Measurement of Horizontal Local Skin Strain on Grooved Texture

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***Abstract*— It is important to clarify the relationship between skin deformation and tactile sensation while tracing a real object. This facilitates the presentation of high-quality tactile sensation in tactile displays. For this purpose, we aimed to record the spatial skin strain while passively tracing a one-dimensional groove surface, with 0.6, 1.0, 2.0, 4.0mm wavelength (λ). We found that the skin strain was spatially generated at a similar wavelength as the texture.**

I. Introduction

Method of texture rendering is necessary to reproduce a photorealistic tactile sensation. Most tactile displays reproduce the skin deformation when an object is touched. Therefore, the spatiotemporal skin deformation on texture is essential. We recently developed a device for measuring spatiotemporal skin deformation on finer textured surfaces [1]. This device enables an optical observation of the skin through the texture by measuring the skin deformation in oil on finely textured acrylic surfaces. In this study, we aimed to observe the skin tangential strain while tracing in one direction over the one-dimensional groove.

II. Experiment

In this experiment, skin local strain in the tangential direction were measured when tracing on a one-dimensional texture with different four pitch widths: 0.6, 1.0, 2.0, 4.0 mm (λ). During the measurement, the texture was submerged in oil to cancel the optical interference caused by the texture [1]. The camera, linear actuator, and sensors were synchronously driven to capture pictures of the fingertip and record the data. The texture moved at a constant speed of 30 mm/s over 20 mm. Participants adjusted the pressing force to 300 gf while checking the visually displayed pressing force. For analysis, skin strain was calculated primarily based on the method by Delhaye et al [2].

Figure 1. left side depicts an example of the frame-to-frame strain change in the X-axis on four different textures, and right sides show the spatial variation of the strain change at 0.50s after the start of tracing and the average strain in the Y-axis (finger short axis), respectively. The spatial strain changes at 0.50 s and 0.52 s are shown to illustrate the temporal change. When the skin traced a rectangular texture with a wavelength of 0.6-4.0 mm, the strain change in the X-axis occurred in the form of stripes, almost identical to the texture wavelength. In addition, the waveform did not change with time, while the phase shifts with time. In addition, the movement of the waveform between 0.50 s and 0.52 s was roughly 0.6 mm, coincides with the movement speed of the plate (30 mm/s).

This spatial variation resembles that of skin deformation associated with static push [3]. In addition, neurological studies have reported the spatial neural coding by coarse textures [4], and our results support it in terms of the skin strain. It is notable that this spatial pattern is observable even with 0.6mm and 1.0mm textures, which are smaller than the two-point discrimination threshold on the fingertip. It seems that spatial skin displacement is necessary to reproducing uneven surfaces of 0.6 mm or more on a tactile display.

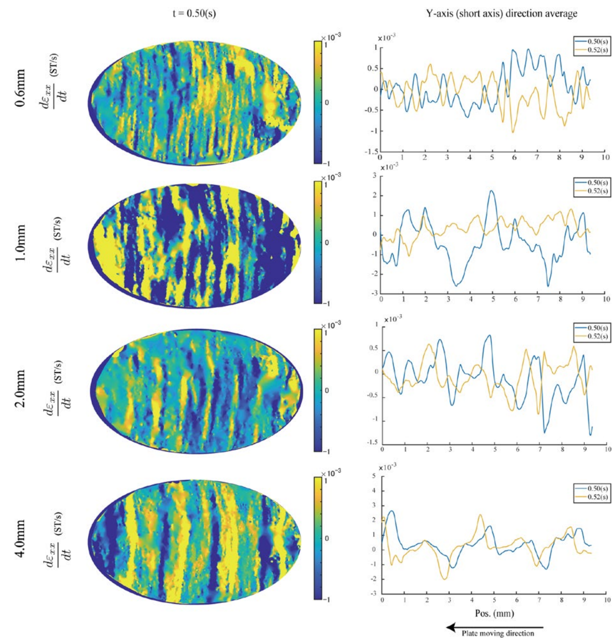

Figure 1. The frame-to-frame difference of the skin strain change of the participant H.A. The results for each texture wavelength are shown from the top to the bottom. (Left) A heat map of the strain change (0.50 s after the start of tracing) while tracing four different textures. (Right) Results of the average strain change along the Y-axis. The time difference between the graphs is 0.02 s. The plate moves in the direction of its origin.

*Research supported by JSPS KAKENHI Grant Number JP15H05923 and JP20J23128.

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