Gum-Gum Shooting: Inducing a Sense of Arm Elongation via Forearm Skin-stretch and the Change in the Center of Gravity

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Figure 1: (Left) Player wears the HMD (head-mounted display) and our arm stretch device during gameplay. (Middle) The gaming screenshot in the HMD. (Right) Arm stretch device attached to player's forearm.

ABSTRACT

Many people sometimes imagine if they can wield superhuman abilities like that appear in games and animation. Among these abilities, we focused particularly on representing the experience of arm stretching beyond the limits of the human body. We proposed a method for inducing a sense of arm stretching by designing the device attached to forearm and giving the user a visual cue by changing the body structure of the user's avatar in the virtual environment. Our device shifts the mass from the elbow to the wrist while stretching the skin of the forearm according to the animation in the virtual environment. The sensation of the elongation of the arm skin as well as the change in the weight of arm is thought to be the feeling when the arms are stretched out. As a result, we introduce these two mechanisms into our device, which allows the user to feel the sense of arm stretching.

CCS Concepts

• Human-centered computing → Virtual reality; Human-centered computing → Haptic devices

KEYWORDS

VR, Body ownership, Skin stretch

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1 INTRODUCTION

In some fictional works such as "ONE PIECE"[Oda 1997], there are characters who can stretch their arm out longer than its original length. Many people think that it is interesting to experience such characters' abilities. Instead of attacking distant objects or enemies, merely stretching out arms seems enjoyable enough. Therefore, we would like to reproduce the sensation of arm stretching in the work. Human body augmentation including arm elongation is a hot research field. Due to the popularization and the development of immersive VR and telepresence robots, people have become able to immerse in virtual avatars other than their own body from subjective viewpoints. When we immerse in a virtual avatar, we may have some sorts of functions out of that body. However, to make the VR experience more realistic, it is important to present body sensations that matches those functions. On the basis of this reason, we designed a haptic device that is able to represent the experience of arm stretching. With our device, users can feel a sense of ownership to the arm not only before and after the arms are stretched out but also can have such a feeling while the arms are in the stretching status.

2 RELATED WORKS

Body ownership is the sensation that one is in complete control of their body. In this research, it is necessary to extend the visual-only perception to a realistic and physical feeling. Below

are some of the previous researches that addressed the topic of the body ownership of the virtual arm which has a very different form from reality. Konstantina and colleagues showed that body ownership can be felt if the movement of the arm and the tactile sensation of the hand are linked with the HMD images and the virtual arm is under 3 times longer than that of the reality[Kilteni et al. 2012]. However, this research does not deal with body ownership when the shape of the virtual arm changes continuously. Sogabe et al. and Ishihara et al. showed that a sense of stretching of arms can be felt by linking HMD images with the feeling of extension of the muscles of the arms caused by hanging on the steel bars and pulling the poles[Sogabe et al. 2016] [Ishihara et al. 2016]. In these researches players were not able to move freely around because they use stationary equipment such as steel bars and poles. In addition, in the field of haptics, skin stretch may be used. Wheeler et al. showed that skin stretch can be a substitute for proprioceptive sensation[Wheeler et al. 2009]. Therefore, we considered that skin stretch would be effective to reproduce the sensation of arm stretching.

3 DESIGN

In this piece of VR work, the player manipulates an avatar whose arm extends when punching. In the following section, we will explain the method for carrying out this content.

3.1 Stimulation Given to the Arm

The stretch simulation device attached to the arm gives a stimulation that matches the elongation of the arm. In order to decide what kind of stimulus that should be given, we considered the situations that would occur when the arms were stretched. As a premise, in this research we decide to install the device on the forearm because it is easier to elongate the skin of the forearm than that of the upper arm. When the arm stretches according to this premise, it can be imagined that (1) the skin in the area between the elbow and the wrist stretches and (2) the center of gravity of the arm gradually moves away from the body. Therefore, we decided to give the stimuli to reproduce these two kinds of feelings.

3.2 Stretch Simulation Device

The stretch simulation device is attached to the arm as shown in Fig. 1 (Right). The operation of the device mainly depends on two motor rotations, which are controlled by PWM. The first one is a combination of a motor (Maxon 256101) with a diameter of 10 mm, 1.5 W, 6 V and a gearhead GGP 10 A 16: 1 (Maxon 218416), and a pulley with a diameter of 2 mm is attached to it. The second motor is the same as above, and a pulley with a diameter of 5 mm is attached to it. The objective of our device is to carry out the aforementioned two feelings, a mechanism for stretching the skin of the forearm and a mechanism for moving the center of gravity. Below we explain each mechanism.

3.2.1 Stretching the Skin of the Forearm

The role of this mechanism is to extend and restore the skin of the forearm in conjunction with the expansion and contraction of the arm of avatar. Grip tapes used for tennis racquets are wrapped at two places near the wrist and the elbow, and four link mechanisms made of ABS resin are sewn on both. When the first motor pulls threads passed through the four link mechanisms, they are pulled down and the forearm skin is stretched. When the motor loosens the thread, the link mechanism returns to its original shape and the skin of the forearm restores to its original state. Each tape is pressed with a force of 2.5 to 3.0 N.

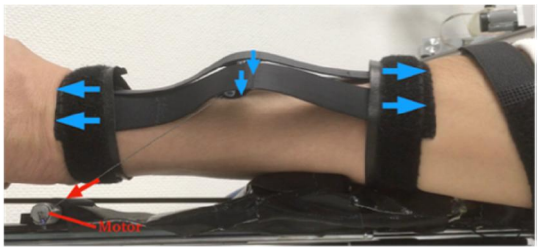

Figure 2: The mechanism for pulling the skin of forearm.

3.3.2 Moving the Center of Gravity of the Stretch Simulation Device

The role of this mechanism is to move the center of gravity of the arm by moving the weight of the arm stretch device in conjunction with the expansion and contraction of the arm of the avatar. There is a sliding rail with a weight of 200g under the forearm, and a rubber belt is attached to this weight. By moving this weight using a pulley and the second motor like a belt conveyor, the center of gravity of the device can then be shifted. While the arm of the avatar is stretched, the motor rotates to move the weight forward, and while the arm is contracting, the motor rotates in the opposite direction.

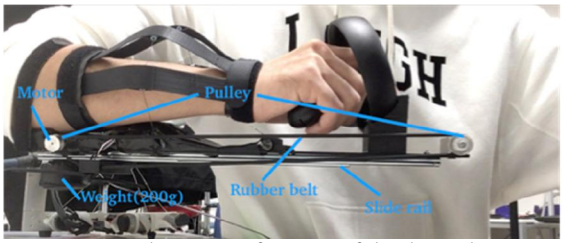

Figure 3: Moving the center of gravity of the device by rotating the motor.

4 CONCLUSIONS AND FUTURE WORKS

When we exhibited this VR work at IVRC2017, many visitors commented "I felt my arms being stretched out", so it seems that the device is able to give the player a sense of ownership of the virtual arm by elongating the users' arms. However, since evaluation is not carried out, it is necessary to conduct an evaluation experiment in the future to comparing user feedback with and without the device attached. Also, since there is a limit to the body ownership of a long arm after elongation[Kilteni et al. 2012], we would like to investigate the body ownership after the arm has elongated.

REFERENCES

Eiichiro Oda. 1997. ONE PIECE, Japan: Shueisha.

K. Kilteni, J-M. Normand, Maria V., Sanchez-Vives, M. Slater. 2012. Extending Body Space in Immersive Virtual Reality: A Very Long Arm Illusion. PLoS ONE 7(7): e40867. doi:10.1371/journal.pone.0040867.

Aiko Sogabe, Koyo Mori, Kenri Kodaka. 2016. Subjective Arm Extension based on Self-weight Measurement during an Action of Hanging from Bar. IPSJ Interaction 2016.

Yuki Ishihara, Koyo Mori, Yu Murota, Kenri Kodaka. 2017. Stretchar(m): Making Illusory Elastic Arm based on Correlation between Physical Action and Visual Body-image Presentation. Entertainment Computing 2017.

J. Wheeler, K. Bark, J. Savall & M. Cutkosky. 2009. "Investigation of Rotational Skin Stretch for Proprioceptive Feedback with Application to Myoelectric Systems", IEEE Transactions on Neural Systems & Rehabilitation Engineering.