Texture Simulation with One Degree of Freedom Normal to the Surface using a Loudspeaker

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ABSTRACT

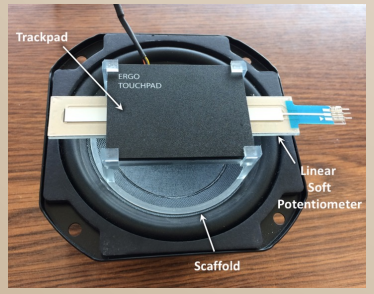
To advance haptic research and technology and enhance consumer immersion, the authors are developing an affordable Texture Simulation Device (TSD) to simulate 2D texture of a surface. This is done by actuating with a single degree of freedom (DOF) normal to the surface in response to motion tangential to the surface. The TSD will potentially have uses in virtual reality applications such as textile marketing, and basic psychophysics research.

TEXTURE SENSATION

- The sensation of texture is partially sensed by vibration- sensitive receptors within the dermis.
- The vibrations come from interactions between the epidermis and small asperities on the textured surface.
- Friction is another highly important component of texture perception.
- The device proposed here is partly based on a previous speaker-based haptic device that simulates tissue forces for surgery[Khera 2016].

QUESTIONS BEING EXPLORED

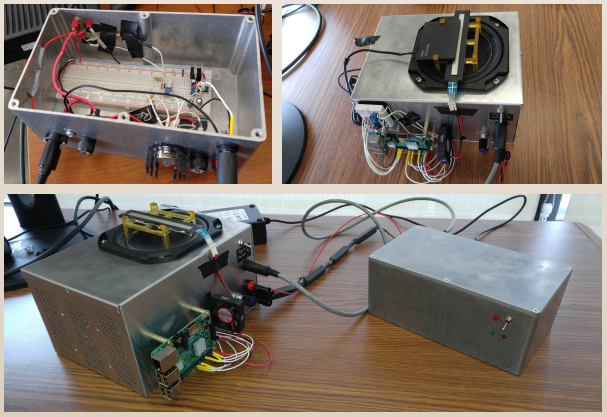
- Can a textured surface be simulated with one degree of freedom?
- Will 1-DOF be enough to fool the human brain?



Early texture simulation device prototype consisting of the speaker, scaffold, and position sensors.

THE DEVICE

- Actors:
  - 5” loudspeaker
  - Raspberry Pi 3
- Sensors:
  - Linear soft potentiometer (SpectraSymbol): Both force and 1D position
  - Computer trackpad (ERGO Touchpad): 2D position
  - Optical distance sensor (Vishay TCRT500L): Height of speaker cone.
- Infrastructure:
  - 3D printed support structure
  - 8-bit SPI DAC (MCP4801)
  - 12-bit I2C ADC (ADS1015)
  - External 555 oscillator



- In clockwise order from top left:
  - Amplifier box, top view.
  - Texture simulator, top view.
  - Texture simulator and custom amplifier.

RESULTS

Several unforeseen challenges presented themselves during this project. The greatest challenge arises from trying to use an active surface to simulate a passive surface. When the user actively explores the device’s surface, often times a “riding” sensation rather than a texture is felt. These sensations are functions of frequency and amplitude, but not all stimuli that could be created with this device can be considered textures.

In-house testing of several standard waveforms have yielded some interesting results. When a sawtooth wave is created on the surface, users can distinguish the direction of the wave crests and report that going against the peaks of the wave feels easier. This result is very significant because it demonstrates the quality and resolution of the generated textures, as well as the TSD’s ability to create textural features that are detectable by humans. When testing user discrimination of three basic waveforms, sinusoid, square, and sawtooth, it was determined that all three can be perceived as distinct textures. For example, the sawtooth wave has been reported to feel like a zipper.

DESCRIPTION OF SENSATIONS PRODUCED FROM SURFACE AND EXPLORATION TYPES

		Surface	
		Active	***Passive***
Exploration Type	***Active***	Riding	Texture
	Passive	Vibration	Shape Discrimination

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