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Abstract
Interaction on the surface usually limited in mechanical movement and does not have surface texture, which results in a lack of haptic feedback. Various techniques have been introduced to supplement this limitation. The main objective of this tutorial is to let the ISS community experience those technologies in hand. By its nature, the haptic interface is hardly explainable with a document, video, and audio. We provide a unique opportunity for the ISS community to feel and experience the wide range of haptic techniques on the surface. In specific, the tutorial will cover the following topics. 1) haptic feedback on a small mobile device 2) Texture rendering on a larger surface 3) An illusion of compliance on a rigid device 4) Pin-array display for information transfer.

Author Keywords
Hatpic, tactile, flat surface, feedback

CCS Concepts
•**Human-centered computing** → **Human computer interaction (HCI);** *Haptic devices;*

Introduction
This tutorial aims to introduce the state-of-the-art haptic technologies available for the flat surface. Interaction on Surface and Space is limited on haptic feedback, due to

lack of mechanical movement and texture.

With the recent growth in the popularity of touch screens, there has been rapid growth in the body of research in haptic feedback technologies for touch screen interaction. A number of techniques have been proposed. In this tutorial, we provide a short lecture and demonstration on each topic listed below. The objective of this tutorial is delivering the gist of the concurrent surface haptic technologies and providing hands-on experience to participants.

Part 1: Mobile-device haptics

Leading haptic feedback technologies for flat-surface mobile devices are twofold: devices that include internal haptic actuators and control external haptic actuators for haptic feedback. The first approach using an internal actuator have used a small-sized vibrotactile actuator, such as an eccentric rotating mass (ERM) or a linear resonance actuator (LRA). Secondly, employing an external actuating system has been studied to provide fertile haptic information while overcoming the spatial limit, such as wearable haptic modules in forms of rings, wristbands, jackets, and armbands.

Gunhyuk Park introduces his two kinds of research on mobile Haptics using an internal ERM actuator and external wearable actuators. The first research is about a plausible vibrotactile feedback library, PhysVib, that autonomously generates vibrations using physical collision information in a mobile device. PhysVib enables more realistic vibrotactile feedback than the other methods as to perceived similarity to the visual events. The second research is about providing spatial information using a 2D illusory tactile sensation on a touchscreen mobile device. A phantom sensation refers to a single illusory sensation perceived in the middle of multiple vibrotactile stimulating points on the skin. In this research, 2D stationary phantom sensation is designed to be provided on 1) a continuous skin of a human hand grasping a phone attaching four vibration actuators and 2) a void space between two hands wearing haptic ring modules on an index finger and a ring finger.

Part 2: Gradient-based surface haptics

This part focuses on haptic rendering of 3D geometry on a 2D touch surface based on the gradient of the touched virtual geometry. Haptic perception process in the real world is closely related to relative tactual experiences. When it comes to tactually exploring a real object, the slope/curvature of the object geometry is an important geometric feature.

Seung-Chan Kim describes two approaches that can reproduce three-dimensional geometries on the flat touch surface based on the local gradients. First, we introduce a tactile-rendering algorithm for simulating 3D geometric features, such as bumps, on touch screen surfaces [7]. In tactile displays based on an electrovibration effect such as TeslaTouch [1], the friction between the sliding finger and the touch screen is produced by injecting a periodic electrical signal into the conductive electrode coated with a thin dielectric layer. Varying the frequency and amplitude of the periodic signal varies the quality of sensations [1]. Second, we introduce a robotic surface display [5] that physically imitates the orientation of virtual 3D geometry touched through a 2D flat screen. The system renders the surface orientation of 3D geometry such that users can tactually obtain relative geometric information about the tangency of a virtual surface is represented by the platform based on the gradient of the touched 3D geometry The robotic surface display physically relocates the boundary between real and virtual space in the context of surface haptics. The system focus on the rotation of the display surfaces.

Part 3: Compliance Illusion

This part focuses on the illusion of compliance or deformation of the surface on a rigid touch surface. One idea that applies the haptic illusion is J. Kildal's work [4], which generated subtle grain feedback when a vertical force changes. The same concept was applied to render various button-press feeling [6] The other is ShearHaptics [2] which is a haptic feedback method that creates an illusion of tangential compliance when a user exerts a tangential force to a rigid force-sensing interface.

Sunjun Kim presents methods simulates that generate the illusion of compliance that uses grain vibrations. It simulates the frictional movement of an object on a textured surface. By measuring the vertical or tangential force exerted on the rigid interface and maps the 2D tangential force vector into a position of a virtual object placed on a textured surface, a human sensory system gets an object is deformed. By differently mapping the force and the texture, frequency, and amplitude of grain signal, a rigid object can simulate different stiffness and textures.

Part 4: Pin array display

The fingertips are one of the most sensitive parts of our body. One way to take the advantage is by using pin array stimulation. The spatiotemporal patterns of the pin array can be used to convey information such as directions and icons [8, 9]. In this tutorial, Jingun Jung describes two studies using PinPad hardware that combines a pin array and a touchpad.

One study targets a PC environment using a touchpad [3], and the other study targets augmenting voice user interfaces in a vehicle. Firstly, we propose four applications for PC. 1) *tactile target* that helps the user to recognize objects like scroll bar, text box, and checkbox. 2) *guide and constraint*, which physically assist the user input direction. 3) *multi-finger output*, which delivers information in a tactile sense, which can be used as secure input and output channel by tactile patterns hidden under the fingers. 4) *dynamic partition* that divides the area of the touchpad according to the situation and provides different functions for each area.

Secondly, we propose four in-vehicle applications. 1) *state feedback*, which solves the turn-taking problem that confuses the user, whether it is her/his turn or not. 2) *list scrolling widget*, which alleviates short-term memory dependency that makes it hard to remember when long speech is output. The user can rewind to hear the previous item or skip the current item to hear the next item. 3) *fine-tune widget*, which improves the inefficient situation where users have to repeat similar commands when fine-tuning values such as volume, brightness, or air conditioning. It provides a knob-shaped widget that allows the user to fine-tune the values by manual input. 4) *command edit widget* which edits incorrectly recognized words in the user command by multimodal interaction.

Participation

Participants will take a short lecture for each part, and will have a chance to experience the technologies in hand. Each part consist of 20-min lecture + 20-min demonstration and discussion.

The tentative structure of this tutorial is as follow:

- Opening (10 min)
- Part 1 and Part 2 (40 + 40 min)
- Break (30 min)
- Part 3 and Part 4 (40 + 40 min)
- Closing (10 min)

Organizers

Sunjun Kim (main contact person) is a postdoc researcher at User Interfaces group, Aalto University, Finland. The group investigates novel computational methods for the design and adaptation of user interfaces. Before joining Aalto, he got his Ph.D. in Computer Science at KAIST. One of his main research topics has been modeling and rendering of tactility during button pressing.

Gunhyuk Park is an assistant professor at GIST, Republic of Korea. He is leading Haptic Assistive Media Laboratory at GIST, which aims for developing haptic device and interfaces in assistive HCI applications. Before joining GIST, he worked on Max Planck Institute as a postdoctoral researcher. He got his Ph.D. in Computer Science and Engineering at Pohang University of Science and Technology.

Seung-Chan Kim is an assistant professor at Hallym University, Republic of Korea. His research got attention on tactile rending of 3D features on a flat surface. He worked on Samsung Advanced Institute of Technology as a senior researcher until 2017 and worked on KAIST as a postdoc researcher until 2014. He got his Ph.D in Mechanical Engineering at KAIST.

Jingun Jung is a Ph.D. student at KAIST, Republic of Korea. He is a member of HCI Laboratory led by Geehyuk Lee. His research interest is on sensory substitution, tactile interface, and smartwatch interaction.

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