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Guest Editorial

Special Issue on Haptics, Tactile and Multimodal Interfaces

Haptics as a science has matured to provide a viable interface for engineering applications. The haptic interface has been widely adopted as a teaching and training tool. Force feedback technology has been used as an interface for training in advanced skills such as surgery, calligraphy, assembly tasks and medical palpation. Haptics has also found applications in rehabilitation of upper limbs affected by stroke. In the field of medicine, many surgical procedures have been simulated using haptic interfaces. Closely engineered systems have been developed to simulate specific surgical procedures, including endovascular therapy, laparoscopy, catheter insertions and robot assisted surgery.

To realize these varied applications, haptic hardware and simulation systems, which closely mimic real procedures, have been developed. On the computational side, researchers have explored faster ways of calculating forces when virtual tools interact with soft tissues. A number of studies have been conducted using these force feedback enabled virtual surgical systems, establishing the benefits and importance of haptic technology.

Another interesting area of research in haptics has been in capturing force parameters involved in skilled tasks. Force profiles have been captured to study various human motor skills involved in tasks ranging from writing, calligraphy, and surgery to operating mechanical devices and handling historic documents and artifacts. Such data collection and subsequent modeling approaches provide researchers with challenging applications requiring more precise haptics models that provide a new insight into motor skill tasks. Such models can lead to improved haptic systems in the future.

Force feedback technology has also successfully made the jump from research labs to the commercial domain. Numerous commercially available products for gaming, cell phones and touch interfaces devices have integrated some form of force feedback technology to provide users with a new modality of interaction and information exchange.

As a large part of haptic science and research is grounded in mechanical engineering concepts, we issued a call for papers to address the latest advancements in this area. This call resulted in an overwhelming response from researchers around the world. To accommodate the large number of quality papers, JCISE has devoted two issues to the cover topics of interest in *Haptics, Tactile and Multimodal Interfaces*. In this second special issue, we have included five full research papers and four technical notes in a wide range of topics related to haptics and tactile systems.

Several of the manuscripts in this issue address the use of haptic or tactile cues for performance enhancement in domains such as driving and piloting unmanned vehicles, or teaching handwriting. Abbink and Mulder describe a technique for providing guidance forces on a steering wheel via force and stiffness feedback of varying magnitude. They show that the inclusion of haptic feedback improves performance, and the degree of improvement depends on the gain of the guidance controller. Troy et al. describe a system that uses haptic interfaces as a steering component to control Unmanned Aerial Vehicles. They developed algorithms to provide position and orientation control of the vehicle, giving visual and haptic feedback to the pilot through a virtual environment. They report that providing haptic feedback led to quicker response and control, allowing more intuitive and realistic teleoperation of systems. Srimathveeravalli et al. developed a Shared Control algorithm based on a concept called Haptic Attributes. This control algorithm was integrated as an assistance technique in a virtual reality training application for handwriting. In an experiment simulating rehabilitation of handwriting in people with poor fine motor control, they reported that the Shared Control algorithm provided better performance for metrics studied as compared to the more traditional Virtual Fixtures assistance technique.

Three manuscripts describe techniques for extending the utility of haptic devices. Goncharenko et al. described a technique for the capture of skillful human movements when controlling a nonholonomic system. They present a dynamic model of a task of rolling a hemisphere on a surface, along with a solver required for real-time rendering of the system. Using the commercially available Phantom haptic device, they explore the performance of three methods for calculating the haptic force. Their simulation and approach will enable the study of nontrivial motion strategies for manipulation of nonholonomic systems with rolling constraints. In another paper, Amemiya and Maeda aim to improve the human's perception of directional forces conveyed via ungrounded haptic devices. They describe a device with a slider-crank mechanism that produces asymmetric oscillations that are perceived as directed forces. Their paper explains the prototype design and experiments, and presents the optimized weight ratio for the device to the reciprocating mass and the desired rate of oscillation for preferred perception of the directed forces. Finally, Martin et al. studied the possibility of substituting the roll degree of freedom (DOF) of wrist movement with what they have termed pseudo haptic feedback. They used dominance of vision in sensory systems to develop visuo-tactile cues that lead to generation of a kinesthetic illusion of a full 3 DOF of torque feedback. Results report that this system was successfully integrated and tested as a 6 DOF large workspace haptic device.

The remaining manuscripts describe techniques to improve the performance of haptic devices by exploring the influence of damping, delay, and sampling rate on the stability of haptic rendering. Gil et al. focus on the influence of damping and delay via theoretical, analytical and experimental techniques using a custom haptic device that is assumed to exhibit linear behavior. O'Malley et al. discuss the importance of sampling frequency on the maximum achievable virtual surface stiffness in a haptic simulation of a rigid surface. The paper presents a technique to enable faster loop rates through the use of a real time operating system and field programmable gate arrays for data acquisition and computation, thereby offloading operations from PC and allowing the display of more rigid surfaces while maintaining passive interactions between the user and the device.

As a final note, we would like to thank our peers who helped us during the review process. With out their timely feedback this special issue would not have been possible.

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Guest Editors