FingerSight™
Fingertip Control and Haptic Sensing of the Visual Environment

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1 Introduction Many devices that transfer input from the visual environment to another sense have been developed. The primary assistive technologies in current use are white canes, guide dogs, and GPS-based technologies. All of these facilitate safe travel in a wide variety of environments, but none of them are useful for straightening a picture frame on the wall or finding a cup of coffee on a counter-top. Tactile display screens and direct nerve stimulation are two existing camera-based technologies that seek to replace the more general capabilities of vision. Notably, these methods preserve a predetermined map between the image captured by a camera and a spatially fixed grid of sensory stimulators. Other technologies use fixed cameras and tracking devices to record and interpret movements and gestures. These, however, operate in a limited space and focus on the subject, rather than the subject's interrogation of his environment. With regard to haptic feedback devices for the hand, most existing devices aim to simulate tactile exploration of virtual objects.

FingerSight™ is the underlying concept for a visual sensing device with haptic feedback that allows users to both actively interrogate and sense the real 3D environment, and to manipulate specific aspects of the environment by gesture. FingerSight™ implementations are not necessarily limited to a specific, predetermined environment. The original goal of FingerSight™ was to aid the visually impaired. Visual sensing combined with haptic feedback allows users to receive additional information about their surroundings without interfering with auditory cues. The introduction of control into FingerSight™ has expanded the potential target population to the general public, who could make use of it as an intuitive and possibly enjoyable new form of remote control. The current model, shown in Figure 1, utilizes a small finger-mounted video camera to track graphical controls on a computer screen and provides vibrotactile feedback via small vibrators mounted on both sides of the finger.

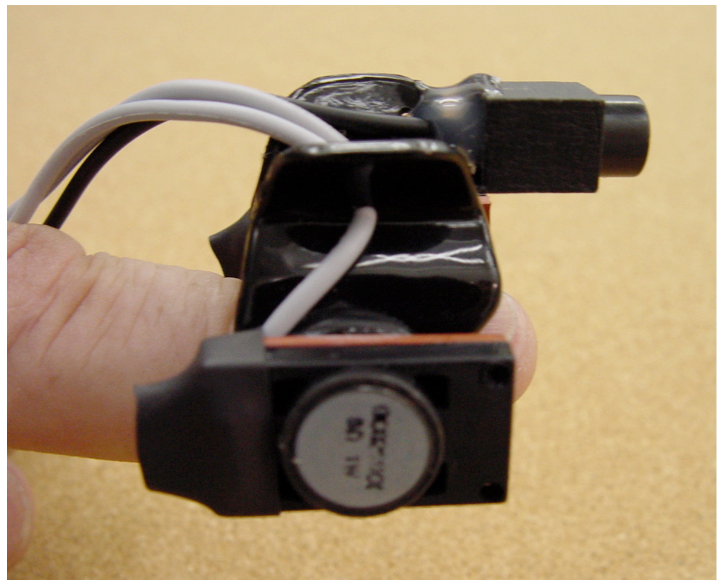

Figure 1. FingerSight™ experimental prototype showing camera and vibrators mounted on index finger.

2 Exposition With FingerSight™ each finger can individually sense and analyze visual information. Finger, wrist, and arm motions replace eye and head movements, controlling the field of view. The camera is mounted to the top (dorsal) side of the finger to avoid interference with the normal operation of the hand. The camera image is analyzed in real-time to identify features such as edges, or entire objects. Computer vision allows for flexible and ever more sophisticated identification. Detection of an object is relayed to the finger through a haptic feedback device mounted behind the camera when key objects have been identified. The feedback allows the user to associate the visual object with the particular finger that "sees" it. In addition to visual sensing, FingerSight™ allows users to remotely control targets with finger motions and hand gestures. This could empower the low-vision population to interact with the distal environment. Sighted users could manipulate objects beyond their reach, enabling them, e.g., to safely interact with remote targets in sterile or hazardous environments, and educators and gamers could use the technology in training simulations and virtual reality systems. Real controls might include a light switch or doorknob (provided a separate control channel is available), and virtual controls can be directly displayed and manipulated on a computer screen. In the presented demo, movement sensed by the camera in relation to virtual controls is used to adjust them. Haptic feedback may inform the user which control they have "locked onto" and the setting thereof. The user can rotate knobs and move sliders, which could be implemented to control arbitrary parameters, such as volume and song selection.

3 Conclusion We are just beginning to realize FingerSight's™ potential as a vision substitution and remote manipulation device. As opposed to previous visual-tactile methods, FingerSight™ does not depend upon a fixed spatial map between the image and the sensory stimulators. Rather, each individual finger explores what amounts to its own receptive field in the visual environment. We are working to incorporate multiple cameras into our implementation of FingerSight™ to allow for "stereo" depth perception, more intricate control pattern recognition, and enhanced navigational cues. We are also working to incorporate more general pattern recognition and increase the information content of the haptic feedback. Psychophysical studies are being designed to understand this new linkage between vision and touch.