F-3-5  A Study of Velvet Hand Illusion Using Psychophysical Experiment

Nader RAJAEI, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan.
Yuki KAWABE, Dai Nippon Printing Co., Japan
Masahiro OHKA, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan.
Testu MIYAOKA, Shizuoka Institute of Science and Technology, Japan.

In this paper we investigate several characteristics of one kind of tactile illusion, called Velvet Hand Illusion (VHI), that operates to tactile display for generating a relation between operator’s fingertip motion and tactile display pad in virtual reality field. In continue, we investigate VHI mechanism base on these characteristics and express mechanoreceptive units are active because of VHI using stable and moving frames equipped two wires. Experimental results show that the strongest intensity of VHI is occurred when the wire spacing almost equals to the movement stroke and that VHI is presented through by SA I and SA II.

Key Words :  Tactile Display, Virtual Reality, Tactile Illusion, Velvet Hand illusion, Psychophysics.

1. Introduction

Since the perceptual mechanism of illusions is closely related to issue encompassed within brain science, many scientists have researched "Tactile Illusions". One of the illusions useful in the study of virtual reality (VR) is the Velvet Hand Illusion (VHI).

In the VHI, which is a major theme in this paper, a person rubs his/her hands together on either side of wires strung through a frame in a grid pattern. The sensation of rubbing his/her hands generates a very smooth and soft surface like velvet.

We investigate the VHI mechanism to obtain insights into how a new improved tactile display might be designed because such tactile illusions play a great role in deceiving the brain so that operators believe that a virtual sensation is real. To elucidate the VHI mechanism, we propose to use psychophysical experiments to test human perceptual models. All of the results obtained in order to experiments, are based on Thurstone's Paired Comparison method.

2- Psychophysical Experiments

To examine VHI, we have produced several kind of wire mesh equipment with different mesh intervals. One of that is shown in Fig 2. The frame is made of acrylic board; two piano wires 0.8 mm in diameter are strung through the frame. Since VHI intensity seems to depend on tension of the wire, piano wore was strung with sufficient tension using a bolt and a nut.

In active touch test, the equipment is fixed on table and human subject bring together on opposite sides of the wires ad move their hands. In the passive touch test, the equipment is fixed on a motorize x-table and is moved with reciprocating motion, while the subjects do not move their hand as shown in Fig 3.

3- Experiment Procedure

To develop models of human perceptual mechanisms using the VHI, we investigated the relationship between wire spacing and the intensity of the illusion sensation using both active and passive touch for five different wire spacing 35, 40, 45, 50 and 55 mm.

In this study, we also investigated the conditions which cause the strongest VHI in order to elucidate the perceptual mechanisms. In a series of experiments, the stroke movement distance of wires, $r$ is varied under constant wire spacing $D$: the velocity of wire movement is varied with both wire spacing and stroke motion distance of the wires held constant. Furthermore, we investigated the velocity effect on VHI.

In this experiment, the velocity of wire during passive touch is changed while holding wire spacing and stroke distance constant. Since some characteristics of mechanoreceptive units depend on frequency, we can deduce which mechanoreceptive units are most active in under these conditions, which allow us to formulate a mathematical model for VHI.

\[ r \text{ is varied under constant wire spacing } D: \text{ the velocity of wire movement is varied with both wire spacing and stroke motion distance of the wires held constant. Furthermore, we investigated the velocity effect on VHI.} \]

![Fig. 1: Frame equipped with two wires for VHI experiment](image1)

![Fig. 2: Frame equipped with two wires for VHI experiment](image2)
4. Results and Discussion

We obtained that the strength of VHI depends on the distance between adjacent wires and also the intensity of VHI, caused by passive touch, was considerably stronger than that caused by active touch as shown in Fig. 3. This result suggests that the VHI can be controlled by manipulation of various aspects of the mechanical external stimulation using tactile displays.

In other hand the results of investigating relationship between wire stroke $r$ and wire spacing $D$ shown that a non-dimensional value $r/D$ was the strongest VHI when $r/D = 1.25$ as shown in Fig. 4. According to this finding some significant details of the VHI mechanism elucidated, so that VHI becomes weaker in both too small ($r/D << 1$) and too large strokes ($r/D >> 1$); the strongest VHI occurs when the stroke is almost equal to the spacing ($r/D = 1$) as shown in Fig. 5; although tangential stimulus is the trigger for VHI, excessive tangential stimulation prevents the occurrence of VHI.

In addition, changing velocity the strongest VHI occurred at a specific velocity, generating tangential vibration of 50Hz. Since this vibration activates SAII and compressive force is sensed by theoretical mechanism.

5. Conclusion

To reveal specification of an actuator for a tactile display enhanced VHI, we investigated the strongest VHI for several different conditions using psychophysical experiment with Thurstone’s Paired Comparison method. According to results have obtained, we determined the VHI mechanism when strongest intensity of VHI occurred which wire spacing and wire stroke was almost equal on maximum wire spacing in passive touch. The mechanism expresses although the area bounded by two wires moves relative to hands, tangential force does not occur on the other hand surface expect for the wire-spacing portion, causing operators to experience the illusion of touching a smooth virtual film with zero coefficients of friction.

Furthermore, VHI is not caused by only one of the four varieties mechanoreceptive units but more than two of them. This finding confirms that VHI does not occur in the mechanoreceptive units themselves but in the brain.

References