Chapter 16
Length Perceptual Characteristics on Raised-Dot Slippages

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ABSTRACT
If line-shape information was physically presented by virtue of some kind of mechanical interface, man-machine communication would be enhanced in the sense of multi-modal interactions. In order for such interactions to be available with ease, they should be realized as simple, small, and cheap devices even though suffering from a bit of performance decrease. Thus, the authors have studied a mouse-like computer-human mechanical interface. The idea is that slippage stimuli on a fingerpad would be effective enough to provide users a piece of motion information, and that the mechanism for slippage can be embodied in mouse interfaces. Here, to enhance the slippage perceptual performance, raised-dots were considered to be useful, and thus, a series of psychophysical experiments were carried out by using raised-dot planes with the period of 1.5, 3.1, 12.5, 30, and 50 mm, together with a without-dot flat plane. It was confirmed that the perceptual lengths were well formulated by a power law: they were proportional to the power of both speed and length. The exponential constants with the length factor were a little less than 1 corresponding to the ideal linear relationship. While the ones with the speed factor were in negative, nearly 0 corresponding to the ideal undisturbed relationship. Then, it was found that the pathway length perceptual accuracies for the raised-dot planes were much superior to that for the flat plane from the viewpoint of (1) length-related perceptual length contractions, (2) speed-induced perceptual length contractions, and (3) perceptual length random errors. This is shown in this chapter.

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INTRODUCTION

Cutaneous sensation on finger pad is one of essential functions in hand-contact-based haptic sense to perceive objects’ physical properties such as shapes and surface roughness. Introducing raised-dot, the authors have studied some sliding length perceptual characteristics on fingerpad in the passive touch framework: the raised-dot pathway was expected to be effective for presenting physical line segments, which can be applied to computer-human interfaces.

Thus, the raised dots are expected to contribute for a new physical-line presenting computer-human interface. Paying notice to the sliding-raised dots with a specific period of interval lengths, the authors have studied cutaneous sensation characteristics on fingerpads in the passive touch scheme (Nomura, Yoshihiko et al. 2013). In the paper, subjects were informed that they should perceive dot slippage based on either a dot-counting scheme with long dot periods or a speed-based scheme in short periods. Although the dot-counting scheme showed better linearity than the other speed-perceptual scheme, that suffers a sampling error because the countable dot numbers were confined to natural numbers. To avoid the sampling errors in the dot-counting scheme for the long dot periods, the latter speed-based scheme was expected to be an alternative to the dot-counting scheme even for the long dot periods as well as the short dot periods.

Thus, in this paper, the authors focused their attention on the speed-based sliding length perceptual scheme not only in a short period but also in a long period.

There have been some studies on mouse type tactile interfaces. Akamatsu and MacKenzie (1996) might first present a tactile-slip displaying mouse-interface: the mouse had a function of presenting 2D slip, the amount of which was limited within a small length. Kyung, Choi, Kwon, and Son (2004) proposed a multi-functional mouse: it reflected 1 DOF grabbing force as well as 2 DOF translation force, and pin array tactile patterns. Kuchenbecker, Provancher, Niemeyer, and Cutkosky (2004) also proposed a haptic device that integrates contact location feedback with grounded point-force display where a roller type of slip display was combined with a haptic device, PHANTOM. Minamizawa, Pratichizzo, and Tachi (2010) also presented a similar concept of a haptic device that integrates kinesthetic feedback to the arm and tactile feedback to the finger. Tsagarakis, Horne, and Caldwell (2005) proposed a genius slip/stretch feedback device that used a V configuration of frustum cones: the device provided sensations of lateral motion (direction and velocity) in arbitrary directions onto the user’s fingertips in the form of producing a vector sum. It was reported that subjects were able to discriminate angle changes of 15 degrees with the correct answer rate of about 70%. Webstar, Todd, Lawton, and Allison (2005) proposed another genius 2 degree of freedom (DOF) tactile device: it reproduced the sensations of sliding contact through the rotation of a ball positioned on the user’s fingertip. In their device, values relating to just noticeable differences (JNDs) with directions were given as 20–25°. Gleeso, Horschel, and Provancher (2010) proposed another fingertip-mounted tactile interface: it reflected a tangential skin displacement feedback.

Here, note that existing mouse-applied slip displays have employed non-bumpy and smooth surfaces. Therefore, the introduction of raised dots allows us to carry out some feasibility studies. Based on the findings described in this paper, the authors develop raised-dot-based mouse interfaces as described in the final section.

BACKGROUND

The cutaneous sensation-based perceptual characteristics have been studied from various viewpoints. For example, slip length perceptual characteristics of moving flat surface were studied as