the area or giving the gentle-touch. Fourthly, the gentle-touch with VR avatar was started randomly with both the same gender and opposite gender, and with a non-avatar, and lastly, the subjects were asked to answer a list of questions below:

- Rank which one is the best from the three; male VR avatar, female VR avatar, or non-avatar (robot)?
- Rank which one is the second most preferred from the three; male VR avatar, female VR avatar, or the non-avatar (robot)?
- Rank which one is the least of the three; male VR avatar, female VR avatar, and non-avatar (robot)?
- Any additional comments or questions.

3.2 Result of Different Gender with VR Avatar

The results of 16 subjects (10 males and 6 females) between the ages of 30 to 60 years old were evaluated for the same and opposite gender or the male and female with VR avatar and non-avatar.

Figure 4 shows the result of male subjects on the left with the blue stripe texture graph, and the result of female subjects on the right with the orange texture graph. The horizontal axis shows the list of preferable answers, with a male avatar, a female avatar, non-avatar, or the both choices being fine. The vertical axis shows the number of subjects.

The result from the questionnaire, showed that 10 out of 16 subjects preferred female VR avatar and that they were best for both male and female subjects. The male avatar was the next best choice after the female avatar, and the non-avatar was least in choice. Only 2 subjects answered anything was fine. The result of 10 male subjects in total, 7 subjects prefer female avatar, and 0 subject prefer male avatar, 1 subject prefer non-avatar (robot itself),

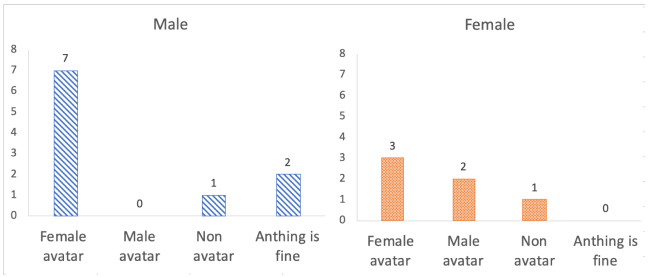

Figure 4: Comparison of same gender and opposite gender in male subjects (left) and female subjects (right).

and 2 subjects answered anything was fine. The result of 6 female subjects in total, 3 subjects prefer female avatar, and 2 subjects prefer male avatar, 1 subject prefer non-avatar (robot itself), and 0 subject answered anything was fine.

3.3 Discussion

From the result of gender apparent differences with VR avatar, both male and female subjects preferred female VR avatar than male VR avatar and non-avatar in the total.

In the gender differences, most of the male subjects who rated female avatar the best, said in their comment, that they were more comfortable and felt relaxed when female VR avatar gives the gentle-touch than male VR avatar and non-avatar.

For the 3 female subjects in a total of 6 subjects who rated female VR avatar as the best, they said in their comment that the female VR avatar had better quality than male VR avatar, and that the appearance of female VR avatar was cuter than others. For the 2 female subjects out of a total of 6 subjects who rated male VR avatar as the best, said in their comments that even if the male VR avatar was just giving touch motion, it was still comfortable and they felt relaxed since the avatar was of an opposite gender.

4 CONCLUSION

This research focuses on the relationship between human comfort and gentle-touch robot, with an apparent difference with VR/AR avatar. Firstly, the effect of the apparent difference with the VR/AR avatar gentle touches on human comfort was studied and how gender differences with VR avatar affected human comfort. About 20 participants in each experiment were investigated, who received the robot's gentle-touch, with an apparent difference with VR/AR avatar, and gender difference with VR avatar. The result suggests the gentle-touch robot with VR/AR avatar was more preferable and more comfortable than the robot itself, and opposite gender robots were more preferred in the gender difference between subject and avatar.

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