Using Electroactive Polymers to Simulate Light Touch and Vibration in a Virtual Reality Environment

Abstract—Virtual reality simulators seek to immerse users in realistic interactive environments. However, at present, while several provide kinesthetic feedback, most lack tactile feedback. Current means of tactile feedback do not generate enough force to the digits, deliver a non-intuitive sense of feedback and are too large or heavy to be used in hand-worn configurations. The tactile feedback system developed herein uses electroactive polymers to create light touch and vibratory sensation to the fingertips, and DC motors to constrict the distal digit. In essence, when current is passed through the electroactive polymer in the shape of a cantilever (7 mm long by 19 mm wide), it bends on its long axis, providing a forces of 25 mN. Vibratory feedback is created by varying input voltage with a sinusoidal waveform. To generate fingertip constriction, two DC motors cinch a wire attached to a rubber thimble. These hardware components are controlled by a computer running X3D software, an ISO standard for representing 3D graphics, which affords a virtual environment for the tracking of one’s hand. Upon contact with a virtual object, the actuators generate prescribed forces or vibrations. With this setup, a series of human-subjects experiments will be conducted whereby the task is to contact and differentiate virtual spheres of differing stiffness. Experiment 1 will test the electroactive polymers to determine the threshold for recognizing light touch, Experiment 2 will test vibrational discrimination, and Experiment 3 will test the ability of the user to differentiate constriction forces.

Fig. 1. Electroactive Polymer Actuator shown as cantilever

Fig. 2. DC Constriction Motor mounted to the glove prototype.

Fig. 3. Map of the data communication in the virtual reality system, which shows the loop involving delivery of tactile feedback to the hand. A collision event in the virtual environment initiates the generation of the appropriate feedback (i.e., magnitude of light touch or frequency) which is delivered as feedback to the hand.
**Hand tracking and visualization in a virtual reality simulation**

Abstract- Tracking a user's hand for 3D rendering and visualization creates a sense of presence in virtual reality environments. At present, tracking devices built for both research and consumer use are increasingly accessible, with ever improving spatiotemporal accuracy. This work seeks to contribute a new design which offers an ability to track the fingers and palm. The hand tracking method described herein ties absolute tracking of the user's palm with relative tracking of individual fingers. A virtually rendered image of the movements of the user's hand is displayed in near real-time to a virtual environment developed with the X3D ISO standard for representing 3D graphics. The tracking system was verified using experiments designed to confirm the accuracy and usability of the device. Experiment 1 tested the absolute positioning capability by tracking the subject's palm. Experiment 2 tested the relative positioning capability by tracking the subject's fingers. The results of the experiments indicate that the tracking component of the virtual reality system is able to accurately detect subjects' interaction with objects in the virtual environment.

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**Fig. 4.** Tracking mechanisms on the hand (flock of birds absolute tracking of fingers, bend sensors relative tracking of fingers) are connected to movements of the virtual hand.

**Fig. 5.** Map of the data communication in the virtual reality system, which shows the loop involving tracking of the hand. A user's hand movement is tracked by absolute (flock of birds) and relative (bend sensors, one per finger) sensors. Data is processed and converted before being displayed to the screen to the user.