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# Guest Editorial

## Special Issue on Haptics, Tactile, and Multimodal Interfaces

Virtual Reality emerged as a new frontier of engineering during the 1990s. The development of the Cave Automatic Virtual Environment (CAVE) and large display systems changed the landscape of many areas of product development, including design of products, visualization of assemblies, and simulation of manufacturing systems and factories. Early applications of such virtual reality systems utilized 3D visualization using stereoscopy and user input devices such as the data glove and wand for interaction. However, it was realized very early during the development of such systems that a key ability lacking in such interactive systems was the lack of sensation of touch—an area that has come to be known as haptics.

While haptics as a science has been investigated and researched from the days of telerobotic systems, it emerged as a new paradigm for interacting with human computer systems only since the mid-1990s. The advent of commercially available haptic devices in 1995, such as the PHANToM™, brought forth an easy to integrate hardware-software system. As a result, haptics became a readily available form of interface for numerous applications. Over the past ten years, haptics and tactile systems have entered the mainstream of commercial products in the form of force feedback gaming interfaces and touch sensitive telephones and mobile devices.

Today, 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 laboratories to the commercial domain. Numerous commercially available products for gaming, cell phones, and touch interface 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 overwhelming response from researchers around the world. To accommodate the large number of quality papers, JCISE will devote the next two issues to cover topics of interest in *Haptics, Tactile, and Multimodal Interfaces*.

In the first special issue, we have included eight full research papers and three technical notes in a wide range of topics related to haptics and tactile systems.

The use of haptics for CAD, product assembly analysis, and product development is emerging as an important area of research and is the focus of five papers in this special issue. Zhu et al. presented an infrastructure for enhancing CAD experience using haptic interfaces. Two papers have addressed the use of haptics in product assembly. Bordegoni and Cugini demonstrated the applicability of haptics in the design of aesthetic products. Seth et al. presented a novel two handed haptic system for assembly evaluation, while a second paper on this topic, Christiansson et al. studied the effects of haptic cues, using a low frequency and a high frequency domain, during tele-operated assembly tasks. Vlachos and Papadopoulo presented a new telemanipulation environment for controlling a 2DOF microrobot driven by centripetal force, using a 5DOF force feedback mechanism.

The application of haptics for manufacturing is the focus of two papers in this special issue. One of the papers related to manufacturing presented by Wei et al. attempts to provide a solution to the issue of calibration using surface tracking for remote welding applications. Improvement of a five-axis finishing processes using haptics is the topic of research in a technical note authored by Tang et al.

Finally, four papers are devoted to the development of haptic interface hardware and tactile feedback systems that directly stimulate the skin. Guan et al. presented a methodology for registration using multiplanar structures for augmented applications. Two papers are focused on the development of exoskeletal haptic interface devices for human machine interface applications. Fesharakifard et al. presented a unique string-based haptic interface that provides 7DOFs of force reflection to the hand for grasping objects in a virtual environment. Sone et al. explored the feasibility of using internal forces calculated from EMG signals in an upper-extremity exoskeleton. The final paper in this issue characterizes the use of tactors in a vibrotactile device. Jones and Held defined the spacing requirements for tactors that may be used to

locate events in a larger environment.

As a final note, we would like to thank our peers who helped us during the review process. Without their timely feedback, this special issue would not have been possible.

The second issue in the series will be published in March of 2009.

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