Novel Tactile Contour Presentation: Embossed Touch Display

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1 Introduction

One way in which we explore the external world is through our sense of touch. The fingertips contain sensitive tactile sensors, and when the fingers touch an object and are moved across its surface, the information sequentially presented to the fingertips is integrated into the total shape of the object. This perceptual integration is based on the important assumption that an object is static during exploratory hand movements. However, if the object moves during the hand movement, the assumption leads to an illusory perception of the object's shape. As shown in Fig 1(a), when the object moves in the same direction as the hand movement, the object is perceived to elongate, since the width is basically judged from the initial and final positions of the moving edges. On the other hand, when the object moves in the opposite direction as in Fig. 1(b), its width is perceived to shrink. Our discovery of this phenomenon led us to develop a novel tactile display called the Embossed Touch Display that can provide any given width of an object by moving the object according to the hand movement.

The Embossed Touch Display features advanced object control performed in accordance with measured hand movements. We implemented the display with a laser distance sensor and a liner slider. The sensor measures the distance between it and the finger, and liner slider is controlled in accordance to the distance. Using this display, we can present realistically rigid edges. We can also present continuous surfaces, which is difficult for prior tactile devices.

2 Design Theory

We investigated the parameter for presenting any given width using this device. The relationship between perceived width and object's velocity is described in Fig. 2. The perceived width and the object's velocity are represented by the ratio to the real width and the finger velocity, respectively. The dashed line is the expected value obtained by $Y = 1/(1 - X)$. Where X and Y are the ratio of object's velocity and perceived width. For example, when the object moves in the same direction as the finger at the half velocity of the finger, say $X = 0.5$, the perceived width would be double ($Y = 2$). On the other hand, the width of the object would be perceived to half ($Y = 0.5$) when the object moves in the opposite direction at the same velocity, $X = -1$.

The results of three subjects are plotted in the vicinity of the expected value (dashed line). This indicates that when the object is moved during active touch movements, the object's width can be perceived as equal to the distance of the finger movement. Therefore we can display any given width by controlling the velocity of the object.

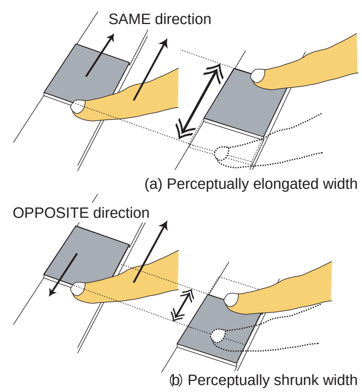

Figure 1: Conceptual figure of display principle.

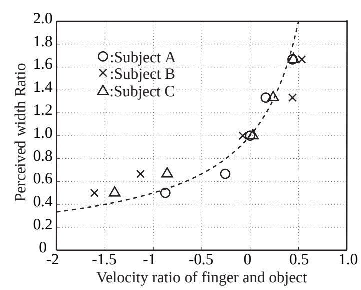

Figure 2: Velocity ratio and perceived width.

3 Conclusion

We have proposed a method where the tactile shape is presented by moving an object according active touch by the finger. In addition, we examined the relation of the object velocity and the perceived object width by experiment. From the results, we confirmed that width is perceived with an almost complete correspondence to the amount of finger movement. It is possible that this method presents shape while the object is traced directly by the finger. We believe that arbitrary two-dimensional shape can be presented using a linear stage of two dimensions.

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