Fingertip Digitizer: Applying Haptics and Biomechanics to Tactile Input Technology

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1 Introduction

Direct finger touch interface in most human-computer interface require smart panels, such as touch screens or pressure pads. With these interfaces, however, a user's tactile activity is limited to few modalities, such as pressing or dragging. Many common tactile activities used in real life such as rubbing, palpating, scratching etc cannot be captured by such devices.

We present the Fingertip Digitizer, a novel fingertip-mounted haptic sensory digitizer. This device captures physical phenomena at the fingertip during dynamic tactile activities. Complex biomechanical characteristics at the finger, such as viscoelastic tissue behavior and joint impedance, are modeled for the applications of delicate tactile activities, such as art, medicine, and industry.

2 Implementation

Novelty: To sense tactile activities of a dynamically moving fingertip, there should be a different paradigm from conventional way of modeling that is often used in passive touch paradigm. The modeling aspect of dynamic fingertip characteristic may be called 'Active Touch' paradigm. In this research, we propose a sensory-enhanced virtual environment where both man and machine perfectly share the haptic stimuli using the active touch paradigm. Therefore, in this environment, user's work performance is enhanced by the machine's digital power that runs in parallel with the human's instinctive exploratory tactile activities [Lederman, Klatzky, and Pawluk, 1992]. For accurate sensing, our system compensates complex biomechanical behaviors of the fingertip, since they interfere and affect the response signal [Fung, 1993; Hajian and Howe, 1997].

Innovation: Our active touch fingertip digitizer interface can replace traditional probe-based stylus. Since the tactile/haptic stimuli at the fingertip are shared by human and computer, a doctor can perform exploratory task - for example, palpation of human body to identify a tumor. Also, our system does not need any electric touch screens. Since the sensing mechanism is focused on the motion and response of active movement of fingertip, any patterned finger motion, or a contact based touch responses are the valid input for a human-computer system.

Demonstration: Our system is demonstrated through a 2D and a 3D application. The 2D application is called 'Touch Painter' with 'Touch Canvas' (Fig.1). In this environment, a participant can draw or paint by direct finger touch and movement. The system, however, does not use any electric screens behind the contact surface. Instead, contact position, force, and acceleration at the fingertip are the important input measures. For instance, splashing of paint on the canvas surface can be simulated by a simple jerky finger movement.

The 3D application is called 'Tactile Tracer' (Fig 2), an object digitizing system. In this system, a user experiences the benefit of sharing haptic stimuli with the instantaneous display. By extending the digitizer's role to perform as a probe, it can also be used to capture object properties, such as surface and sub-surface geometry, roughness, and even material property [Kim and Kesavadas, 2006].

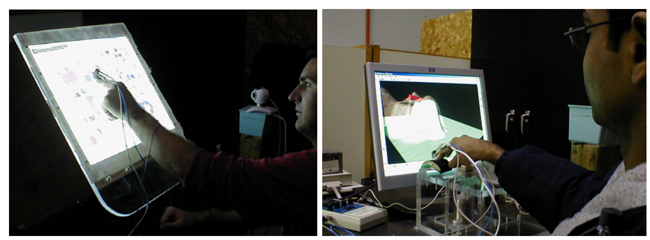

Figure 1. Touch Painter (left) and Tactile Tracer (right).

3 Conclusion

There is tremendous potential for active human finger activities. Our free-hand touch technology, that does not require smart screen with electric touch sensors, will has the potential of improving or changing the conventional input paradigm in many manual tasks that require skill, such as in art, medicine, and industrial design. For a specific example, this system could lead to the development of a new 3D reverse engineering system that can be used to model digital shapes from objects – both hard and soft.

Reference

FUNG, Y. C. 1993. Biomechanics: Mechanical properties of living tissues. New York: Springer-Verlag.

HAJIAN, A. Z., AND HOWE, R. D. 1997. Identification of the mechanical impedance at the human finger tip. ASME Journal of Biomechanical Engineering, 119(1), 109-114.

KIM, Y. -S. AND KESAVADAS, T. 2006. Material property recognition by active tapping for fingertip digitizing. Presented at Haptics Symposium 2006: Haptic Interfaces for Virtual Environment and Teleoperator Systems, 133-139. Alexandria, VA.

LEDERMAN, S. J., KLATZKY, R. L., AND PAWLUK, D. T. 1992. Lessons from the study of biological touch for robotic haptic sensing. In H. R. Nicholls (Ed.), Advanced tactile sensing for robotics. New Jersey: World Scientific.

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