Characteristics of a Tactile Rendering Algorithm

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Abstract

During active exploration of a virtual surface, a tactile renderer specifies drive signals for a 24-channel tactile display on the fingertip. Characteristics of these drive signals indicates that the renderer offers a wide range of touch sensations to the user, providing a basis for discrimination of different surfaces.

1. Introduction

The skin is populated by four types of touch receptors that can be divided into two groups: Pacinian receptors, which respond mainly to higher frequencies (100–400 Hz), and non-Pacinian receptors which provide sensitivity at lower frequencies. In this study a 24-contactor tactile display is used to produce spatiotemporal patterns of virtual touch sensation on the fingertip by stimulating these two groups of receptors in the fingertip.

Two of the authors were previously involved in the EU-funded HAPTEX project [1] in which a virtual touch system was developed to create the sensation of exploring the surface of a textile. The present study involves hardware and software based on that from the HAPTEX project, but with a number of improvements and modifications. The emphasis here is on the characteristics of the tactile-rendering algorithm – work which was beyond the scope of the HAPTEX project.

2. Hardware and Software

The present study involves hardware and software based on that from the HAPTEX project, but with a number of improvements and modifications. The tactile display is an array of 24 contactors covering 1 cm^2 on the fingertip (figure 1) which are driven by piezoelectric bimorphs that convert the signals from the drive electronics to mechanical movement of the contactors. The display moves with the user's finger during active exploration of a virtual surface with a graphics tablet providing the position and velocity information of the user's finger.

The renderer software runs in real time on a standard PC, calculating the data to specify the 24 drive signals for the display. The drive signal to each contactor in the display is a combination of a 40 Hz sine wave and a 320 Hz sine wave, addressing the non-Pacinian and Pacinian touch receptors, respectively. The amplitudes of these sine waves, A_{40} and A_{320}, are calculated separately for each contactor every 25 ms, based on local Fourier transforms of the surface profile, at the location of the contactor on the textile surface, as well as information on the position and velocity of the tactile display and band-pass filter functions H_{40} and H_{320}, centred on 40 Hz and 320 Hz, based on tactile detection thresholds [2].

3. Characteristics

Information on surface texture is provided to the user as time-varying patterns of A_{40} and A_{320}, distributed over the 24 contactors of the tactile display (left panel, figure 1). The center and right panels in figure 1 indicate that the renderer offers a wide range of texture information to the user, providing a basis for discrimination of different textiles.

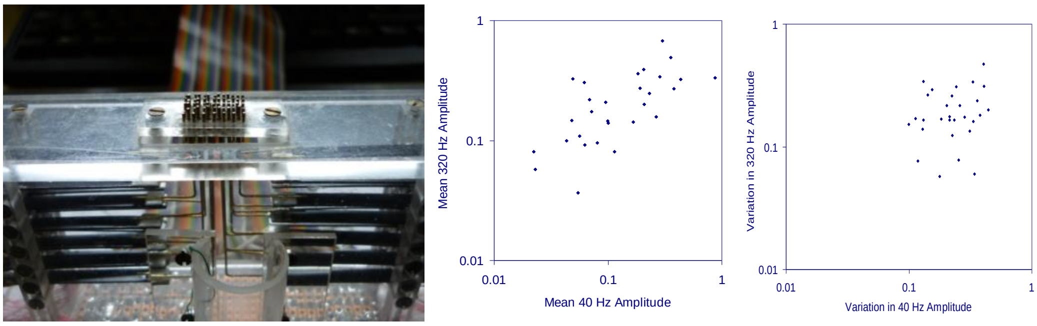

Figure 1: The tactile display (left panel), with 24 contactors each driven by a piezoelectric element, with the mean values (center panel) and coefficient of variation (right panel) of A_{40} and A_{320} during exploration of the textile surface at 10 cm s^{-1}, for 29 different textiles.

4. Conclusions and Future Work

By generating signals that stimulate the two groups of touch receptors in the skin, this virtual touch system attempts to recreate the tactile sensation of exploring a surface. The renderer can provide a wide range of touch sensations to the user. In future, a comparison will be made between the virtual sensation and the real sensation of exploring the textile surface, to test the fidelity of the system. This system was used in January of 2011 at the National Museum of Scotland to recreate the sensation of exploring the surface of an artefact.

References

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