Research Status of Haptics in Korea

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1. Introduction

This article presents a brief overview on the status of the haptic research that has been carried out in Korea. Consistent with the interdisciplinary nature of haptics, haptics research ongoing in Korea ranges from fundamental haptic science to cutting-edge haptic technology, along with strong industrial efforts for commercialization. The majority of researchers have a background in mechanical engineering, in particular, robotics, or in computer science, especially graphics or human-computer interaction. In the rest of this article, the highlights of Korean haptics research are given in the three categories of research institutions: universities, government-funded laboratories, and industry.

2. Haptics Research in Korean Universities

Similar to most countries where universities are still a key player in haptics research, renowned researchers in several universities have led haptics research in Korea. One of the most influential and active group is one directed by Dong-Soo Kwon at KAIST (robot.kaist.ac.kr). Beginning from haptics technology for teleoperation in the 1990s, this group has developed state-of-the-art haptic technology in various domains, including tactile pin-array displays, thermal displays, thermal-combined pin arrays, as well as miniature tactile actuators for mobile phones. Recently, they developed a tiny tactile actuator that can endow the display function of elastic and electromagnetic force to mobile devices (Fig. 1) [17].

At the same institution, Jung Kim manages the

Biorobotics laboratory that develops tools for improving training effects and performance in minimally invasive surgery and medical instrumentation (medev.kaist.ac.kr). They integrate information technologies and intelligent machines to medical environments, especially surgical operating rooms. Their research outcomes have been accumulated in a virtual reality-based surgical simulator for training surgeons in computer-generated environments [4].

In computer science at KAIST, Jinah Park directs Computer Graphics and Visualization Laboratory (cgv.kaist.ac.kr), where the research focus is on a dental simulator with haptic feedback for comprehensive dental implant surgery training (Fig. 2). This haptic dental stimulator is enabled by a real-time collision model in which the tooth is represented as a volume model with a distance field to represent its plastic deformation [7]. It can cover prevalent dental diseases, including impacted wisdom teeth, dental caries, and calculus.

Moreover, two young researchers, Jee-Hwan Ryu and Sang-Youn Kim, at the Korea University of Technology and Education have produced impressive research output. Jee-Hwan Ryu conducts haptics and robotics research in BioRobotics Laboratory (robot.kut.ac.kr) with approximately 20 students. A principal interest
of this group is in human-robot haptic interfaces, especially the design of haptic interfaces, improving the quality of haptic feedback, and dealing with the effects of delayed network transmissions to enhance the realism of virtual and teleoperated environments. In particular, the time-domain passivity control proposed by Jee-Hwan Ryu [1] has been used in a number of applications worldwide, including space telepresence based on the time-domain passivity control (Fig. 3).

Sang-Youn Kim runs Interaction Laboratory (iLab.kut.ac.kr), whose research topics include haptic rendering for volumetric deformable objects using the S-chain model, miniature tactile actuators, vibrotactile rendering for mobile devices, and microprocessor-based embedded haptic controllers for tactile displays. They recently developed a driver IC for mobile phones that supports vibrotactile rendering of tactile flows using multiple actuators [8].

In GIST, a sibling university of KAIST, Jeha Ryu has been leading another major haptics group over the past 15 years (dyconlab.gist.ac.kr). Their research spectrum is very broad, from mechanical haptic interface design to haptic rendering software. Notable recent results include: 1) energy-bounding algorithm for passive and stable haptic interaction [6]; 2) accurate and efficient hybrid CPU/GPU-based haptic rendering algorithm [5]; and 3) tactile movie watching system with a dedicated authoring tool [9] (Fig. 4).

Dongjun Lee recently founded Interactive & Networked Robotics Laboratory (inrol.smu.ac.kr) at Seoul National University. This group strives to lay theoretical foundations for passivity-based haptic rendering and control for a single or network-connected multiple haptic devices. Some representative results include: 1) extension of the well-known Colgate’s passivity condition to variable-rate virtual coupling [12]; 2) passive set-position modulation [13], which not only ensures passivity in the presence of variable-rate, varying-delay, packet-loss, etc., but also optimizes haptic performance by selective passifying actions; and 3) peer-to-peer distributed passive control framework for multiuser haptic interaction over the Internet [14].

The author’s research group, Haptics and Virtual Reality Laboratory (hvr.postech.ac.kr) at Pohang University of Science and Technology (POSTECH), has also been active in haptics research. Research topics cover various aspects of haptics, including kinesthetic rendering of hardness and texture, tactile rendering, sensorimotor skill modeling and transfer, haptic augmented reality, mobile haptic interface, data haptization, and applied perception. The outcomes of these studies have been applied to mobile devices, automobiles, virtual
prototyping, and motion-based remote controllers. The most noble recent results are the introduction of haptic disturbance to motor skill learning[15], the establishment of the notion of haptic augmented reality [2], and the associated stiffness modulation algorithms[3]. In addition, Fig. 5 shows a recently-developed visual-haptic simulator of the refrigerator front door for the virtual prototyping of door opening/closing haptic sensations[16].

3. Haptic Research in Korean National Laboratories

Among the many government-funded research laboratories in Korea, KIST (Korean Institute of Science and Technology) and ETRI (Electronics and Telecommunication Research Institute) have produced visible research results for haptics. At KIST, Laehyun Kim has been leading a medical simulation group with emphasis on the use of haptic feedback. Their laparoscopic surgery simulation system provides efficient and safe training to medical students and novice surgeons. With the in-house key technologies including 3D geometrical modeling of human organs, real-time deformable body modeling, collision detection, high-fidelity haptic rendering, and haptic interface hardware, this group focuses on the simulation of gallbladder removal surgery using laparoscopic instruments (Fig. 6). They also developed the dental simulation system that supports various dental procedures, such as dental probing, diagnosis of carious lesions, drilling operation for cavity preparation, and filling cavities with amalgam, as well as a needle insertion simulator providing realistic haptic and visual feedback for intravenous injection simulation.

At ETRI, the research team of Junsuk Park and Ki-Uk Kyung has developed noble tactile displays since 2006. Their work for Ubi-Pen resulted in a series of stylus-type haptic interfaces for interaction with a touch screen[10]. Its type I can generate vibration, impact, texture, and sound in a stand-alone platform with a wireless communication function. The type II, while sacrificing the texture display module, is a miniaturized version for usability. They also proposed a new interaction scheme on the Windows GUI with tactile feedback using the Ubi-Pen. At present, this group is leading a large government project, called the TAXEL (Tactile Pixel) project, that aims at developing a self-morphing visuo-haptic display for mobile devices (Fig. 7) [11].

4. Haptic Research in Industry

The Korean industry has been keen on commercializing haptics products, especially in mobile phones and automobiles. For example, Samsung Electronics has released a number of Haptic Phones since 2008. Hyundai Motor Company recently began to install a haptic seat...
5. Conclusions

In this short article, the status of haptics research being conducted in Korea are briefly summarized, with a hope to facilitate locating prominent Korean haptics researchers for the possible communication and collaboration between Japan and Korea. In 2013, the Korea Haptics Community (www.haptics.or.kr) will host the IEEE World Haptics Conference (the 5th joint Eurohaptics Conference and IEEE Haptics Symposium) in Daejeon, Korea (General Chair: Dong-Soo Kwon). This can be an excellent opportunity to experience the tangible outputs of the active haptics research in Korea.

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References


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