

Psychophysical Influence on Temperature Perception by Mixed-Reality Visual Stimulation

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ABSTRACT

In Mixed-Reality (MR) space, the visual appearance (shape, texture, etc.) of a real object can be changed by superimposing a virtual object on it. Therefore, by creating systematic differences between visual and haptic perceptions using MR technology, we can analyze their influence on temperature perception. In our research group, we defined the changes in the visual information of a real object in MR space as “MR visual stimulation” and examine the influence of the haptic sense using MR visual stimulation [1]. For our research, we focused on the temperature perception of the skin. In the first step, we verified the influence presenting MR visual stimulation has on the perceived position of the temperature perception. In the experiment, we presented MR visual stimulation and temperature stimulation in different positions. We confirmed the influence this difference has on the temperature perceived position. Our results demonstrate that temperature perception is strongly affected by visual stimulation.

Keywords: Temperature Perception, Mixed-Reality.

Index Terms: K.6.1 [Management of Computing and Information Systems]: Project and People Management—Life Cycle; K.7.m [The Computing Profession]: Miscellaneous—Ethics

1 INTRODUCTION

By using Mixed-Reality (MR) technology, virtual objects can be superimposed on the perceived tactile position in real time, and we can investigate the influence of interaction between visual and haptic perception. The MR visual stimulation can also influence perceived position of tactile sensation, for example, by superimposing virtual bees linked with pain stimulation, we can perceive bees stinging our arms [2]. In this study, we focused on the influence of MR visual stimulation on temperature perception. Temperature is perceived by receptors on the arm called warm and cold spots. The numbers of temperature receptors are less compared to other sensations, therefore temperature perception is less sensitive with regard to localization. However, it is known that by utilizing the interaction between visual and haptic perception, the perceived position of temperature can be sensed more accurately [3]. In addition, since the number of warm spots is fewer than cold spots, the perceived position of the warm spot is even less precise. Therefore, in this study, we confirm the influence of MR visual stimulation on the perceived position of warm and cold sensation.

2 OBJECTIVES AND PREPARATION

2.1 Objectives

This paper describes experimental result on the influence of visual stimulation position of temperature on the arm in MR environments.

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IEEE Virtual Reality Conference 2016
19–23 March, Greenville, SC, USA
978-1-5090-0836-0/16/\$31.00 ©2016 IEEE

2.2 Preparation

【EXPERIMENT ENVIRONMENT】

Figure 1 shows the configuration of the MR Platform system used for the experiment. In this experiment, a video see through-type Head Mounted Display (HM-A1, Canon Inc. Display resolution is 1280×1024 and running frame rate is 30fps.) was used. The position posture information for the head section of the test subject and the actual object were acquired using magnetic sensors. The sampling rate of the magnetic sensor is 120Hz.

【WARM AND COLD STIMULATION】

We present warm and cold stimulation by using a peltier (size: 20×20mm) temperature controller set (VPE20-5-20S, Ltd. VICS, Figure 2). Considering the stability of the temperature stimulation, we present the temperature stimulation in the inside of the forearm. The experiment was conducted in a room with a constant temperature of 25°C. We set the peltier controller to produce temperature stimulation six levels of temperature stimulation (cold stimulation: 11, 13, 15°C, warm stimulation: 40, 42, 44°C). We set the position of temperature stimulation in the center of the forearm. We also placed several dummy peltier temperature controllers. Although temperature stimulation can be felt as pain when the temperature reaches the limit value (cold stimulation: 10°C, warm stimulation: 45°C), these preset temperatures do not reach the limit value [4].

【MR VISUAL STIMULATION】

MR visual stimulation product simple rectangle. The size of rectangle is the length of 120mm, and the width of 20mm. This width of virtual object adjust size of the peltier (size: 20×20mm). This virtual object color is red (R: 255, G: 0, B: 0) in case of warm stimulation, and blue (R: 0, G: 0, B: 255) in case of cold stimulation. In the preliminary experiment, we confirmed temperature perception did not affect by object color. But, a subject is easily imaged temperature perception using warm and cold color. The position of MR visual stimulation is located the same temperature perceived position under the inside of forearm (Figure 3).

3 EXPERIMENT

For this experiment, we confirm the effect of temperature perceived position by MR visual stimulation when warm and cold stimulation is presented at one point on the forearm.

3.1 Procedure

The subjects put the right forearm on the temperature presenting device, and they record the temperature perceived position on white paper (Figure 4). There are six levels of temperature stimulation (cold stimulation: 11, 13, 15°C, warm stimulation: 40, 42, 44°C). For the visual stimulation, we changed the center of the rectangular virtual object to the center of the forearm, near the wrist, and near the elbow. Each position is set so that there are 27.5mm of interval between them. Additionally, in order not to

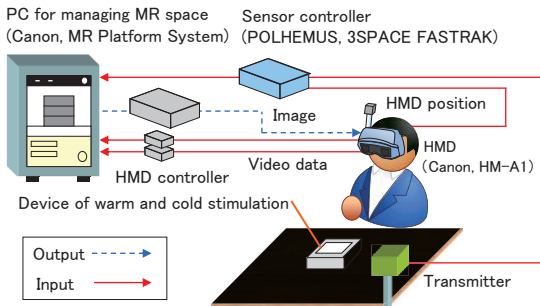


Figure 1: System configuration

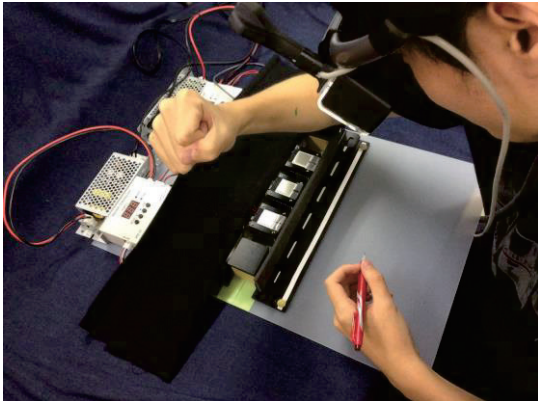


Figure 4: Environment of the experiment

judge only the visual stimulation, we present some dummy stimulation (visual only, presenting temperature stimulation on wrist and elbow side). There are a total of 18 possible combinations of temperature level and presentation position that can be used as presentation patterns, and these patterns are repeated three times. The number of the subjects are five males in their twenties. The Subjects have prior knowledge. The experiment procedures are as follows.

- 1) Measure the center position of the forearm
- 2) Select one combination from the presenting patterns, and set the temperature
- 3) Place the forearm on temperature presenting device, and at the same time, present MR visual stimulation
- 4) Subjects record the position of the perceived temperature perception on the white piece of paper
- 5) Change the white piece of paper used for recording data
- 6) Provide sufficient interval to eliminate the effect of temperature changes in the skin
- 7) Steps (2) to (6) are repeated for the remaining patterns

3.2 Results of the Experiment

The results are shown in Figure 5. The vertical axis indicates the position where the subjects perceived the temperature perception, and the horizontal axis indicates the position presenting MR visual stimulation. The results are as follows.

- i) We confirmed the warm and cold perceived position change when using MR visual stimulation
- ii) Warm and cold sensation is perceived on the same position as the MR visual stimulation
- iii) The influence of MR visual stimulation is not affected by the temperature

Temperature perception should be perceived on the center of forearm, same as conditions without MR visual stimulation. However, some subjects' temperature perceived position changed

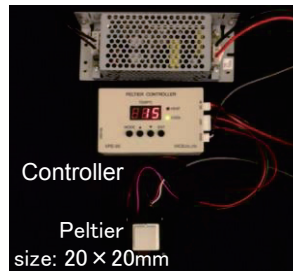


Figure 2: Peltier controller

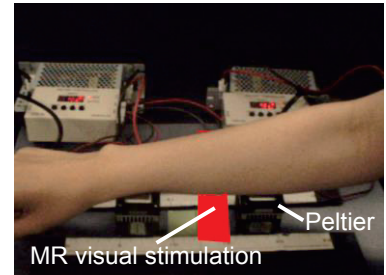


Figure 3: MR visual stimulation

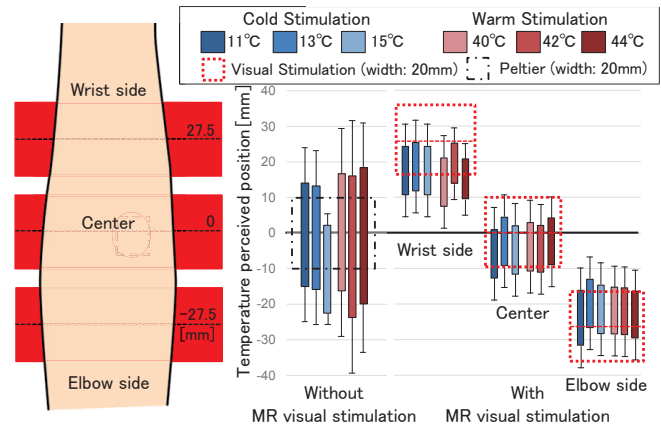


Figure 5: Result of experiment

when using MR visual stimulation. In addition, warm and cold sensation is perceived at the same position as the MR visual stimulation. We originally expected warm and cold sensation to be affected differently by visual stimulation. We confirmed that temperature perception is affected more by visual stimulation than we had expected.

4 CONCLUSION

In this study, we focused on one tactile sensation, the temperature perception. We confirmed the effect that presenting MR visual stimulation has on the perceived position of the warm and cold stimulation. In the experiment, we found that the warm and cold perceived position changes when using MR visual stimulation. We expected warm and cold sensation to be affected differently by visual stimulation, but temperature perception is strongly affected by visual stimulation.

ACKNOWLEDGMENT

We are grateful to H.Nakao, D.Nakashima for helpful experiment. This research is partly supported by Grant-in-Aid for Young Scientists (B) No. 26730109.

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