AsiaHaptics 2018

November 14~16, 2018

Songdo Conventia, Incheon, Korea

AsiaHaptics 2018

Contents

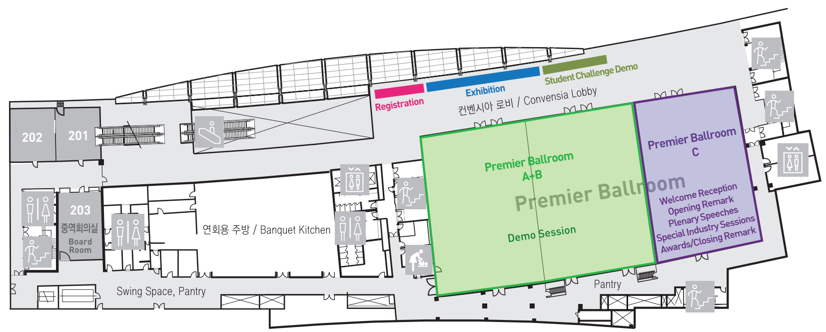
Program at a Glance

Time\Place	Day 0 Nov 14, Wed			Day 1 Nov 15, Thur				Day 2 Nov 16, Fri		
	Room (104~111)	Premier Ballroom	Lobby	Room (110-111)	Premier Ballroom A+B	Premier Ballroom C	Lobby	Premier Ballroom A+B	Premier Ballroom C	Lobby
09:00~09:30			Registration			Opening Remark/ Plenary Speech I	Registration/ Company Exhibition		Plenary Speech III	Registration/ Company Exhibition
09:30~10:00	Workshops									
10:00~10:30				Student Challenge Presentation	Live Demo Presentation Session 1 (D1A1~D1A30)			Live Demo Presentation Session 3 (D2A1~D2A25)		
10:30~11:00										
11:00~11:15								Demo & Video (D2) Core Time		
11:15~11:30										
11:30~12:00					Demo (D1) Core Time					
12:00~12:30										
12:30~13:30	Lunch									
13:30~14:00	Workshops	Setting up Demo	Registration & Setting up Company Exhibition Booth			Plenary Speech II	Registration/ Company Exhibition/ Student Challenge Demo	Video Presentation (D2V1~D2V15)		Registration/ Company Exhibition
14:00~14:30								Demo & Video (D2) Core Time		
14:30~15:00					Live Demo Presentation Session 2 (D1P1~D1P26)					
15:00~15:30										
15:30~15:45										
15:45~16:00										
16:00~16:30					Demo (D1) Core Time				Special Industry Session	
16:30~17:00										
17:00~17:30									Awards/ Closing Remark	
17:30~18:00										
18:00~18:30										
18:30~19:30	Reception (Gand Ballroom/Songdo Convensia)			Banquet (Central Park Hotel, 3rd FL)						
19:30~20:00										
20:00~20:30										

Floor Plan

Main Building 1F

Main Building 2F



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Exhibition

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I. Welcome Message

AsiaHaptics2018, Incheon, South Korea

Message from the General Chair

It is my great pleasure to welcome all of you to AsiaHaptics 2018, the third AsiaHaptics conference will be held in Incheon, South Korea. AsiaHaptics is a new type of international conference, featuring interactive presentations with demos. Since the first AsiaHaptics has been held in Japan on 2014, AsiaHaptics will be held for the first time in South Korea, and continue experimenting our unique concept that the conference participants are considered to be subjects as well as presenters and audience; that is, the conference provides opportunities of haptics experiments with hundreds of potential subjects gathering as presenters and audience, which genuinely contributes to researches on site.

Succeeding this unique and innovative conference style, the third AsiaHaptics accepted 81 live demos as well as 15 video demos, that is a modest increase in number from the second conference. Especially, we have introduced new type of contribution, video demo, for the researchers who have difficulties bringing their hardware setup and researchers who are mainly doing psychophysics oriented experiments, but are still willing to participate in AsiaHaptics. In addition, we are proud to announce student challenge in automotive haptics. In this challenge, undergraduate and graduate students from all over the world proposed and created innovative haptics solutions for the next generation vehicles. 8 student teams will compete for a prize of $5,000 in cash prizes during the AsiaHaptics2018. In order to reflect the expanded interest of haptics in industry, we organized special industry talks and industry exhibitions. Also, don't forget about the plenary speeches from three prominent speakers, and 4 workshops with very interesting topics.

Finally, I would like to express my sincere gratitude toward the organizing committee members for their hard work, and all the participants for their contribution to AsiaHaptics2018. I hope all the participants will fully enjoy the demos and talks in AsiaHaptics2018, which will trigger a new growth of Haptics.

Jee-Hwan Ryu
General chair of AsiaHaptics2018

II. Committees

▪ Steering Committee

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Dong-Soo Kwon (KAIST, Korea)
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Hiroyuki Kajimoto (UEC, Japan)
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Jee-Hwan Ryu (KoreaTech, Korea)
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Gerard Jounghyun Kim (Korea University, Korea)
Yuru Zhang (Beihang University, China)

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Jin Ryong Kim (Alibaba Research, USA)

Web Chairs

Inwook Hwang (ETRI, Korea)
Jaeyoung Park (KIST, Korea)

Local Chairs

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Seung-Chan Kim (Hallym University, Korea)
Yeongjin Kim (Incheon National University, Korea)

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Andrea Bianchi (KAIST, Korea)
Antonio Frisoli (SSSA, Italy)
Kouta Minamizawa (Keio University, Japan)

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Won-Hyeong Park
Yasutoshi Makino
Yem Vibol
Yon Visell
Yoshihiro Tanaka
Yuichi Kurita

III. Conference Information

1. Registration

Venue: Lobby, 2F, Songdo Convensia

Credit cards and cash are the only accepted forms of payment for on-site registration. The registration desk is open during the conference, according to the following schedule.

Operating Hours

Date	Nov.14(Wed)	Nov.15(Thur)	Nov.16(Fri)
Time	08:00-18:00	08:00-18:00	08:00-18:00

On-site Registration Fee

Category	Pre-Registration	On-site Registration
Regular	KRW 650,000	KRW 750,000
Student	KRW 450,000	KRW 550,000

- Those who have paid the registration fee will have access to all demo sessions, workshops, tutorials, exhibitions, coffee breaks, welcome reception, banquet, and all of the other official events associated with AsiaHaptics 2018 with no other designated fee.

Registration Packets

Registration packets for advance registrants will be distributed at the registration desk. They contain a name tag, coupons for the conference and for any official gathering that you may have registered.

Name Tag

Participants are required to wear their name tag in the session room, which are given upon registration.

Secretariat Office

- Venue: Room 109, Songdo Convensia

- Operating Hours

Date	Nov.14(Wed)	Nov.15(Thur)	Nov.16(Fri)
Time	08:00-18:00	08:00-18:00	08:00-18:00

AsiaHaptics 2018

2. Social Events

Opening Ceremony

- **Date/Time:** November 15, Thursday / 09:00
- **Venue:** Premier Ballroom C, Songdo Convensia

Welcome Reception

- **Date/Time:** November 14, Wednesday / 18:30-20:00
- **Venue:** Premier Ballroom C, Songdo Convensia

All participants are cordially invited to the Welcome Reception. It will be a great opportunity to develop a broad, deep and diverse network of personal connections with participants from all over the world.

Banquet

- **Date/Time:** November 15, Thursday / 18:30-20:30
- **Venue:** 3F, Diamond Hall, Songdo Central Park Hotel

The highlight of the social program will be the Banquet. There will be a special performance. We hope you have a wonderful night with delightful food and performances.

- **Location and Access Map**

3. Restaurants near the Venue

1 Songdo Town

Food Zone **across the Convensia** on the left bottom side
Address: 124, Harmony-ro, Yeonsu-gu, Incheon
Walkable, about 10 minutes

2 Central Park Prugio Shopping Center

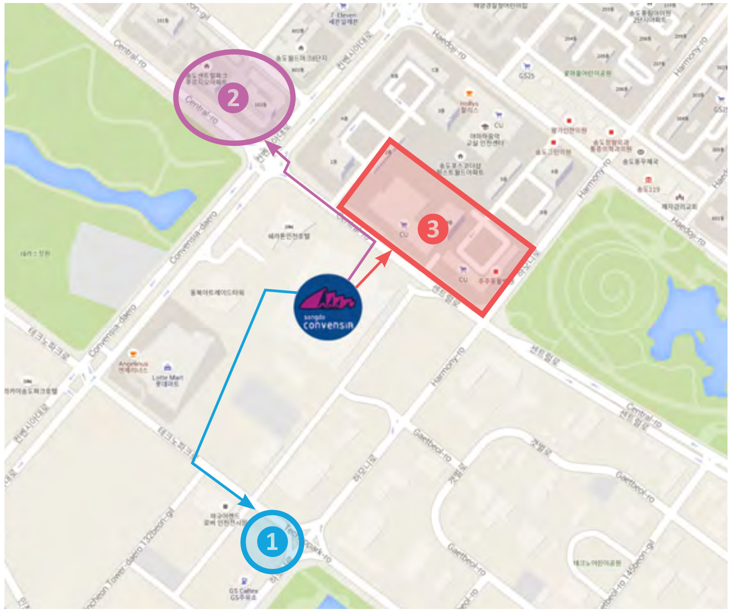
Restaurants on the **left top side in the map**
Address: 160, Central-ro, Yeonsu-gu, Incheon
Walkable, about 5 to 10 minutes

3 The Shop First World

Food Zone **across the Convensia**
Address: 107, Haedoji-ro, Yeonsu-gu, Incheon
Walkable, about 5 minutes

4 Convensia Food Court

1F and B1



4. Tourist Attractions in Incheon

Inquiries for Tour in Korea

1330 Travel Hotline:+82-2-1330(Supports in Korean, English, Japanese, Chinese)

Top 4 Places

A. Incheon China Town B. Songdo Central Park C. WolMiDo Street D. Shinpo International Market

A. Incheon China Town

Information

Address : Seollin-dong / Bukseong-dong, Jung-gu, Incheon
Homepage : www.ichinatown.or.kr (Korean only)
From Incheon Airport :16.5 km /From Sondo Convention : 9.4 km
Travel Time : 26 minute by car, 54 minute by public transportation

Available Facilities

∨ Authentic Korean-Chinese Food
∨ Sight-Seeing
∨ Temples
∨ Museums

Incheon's Chinatown came into being with the opening of Incheon Port in 1883 and Incheon's designation as an extraterritoriality of the Ching Dynasty in the following year. In the past, the area held many stores trading goods imported from China, but currently most Chinese businesses in the area are restaurants. Today, the residents of Chinatown are mostly 2nd or 3rd generation Chinese, descendents of the early Chinese settlers. The area harbors many of the flavors of China, while the traditional culture of the first generation are preserved.

B. Songdo Central Park

Information

Address : 196, Techno park-ro, Yeonsu-gu, Incheon
Homepage : www.insiseol.or.kr (Korean only)
From Incheon Airport : 28.25 km /From Sondo Convention : 800 m
Travel Time : 3 minute by car, 3 minute on foot

Available Facilities

∨ Canoe
∨ Family Boat
∨ Bike cycle Rental
∨ Kayak
∨ Stand Up paddle
∨ Beautiful Night view

Songdo Central Park is a seaside park built within Songdo International City, a green paradise found among the crowded skyscrapers in the city. Visitors can enjoy a water taxi ride on the man-made waterway, take a stroll at the walking promenades or various themed meadows around.

C. WolMiDo Street

Information

Address : 36, Wolmimunhwa-ro, Jung-gu, Incheon
Homepage : http://www.my-land.co.kr
From Incheon Airport :14.7 km /From Sondo Convention : 8.5 km
Travel Time : 34 minutes by Car, 76 minute by Public Transportation

Available Facilities

∨ Cultural Street
∨ Amusement Park
∨ Restaurant, Outdoor stage
∨ Wolmi Cruise Ship

Remove Wolmido Island (월미도), located roughly 1km off the coast of Incheon, has since become part of the mainland with the creation of a new highway. The name Wolmido Island comes from the shape of the island as it resembles the tail of a half moon. Thanks to its location near Seoul and the convenient transportation, many people visit here during weekends. The Culture Street starts with Doodle Pillar, and continues onward to Meeting Square, Arts Square, Performance Square, Good Harvest Square and several other notable highlights. Throughout these areas, spontaneous performances are performed, and street artists can draw for you on the spot. Moreover, many cafes and seafood restaurants are lined along the coast so you can enjoy coffee or fresh seafood while viewing the sea. A must-see attraction on Wolmido Island is "Play Hill." It's not as large as other theme parks in Korea, but the Apollo Disco and the Viking rides are truly thrilling. If you're not into rides, the Apollo Disco ride is still fun just watching. You can also get on a cruise to look around the island.

D. Sinpo International Market

Information

Address : 11-5, Uhyeon-ro 49beon-gil, Jung-gu, Incheon
Homepage : www.sinpomarket.com (Korean, English, Japanese, Chinese)
From Incheon Airport :16.8 km /From Sondo Convention : 9 km
Travel Time : 25 minute by Car, 57 minute by public transportation

Available Facilities

∨ Traditional Markets
(Crops, meat, fish, vegetables, fruits, bread, rice cakes, side dishes, restaurants, clothes, shoes, general goods, etc.)
∨ Sightseeing

Located in Sinpo-dong, Jung-gu, Incheon, Sinpo Market (3,300m^2) dates back to the late 19th century when vendors began selling fresh vegetables to the Japanese, Chinese, and Westerners who settled in the area. Sinpo Market was officially registered as a market in 1970 and now boasts over 140 stores. An increasing number of tourists and international merchants have visited Incheon by ferries and cruise ships, turning the local market into an international shopping area over the past few decades. The information desk and office at the market even provide a variety of services (translation services, trade and shopping information, etc.) for tourists and merchants from home and abroad. The most famous item of the market is dakgangjeong, a Korean dish of crispy fried chicken coated in a sweet and spicy sauce. Other popular dishes include yuni jjajang, egg tart, freshwater fish jeon, mandu, and jjolmyeon(chewy noodles).

IV. Plenary Speeches

Speech I

- Date/Time: November 15, Thursday / 09:00-10:00
- Venue: Premier Ballroom C, Songdo Convensia

Hurdles in the Hunt for a Haptic Killer App

Prof. Mandayam Srinivasan
Director, MIT and UCL Touch Labs
Professor of Haptics, Department of Computer Science, University College London, UK

Biography

Dr. Srinivasan's research over the past 3 decades on the science and technology underlying information acquisition and object manipulation through touch has played a pivotal role in establishing the multidisciplinary field of modern Haptics. He has been recognized worldwide as an authority on haptic computation, cognition, and communication in humans and modern machines such as computers and robots. His pioneering scientific investigations of human haptics involving biomechanics, neuroscience and psychophysics has led to significant advances in our understanding of how nerve endings in the skin enable the brain to perceive the shape, texture and softness of objects through the sense of touch. His work on machine and computer haptics involving design and development of novel robotic devices, mathematical algorithms and real-time control software has enabled touching, feeling and manipulating objects that exist only virtually as programs in the computer. He has also demonstrated novel haptic applications such as virtual reality based simulators for training surgeons, real-time touch interactions between people across continents and direct control of robots from brain neural signals. More recently, he has been working on developing haptic aids for blind people, smartphone based healthcare for underserved populations, novel robotic fingertips, and teleoperation systems for micro/nano manipulation capable of performing surgery on a single cell with micron precision.

Abstract

Finding a haptic killer app would greatly accelerate the investment and growth of research and development in all aspects of haptics. Despite decades-long efforts around the world, success has been limited, owing to multiple hurdles that span scientific, technological, and business related issues. In this talk, I will trace our adventures in this hunt for a haptic killer app and identify the hurdles in human, machine, and computer haptics that have been overcome as well as those that still remain. I will illustrate my reasoning with autonomous, virtual reality and teleoperation systems we have developed for a variety of application areas such as robotics, entertainment, training, rehabilitation, and healthcare.

Speech II

- Date/Time: November 15, Thursday / 13:30-14:30
- Venue: Premier Ballroom C, Songdo Convensia

Telerobotic Touch

Dr. Katherine J. Kuchenbecker
Director, Haptic Intelligence Department, Max Planck Institute for Intelligent Systems, Stuttgart, Germany

Biography

Katherine J. Kuchenbecker directs the Haptic Intelligence Department at the Max Planck Institute for Intelligent Systems in Stuttgart, Germany. She earned her Ph.D. in Mechanical Engineering at Stanford University in 2006, did postdoctoral research at the Johns Hopkins University, and was an engineering professor at the University of Pennsylvania before she moved to Max Planck in 2017. Her research centers on haptic interfaces, which enable a user to touch virtual and distant objects as though they were real and within reach, as well as haptic sensing systems, which allow robots to physically interact with objects and people. She delivered a TEDYouth talk on haptics in 2012 and has been honored with a 2009 NSF CAREER Award, the 2012 IEEE Robotics and Automation Society Academic Early Career Award, a 2014 Penn Lindback Award for Distinguished Teaching, and various best paper and best demonstration awards. She co-chaired the IEEE Technical Committee on Haptics from 2015 to 2017 and co-chaired the IEEE Haptics Symposium in 2016 and 2018.

Abstract

I define a haptic interface as a mechatronic system that modulates the physical interaction between a human and his or her tangible surroundings. After describing three archetypal haptic interface designs and explaining how such systems typically function, this talk will trace the trajectory of my research on telerobotic touch from 2002 to the present. Motivated by applications from robot-assisted surgery to household robotics, my co-authors and I have looked for clever ways to enable a human to feel what a teleoperated robot is touching. The haptic interfaces we have created tend to focus on providing naturalistic tactile cues, such as high-frequency vibrations and fingertip contact, rather than more commonly studied kinesthetic cues like force and torque. We have repeatedly found that well-designed tactile cues enhance system usability and increase operator performance because they convey rich manipulation-relevant information without compromising the teleoperator's closed-loop stability.

Speech III

- **Date/Time:** November 16, Friday / 09:00-10:00
- **Venue:** Premier Ballroom C, Songdo Convensia

Journey of KAIST Research in Haptics

Prof. Dong-Soo Kwon
Director, Human-Robot Interaction Research Center and Center for Future Medical Robotics, KAIST, Korea

Biography

Dong-Soo Kwon is a Professor in the Department of Mechanical Engineering at the Korea Advanced Institute of Science and Technology (KAIST), Director of the Human-Robot Interaction Research Center, Director of the Center for Future Medical Robotics. He is serving the IEEE Robotics and Automation Society (RAS) as a member of the Administrative Committee (AdCom). In addition, He is the founder CEO of EasyEndo Surgical Inc., Chairman of the board of directors of Korea Institute of Robot and convergence (KIRO), and a member of National Academy of Engineering of Korea (NAEK).
His research deals with Medical Robotics, Haptics, and Human-Robot Interaction. He has contributed to the advancement of several robot venture companies by technology transfer. Recently, he has established a start-up company based on his medical robot research results.
He had worked as the Research Staff in the Telerobotics section at Oak Ridge National Laboratory from 1991 to 1995. He was a Graduate Research Assistant in Flexible Automation Lab. at Georgia Institute of Technology from 1985 to 1991, and the Section Chief, Manager at R&D Group of Kanglim Co., Ltd from 1982 to 1985. He received the Ph.D. in the Department of M.E. at Georgia Institute of Technology in 1991, M.S. in the M.E. at KAIST in 1982, and B.S. in the M.E. at Seoul National University in Korea in 1980.

Abstract

Telerobotics and Control Laboratory (TCL) at KAIST was established in 1995, and has 23 doctoral and 46 master's graduates. The beginning of the haptics was research on 6 DoF haptic master for telerobotics, and the field has continued to develop a wide range of technology from actuators that generate various tactile sensation in mobile devices to tactile displays that render texture and shape on touch surfaces. Using the knowhow from research, TCL is broadening the use of its technology by developing haptic braille pad and braille display module for the visually impaired working with a startup company. During TCL's growth, graduates from the program also planted the "seed" of haptic research to grow and bear fruit in diverse fields. Research on telerobotics has become a "seed" of rehabilitation and surgical robots, and research on tactile display has become a "seed" of soft robotics. Much of the research that originally started from the field of haptics has expanded into a variety of fields such as virtual reality interface and deep-learning based haptic interaction, and the journey has been remarkable. Therefore, I would like to take this opportunity to introduce the research history of TCL, haptics group graduates, and their research journeys.

V. Workshop

- **Date/Time:** November 14, Wednesday / 09:30-18:00
- **Venue:** Room 104-105, Room 107-108, Room 110-111, Songdo Convensia

<table>
<tr><th>Time</th><th>Track A
Room 104-105</th><th>Track B
Room 107-108</th><th>Track C
Room 110-111</th></tr>
<tr><td>09:30-10:45(75')</td><td>W1: Data-Driven Haptic Rendering</td><td>W2: Mobile VR</td><td></td></tr>
<tr><td>10:45-11:00(15')</td><td colspan="3">Break</td></tr>
<tr><td>11:00-12:30(90')</td><td>W1: Data-Driven Haptic Rendering</td><td>W2: Mobile VR</td><td></td></tr>
<tr><td>12:30-13:30(60')</td><td colspan="3">lunch</td></tr>
<tr><td>13:30-14:30(60')</td><td rowspan="2">W1: Data-Driven Haptic Rendering</td><td></td><td rowspan="2"></td></tr>
<tr><td>14:30-15:00(30')</td><td>W4: Robot Gripper</td></tr>
<tr><td>15:00-15:15(15')</td><td colspan="3">Break</td></tr>
<tr><td>15:15-15:30(15')</td><td rowspan="6"></td><td></td><td rowspan="6">W3: Haptipedia</td></tr>
<tr><td>15:30-16:00(30')</td><td rowspan="4">W4: Robot Gripper</td></tr>
<tr><td>16:00-16:30(30')</td></tr>
<tr><td>16:30-17:00(30')</td></tr>
<tr><td>17:00-18:00(60')</td></tr>
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</table>

W1: Data-Driven Haptic Rendering with Multimodal Improvements for Highly Realistic Virtual Experiences
Organizer: Seungmoon Choi, POSTECH, Korea
Room 104-105 / 9:30 am ~ 15:00 pm (All Day)

W2: Mobile Virtual Reality Technology and Its Applications
Organizer: Soomi Choi, Sejong University, Korea
Room 107-108 / 9:30 am ~ 12:30 pm (Morning, Half Day)

W3: Haptipedia: An Interactive Database for Selecting, Ideating, and Learning about Grounded Force-feedback Devices
Organizer: Hasti Seifi, Max Planck Institute for Intelligent Systems, Germany
Room 110-111 / 15:15 pm ~ 18:00 pm (Afternoon, Half Day)

W4: Shape Compliant Electro-Adhesive Gripper
Organizer: Haesook Hwang, Dawoo FA, Korea
Room 107-108 / 14:30 pm ~ 17:00 pm (Afternoon, Half Day)

VI. Student Challenge in Automotive Haptics

- Date/Time: November 15, Thursday / 10:00-12:00
- Venue: Room 110-111, Songdo Convensia

In this challenge, undergraduate and graduate students from all over the world to propose and create innovative haptics solutions for the next generation vehicles. They will compete for $5,000 in cash prizes in AsiaHaptics 2018.

Selected Ideas from the first round. Congratulations!

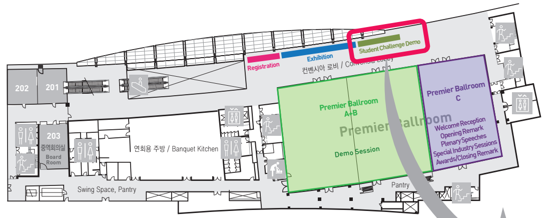
No.	Team Name	Team Members	Idea	Affiliation	Country
1	HVR-KHU	Arsen Abdulali, Ruslan Rakhmatov, Seokhee Jeon	Vibrotactile push latch effects on the automotive handleless doors.	Kyung Hee University	Korea
2	KoreaTech BioRobotics	Syed Zain Mehdi, Junhyung Jang, Jinsung Hwang	Windshield display haptic control by the 3D TOF camera with eye and finger recognition algorithm and its feedback for drivers.	KoreaTech	Korea
3	Kyodai Haptics	Sajid Nisar, Hardik Parwana, Mintaek Oh, Anh-Quy Hoang, Farhad Shabani	Haptic Cushion: A plug and play Solution to Improve Drivers' Response and Safety at Traffic Lights.	Kyoto University	Japan
4	SEA Brake Pedal	Umut Çalışkan, Ardan Apaydın, Ata Otaran	A Series Elastic Brake Pedal for Regenerative Braking.	Sabanci University	Turkey
5	Team bsys aka おもてなし	Wataru Sakoda, Kazuyuki Matsumura, Yuya Ishibashi, Masahiro Fukada, Kazumasa Yoshimura	Fit you ~ You can take your original driver interface.	Hiroshima University	Japan
6	Sant'Anna Haptics	Domenico Chiaradia, Antonio Di Guardo, Antonio Frisoli	Haptic Gearshift's Engagement Assistant: Haptic Knob and Pedal to Improve the Gearshift's Engagement Maneuvers.	Sant'Anna School of Advanced Studies	Italy
7	Robotory	Hyouk Ryeol Choi, Hoa Phung, Phi Tien Hoang, Hosang Jung, Vinh Phuc Ngo Thai	Interactive haptic display based on soft actuator and soft sensor.	Sungkyunkwan University	Korea
8	Woodpecker	Zhuoluo Ma, Dejiang Ye, Lu Zhao	Vibrotactile Wristband for Warning and Guiding in Automated Vehicles.	Beijing Institute of Technology	P.R. China

Awards

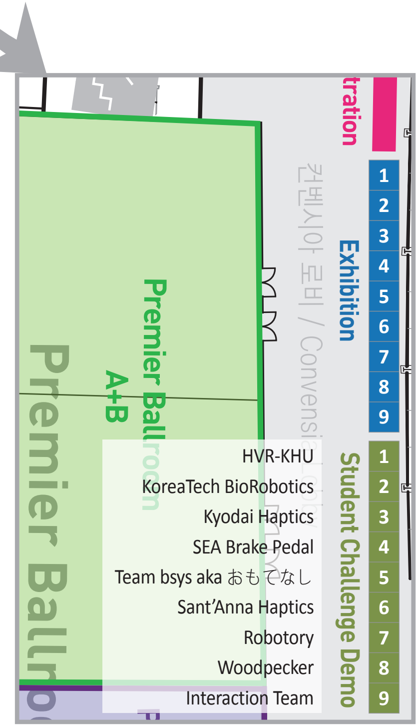
The top three teams will earn cash prizes as follows:

- 1st place team: $5,000 USD
- 2nd place team: $2,000 USD
- 3rd place team: $1,000 USD

Student Challenge Layout



Place : 2F, Song-do Convensia
(In front of Premier Ballroom)



Student Challenge Demo

Booth No.	Team Name	Affiliation
1	HVR-KHU	Kyung Hee University
2	KoreaTech BioRobotics	KoreaTech
3	Kyodai Haptics	Kyoto University
4	SEA Brake Pedal	Sabanci University
5	Team bsys aka おもてなし	Hiroshima University
6	Sant'Anna Haptics	Sant'Anna School of Advanced Studies
7	Robotory	Sungkyunkwan University
8	Woodpecker	Beijing Institute of Technology
9	Interaction Team	KoreaTech

VII. Special Industry Sessions

Speech I

- **Date/Time:** November 16, Friday / 16:00-16:30
- **Venue:** Premier Ballroom C, Songdo Convensia

Vehicle Sound Design and Haptics

Dr. Dong Chul Park
Lab Director, Hyundai Motor Group, Korea

Abstract

In our 5 sensations, the auditory and haptic sensation is 2nd and 3rd important one. But at driving situation auditory and haptics are a most important sensation for delivering information and emotion. In this presentation, sound design activates in automotive industries will be shown;
• Engine Sound Design: strategy & new technology
• Auditory User Interface design: alarm & warning sound design
• Vehicle sound & Brand strategy
As a final comment, the role of sound and haptics in next-generation vehicles will be presented.

Speech II

- **Date/Time:** November 16, Friday / 16:30-17:00
- **Venue:** Premier Ballroom C, Songdo Convensia

The World Where Blind People Can See with Their Hands

Mr. Ki Kwang Sung
CTO, Dot Inc., Korea

Abstract

There are approximately 285 million blind people around the world, and they rely on touch rather than vision to receive a variety of information. 'Dot' is now telling you the story how we make valuable result with our Touching technology for better and easy life for those blind people in the world.

AsiaHaptics 2018

VIII. Technical Programs

AsiaHaptics 2018

1. Instruction for Demo

Two types of presentation will be presented in AsiaHaptics 2018: 81 live demo presentations and 15 video presentations.

Please read the following introductions carefully for your presentation on Asiahaptics 2018.

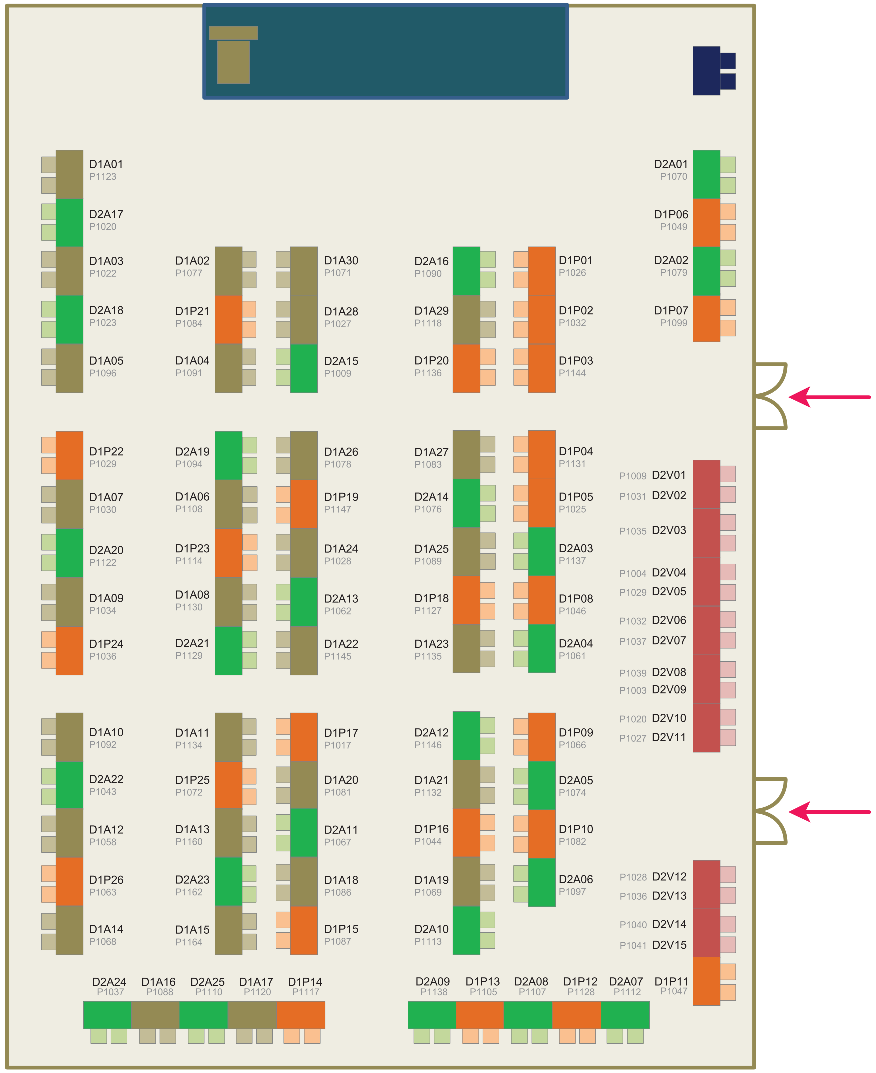
(1) Live Demo Presentation

- 20~30 demo presentations will be presented during the ‘Live Demo Presentation Session.’
- The session will be held as a live-broadcasting event and the presenters will present their demo for 2 minutes in front of a camera.
- Live demonstration will be broadcasted on the main screen in the conference room.
- The session chair may spend additional 1 minute to introduce a demo, asking questions and moving between demos.
- Demonstration schedule is posted on the conference website (http://asiahaptics.org/program/).
- All presenters should demonstrate their systems for 3 hours core time for other participants.
  Core time for demos in Session I & II (D1A1~A30, D1P1~P26) is Thursday. Core time for demos in the session III (D2A1~A25) is Friday.
  But we strongly recommend that all presenters’ demonstrates their systems for 2 days in order to share your excellent achievement with all participants.
- A board for a printed poster, 1m x 1.5m, will be provided for each demo.
- For invited demos, D1P1~D1P5, 5 minutes will be given for live broadcasting of demos, descriptions, sharing know-hows and etc.

(2) Video Presentation

- 15 video demos, D2V1~D2V15, will be played in the ‘Video Presentation Session.’
- The session is a podium talk and a video demo presenter must submit a file via email to the secretariat that includes a video formatted as ‘.pptx’ format file including videos to secretariat (secretary2018@asiahaptics.org) before 13 Nov.
- A presentation should be completed in 2 minutes.
- Demonstration schedule is posted on the conference website (http://asiahaptics.org/program/).
- Core time for video demos for visitors is Friday and a video should be played on the demo table.
- A board for a printed poster, 1m x 1.5m, will be provided for each demo.

2. Demo Layout



Live Demo 1
Live Demo 2
Live Demo 3
Video Demo

Live Demo Presentation Session 1 (D1A1~D1A30)

Premier Ballroom A+B

Session Chair	Antonio Frisoli (SSSA, Italy)
Date	November 15, 2018 (Thursday)
Time	10:00~11:30

D1A01 10:00-10:03(3`) **Drone Based Kinesthetic Haptic Interface for Virtual Reality Applications**
Muhammad Abdullah[1], Ahsan Raza[1], Yoshihiro Kuroda[2], and Seokhee Jeon[1]
[1]Kyung Hee University, Korea, [2]Osaka University, Japan

D1A02 10:03-10:06(3`) **Encounter-type Haptic Feedback System Using an Acoustically Manipulated Floating Object**
Takuro Furumoto, Yutaro Toide, Masahiro Fujiwara, Yasutoshi Makino, and Hiroyuki Shinoda
The University of Tokyo, Japan

D1A03 10:06-10:09(3`) **A Surface Texture Display for Flexible Virtual Objects**
Lei Lu, Yuru Zhang, Xingwei Guo, and Dangxiao Wang
Beihang University, China

D1A04 10:09-10:12(3`) **Tactile Perception Effects of Shear Force Feedback and Vibrotactile Feedback on Virtual Texture Representations**
Chia-Wei Lin and Shana Smith
National Taiwan University, Taiwan

D1A05 10:12-10:15(3`) **Whole Body Haptic Experience Using 2D Communication Wear**
Kohki Serizawa[1], Yuichi Masuda[1], Shun Suzuki[1], Masahiro Fujiwara[1], Akihito Noda[2], Yasutoshi Makino[1], and Hiroyuki Shinoda[1]
[1]The University of Tokyo, Japan, [2]Nanzan University, Japan

D1A06 10:15-10:18(3`) **A Haptic Feedback Touch Panel**
Seung Mo Jeong[1], Dongbum Pyo[2], Ki-Uk Kyung[1], and Sungryul Yun[2]
[1]Korea Advanced Institute of Science and Technology, Korea,
[2]Electronics and Telecommunications Research Institute, Korea

D1A07 10:18-10:21(3`) **LinkGlide: A Wearable Haptic Display with Inverted Five-Bar Linkages for Delivering Multi-contact and Multi-Modal Tactile Stimuli**
Miguel Altamirano Cabrera and Dzmitry Tsetserukou
Skolkovo Institute of Science and Technology, Russian Federation

D1A08 10:21-10:24(3`) **Pneumatic Actuated Haptic Glove to Interact with the Virtual Human**
Aishwari Talhan, Hwangil Kim, Sanjeet Kumar, Ahsan Raza, and Seokhee Jeon
Kyung Hee University, Korea

D1A09 10:24-10:27(3`) **Wearable Haptic Device that Presents the Haptics Sensation of a Finger Pad to the Forearm and Fingertip**
Taha Moriyama and Hiroyuki Kajimoto
University of Electro-Communications, Japan

D1A10 10:27-10:30(3`) **Thermal-Radiation-Based Haptic Display - Laser-Emission-Based Radiation System -**
Satoshi Saga
Kumamoto University, Japan

D1A11 10:30-10:33(3`) **Spatial Haptic Feedback Virtual Reality Controller for Manipulator Teleoperation Using Unreal Engine**
Jae Min Lee, Dong Yeop Kim, and Jung-Hoon Hwang
Korea Electronics Technology Institute, Korea

D1A12 10:33-10:36(3`) **A Two-DOF Impact Actuator for Haptic Interaction**
Sangyoon Kim[1], Bukun Son[1], Yongheon Lee[2], Hyunwoong Choi[1], Woochan Lee[3], and Jaeyoung Park[2]
[1]Seoul National University, Korea, [2]Korea Institute of Science and Technology, Korea, [3]Incheon National University, Korea

D1A13 10:36-10:39(3`) **Conceptual Design of Soft Thin Self-sensing Vibrotactile Actuator**
Siho Ryu, Dong-Soo Choi, and Sang-Youn Kim
Korea University of Technology and Education, Korea

D1A14 10:39-10:42(3`) **A Novel Haptic Interface for the Simulation of Endovascular Interventions**
Hafiz Ramli[1], M. Iqbal Saripan[1], and Fernando Bello[2]
[1]Universiti Putra Malaysia, Malaysia, [2]Imperial College London, UK

D1A15 10:42-10:45(3`) **Collaborating through Magic Pens: Gounded Forces in Large Overlappable Workspaces**
Soheil Kianzad and Karon E. MacLean
University of British Columbia, Canada

D1A16 10:45-10:48(3`) **A Ball-type Haptic Interface to Enjoy Sports Games**
Takuya Handa, Makiko Azuma, Toshihiro Shimizu, and Satoru Kondo
NHK (Japan Broadcasting Corporation), Japan

D1A17 10:48-10:51(3`) **Highly Stretchable Optical Strain Sensor for Human Motion Detection**
Jaeyeon Jeong, Taeyeon Kim, and Ki-Uk Kyung
Korea Advanced Institute of Science and Technology, Korea

D1A18 10:51-10:54(3`) **Improvement of Walking Motivation by Vibratory Display Powered by an Ankle-Worn Generation Device**
Minatsu Sugimoto, Hiroo Iwata, and Hiroya Igarashi
University of Tsukuba, Japan

D1A19 10:54-10:57(3`) **Deformation and Friction: 3D Haptic Asset Enhancement in E-Commerce for the Visually Impaired**
Hong Jian Wong[1], Kian Meng Yap[1], Wei Kang Kuan[1], Andrew Jian Yue Chan[1], Sam-uel John Omamalin[1], Alyssa Yen-Lyn Ding[1], Mei Ling Soh[1], and Ahmad Ismat Bin Abdul Rahim[2]
[1]Sunway University, Malaysia, [2]Telekom Research & Development Sdn. Bhd., Malaysia

D1A20 10:57-11:00(3`) **Controlling Robot Vehicle Using Hand-Gesture with Mid-Air Haptic Feedback**
Tao Morisaki, Masahiro Fujiwara, Yasutoshi Makino, and Hiroyuki Shinoda
The University of Tokyo, Japan

D1A21 11:00-11:03(3`) **Gravity Ball: A Virtual Trackball with Ultrasonic Haptic Feedback**
Jemin Lee and Seokhee Jeon
Kyung Hee University, Korea

D1A22 11:03-11:06(3`) **Data-driven Multi-modal Haptic Rendering Combining Force, Tactile, and Thermal Feedback**
Seongwon Cho, Hyejin Choi, Sunghwan Shin, and Seungmoon Choi
Pohang University of Science and Technology, Korea

D1A23 11:06-11:09(3`) **Painting Skill Transfer Through Haptic Channel**
Ahsan Raza, Muhammad Abdullah, Waseem Hassan, Arsen Abdulali, Aishwari Talhan, and Seokhee Jeon
Kyung Hee University, Korea

D1A24 11:09-11:12(3`) **A Hand Wearable Device Used in Local Curvature Recovery**
Tao Zeng[1,2] and Shizhen Huang[1,2]
[1]Xiamen University, China [2]Shenzhen Research Institute of Xiamen University, China

D1A25 11:12-11:15(3`) **Signal Generation for Vibrotactile Display by Generative Adversarial Network**
Shotaro Agatsuma[1], Junya Kurogi[2], Satoshi Saga[2], Simona Vasilache[1], and Shin Takahashi[1]
[1]University of Tsukuba, Japan, [2]Kumamoto University, Japan

D1A26 11:15-11:18(3`) **Shape and Stiffness Sensation Feedback with Electro-tactile and Pseudo-Force Presentation When Grasping A Virtual Object**
Vibol Yem[1], Yasushi Ikei[1], and Hiroyuki Kajimoto[2]
[1]Tokyo Metropolitan University, Japan [2]The University of Electro-Communications, Japan

D1A27	11:18-11:21(3`)	**Presenting a Pseudo-Force Sensation Using a Clothespin** *Masahiro Miyakami and Hiroyuki Kajimoto* The University of Electro-Communications, Japan
D1A28	11:21-11:24(3`)	**Presentation of Stepping Up and Down by Pneumatic Balloon Shoes Device** *Masato Kobayashi, Yuki Kon, and Hiroyuki Kajimoto* University of Electro-Communications, Japan
D1A29	11:24-11:27(3`)	**Analysis and Design of Surgical Instruments for The Development of a Shoulder Joint Arthroscopic Surgery Simulator** *Tae-Keun Kim[1], Geon Won[1], Jong-bum Park[1], Saehan Kim[1], Byung-jin Jung[1], Jung-Hoon Hwang[1], Jaeuk Ahn[2], Minju Song[2], and Chang Nho Cho[3]* [1]Korea Electronics Technology Institute, Korea, [2]Naviworks, Korea, [3]Korea Electrotechnology Research Institute, Korea
D1A30	11:27-11:30(3`)	**Development of Virtual Diving Interface by Flutter Kick Motion** *Masaki Orimoto and Masamichi Sakaguchi* Nagoya Institute of Technology, Japan

Live Demo Presentation Session 2 (D1P1~D1P26)

Premier Ballroom A+B

Session Chair	Andrea Bianchi (KAIST, Korea)
Date	November 15, 2018 (Thursday)
Time	14:30~16:00

D1P01	14:30-14:35(5`)	[Invited] **Stiffness Perception of Virtual Objects Using FOLDAWAY-Touch** *Marco Salerno, Stefano Mintchev, Alexandre Cherpillod, Simone Scaduto, and Jamie Paik* EPFL, Switzerland
D1P02	14:35-14:40(5`)	[Invited] **Smart Bracelets to Represent Direction of Social Touch with Tactile Apparent Motion** *Taku Hachisu and Kenji Suzuki* University of Tsukuba, Japan
D1P03	14:40-14:45(5`)	[Invited] **"HaptiComm", a Haptic Communicator Device for Deafblind Communication** *Basil Duvernoy[1], Sven Topp[2], and Vincent Hayward[3]* [1]Institut des Systemes Intelligents et de Robotique, France, [2]University of Sydney, Australia, [3]University of London, UK
D1P04	14:45-14:50(5`)	[Invited] **A Novel Fingertip Tactile Display for Concurrently Displaying Texture and Orientation** *Harsimran Singh[1], Sang-Goo Jeong[2], Syed Zain[2], and Jee-Hwan Ryu[2]* [1]Institute of Robotics and Mechatronics in the German Aerospace, Germany, [2]Korea University of Technology and Education, Korea
D1P05	14:50-14:55(5`)	[Invited] **Estimation of Racket Grip Vibration from Tennis Video by Using Neural Network** *Kentaro Yoshida, Yuuki Horiuchi, Tomohiro Ichiyama, Seki Inoue, Yasutoshi Makino, and Hiroyuki Shinoda* The University of Tokyo, Japan
D1P06	14:55-14:58(3`)	**Skin Vibration-Based Tactile Tele-Sharing** *Tomohiro Fukuda and Yoshihiro Tanaka* Nagoya Institute of Technology, Japan
D1P07	14:58-15:01(3`)	**An Attempt of Displaying Softness Feeling Using Multi-Electrodes-Based Electrostatic Tactile Display** *Hirobumi Tomita[1], Satoshi Saga[2], Hiroyuki Kajimoto[3], Simona Vasilache[1], and Shin Takahashi[1]* [1]University of Tsukuba, Japan, [2]Kumamoto University, Japan, [3]The University of Electro-Communications, Japan

D1P08 **15:01-15:04(3`)**
Development of a Teleoperation Precision Grasping System with a Haptic Feedback Sensation on the User's Fingertip
Aiman Omer[1], Jamal Hamdi[2], and Atsuo Takanishi[1]
[1]Waseda University, Japan, [2]Umm Al-Qura University, Saudi Arabia

D1P09 **15:04-15:07(3`)**
Interactive Virtual Fixture Generation for Shared Teleoperation in Unstructured Environments
Vitalii Pruks and Jee-Hwan Ryu
Korea University of Technology and Education, Korea

D1P10 **15:07-15:10(3`)**
Preliminary Study on Gap Detection Threshold of Textured Surface
Seitaro Kaneko[1], Kohei Matumori[2], Naoki Saito[2], and Hiroyuki Kajimoto[1]
[1]The University of Electro-Communications, Japan, [2]Shiseido Grobal Innovation Centor, Japan

D1P11 **15:10-15:13(3`)**
VR Training System of Step Timing for Baseball Batter Using Force Stimulus
Wataru Sakoda[1], Toshio Tsuji[1], and Yuichi Kurita[1,2]
[1]Hiroshima University, Japan, [2]JST PRESTO, Japan

D1P12 **15:13-15:16(3`)**
Reducing 3D Vibrations to 1D in Real Time
Gunhyuk Park and Katherine J. Kuchenbecker
Max Planck Institute for Intelligent Systems, Germany

D1P13 **15:16-15:19(3`)**
A Soft Tactile Display Using Dielectric Elastomer Actuator for Fingertip Interaction
Jung-Hwan Youn, Seung-Mo Jeong, Young-Seok Choi, and Ki-Uk Kyung
Korea Advanced Institute of Science and Technology, Korea

D1P14 **15:19-15:22(3`)**
Configuration of Haptic Feedback Based Relief Robot System
Byung-jin Jung[1], Tae-Keun Kim[1], Geon Won[1], Dong Sub Kim[1], Jung-Hoon Hwang[1] and Jee-Hwan Ryu[2]
[1]Korea Electronics Technology Institute, Korea, [2]Korea University of Technology and Education, Korea

D1P15 **15:22-15:25(3`)**
TouchPhoto: Enabling Independent Picture-Taking and Understanding of Photos for Visually-Impaired Users
Yongjae Yoo, Jongho Lim, Hanseul Cho, and Seungmoon Choi
Pohang University of Science and Technology, Korea

D1P16 **15:25-15:28(3`)**
Human-Agent Shared Teleoperation: A Case Study Utilizing Haptic Feedback
Affan Pervez[1], Hiba Latifee[2], Jee-Hwan Ryu[2], and Dongheui Lee[1,3]
[1]Technical University of Munich, Germany, [2]Korea University of Technology and Education, Korea, [3]German Aerospace Center, Germany

D1P17 **15:28-15:31(3`)**
Induced Pulling Sensation by Synthesis of Frequency Component for Voice-Coil Type Vibrators
Takeshi Tanabe, Hiroaki Yano, and Hiroo Iwata
University of Tsukuba, Japan

D1P18 **15:31-15:34(3`)**
Hands-on Demonstration of Heterogeneous Haptic Texturing of Mesh Models Based on Image Textures
Arsen Abdulali, Waseem Hassan, Baek Seung Jin, and Seokhee Jeon
Kyung Hee University, Korea

D1P19 **15:34-15:37(3`)**
Real-time Mapping of Sensed Textures into Vibrotactile Signals for Sensory Substitution
Jaeyoung Park, Woo-seong Choi, and Keehoon Kim
Korea Institute of Science and Technology, Korea

D1P20 **15:37-15:40(3`)**
Towards Automatic Synthesis of Motion Effects
Sangyoon Han[1], Jaebong Lee[2], and Seungmoon Choi[1]
[1]Pohang University of Science and Technology, Korea, [2]NVIDIA, USA

D1P21 **15:40-15:43(3`)**
Development of a Rigidity and Volume Control Module Using a Balloon Filled with Dilatant Fluid
Saizoh Kojima, Hiroaki Yano, and Hiroo Iwata
University of Tsukuba, Japan

D1P22 **15:43-15:46(3`)**
Using Wearable Haptics for Thermal Discrimination in Virtual Reality Scenarios
Guido Gioioso[1], Maria Pozzi[1],[2], Mirko Aurilio[2], Biagio Peccerillo[1], Giovanni Spagnoletti[1], and Domenico Prattichizzo[1,2]
[1]University of Siena, Italy, [2]Istituto Italiano di Tecnologia, Italy

D1P23 **15:46-15:49(3`)**
A Wearable Hand Haptic Interface to Provide Skin Stretch Feedback to the Dorsum of a Hand
Hyunwoong Choi[1], Bukun Son[1], Sangyoon Kim[1], Yonghwan Oh[2], and Jaeyoung Park[2]
[1]Seoul National University, Korea, [2]Korea Institute of Science and Technology, Korea

D1P24 **15:49-15:52(3`)**
The Thermal Feedback Influencer: Wearable Thermal Display for Enhancing the Experience of Music Listening
Yuri Ishikawa[1], Anzu Kawazoe[2], George Chernyshov[1], Shinya Fuji[1], and Masashi Nakatani[1,3]
[1]Keio University, Japan [2]The University of California, USA, [3]JST PRESTO, Japan

D1P25 **15:52-15:55(3`)**
Midair Ultrasound Haptic Display with Large Workspace
Shun Suzuki, Masahiro Fujiwara, Yasutoshi Makino, and Hiroyuki Shinoda
University of Tokyo, Japan

D1P26 **15:55-15:58(3`)**
Haptopus : HMD with Built-In Pressure Sense Presentation Device by Suction Stimulus
Takayuki Kameoka, Yuki Kon, Takuto Nakamura, and Hiroyuki Kajimoto
The University of Electro-Communications, Japan

Live Demo Presentation Session 3 (D2A1~D2A25)

Premier Ballroom A+B

Session Chair	Kouta Minamizawa (Keio University, Japan)
Date	November 16, 2018 (Friday)
Time	10:00~11:15

D2A01 **10:00-10:03(3`)** **Human Rendezvous via Haptic Suggestion**
Gianluca Paolocci[1,2], Tommaso Lisini Baldi[1], and Domenico Prattichizzo[1,2]
[1]University of Siena, Italy, [2]Istituto Italiano di Tecnologia, Italy

D2A02 **10:03-10:06(3`)** **Circular Lateral Modulation in Airborne Ultrasound Tactile Display**
Ryoko Takahashi, Saya Mizutani, Keisuke Hasegawa, Masahiro Fujiwara, and Hiroyuki Shinoda
The University of Tokyo, Japan

D2A03 **10:06-10:09(3`)** **2D Braille Display Module Using Rotating Latch Structured Voice Coil Actuator**
Joonyeong Kim, Byung-Kil Han, and Dong-Soo Kwon
Korea Advanced Institute of Science and Technology, Korea

D2A04 **10:09-10:12(3`)** **Remotely Displaying Cooling Sensation Using Ultrasound Mist Beam**
Mitsuru Nakajima, Keisuke Hasegawa, Yasutoshi Makino, and Hiroyuki Shinoda
The University of Tokyo, Japan

D2A05 **10:12-10:15(3`)** **Efficiency of Haptic Search Facilitated by the Scale Division**
Hirotsugu Kaga and Tetsuya Watanabe
University of Niigata, Japan

D2A06 **10:15-10:18(3`)** **Body-Ownership Illusion by Gazing at a Blurred Fake Hand Image**
Hikaru Hasegawa[1], Shogo Okamoto[1], Nader Rajaei[1], Masayuki Hara[2], Noriaki Kanayama[3], Yasuhiro Akiyama[1], and Yoji Yamada[1]
[1]Nagoya University, Japan, [2]Saitama University, Japan, [3]National Institute of Advanced Industrial Science and Technology, Japan

D2A07 **10:18-10:21(3`)** **Allowable Range of Consistency Between the Visual and Tactile Presentations of a Linear Grating Texture**
Shun Yamaguchi, Seitaro Kaneko, and Hiroyuki Kajimoto
University of Electro-Communications, Japan

D2A08 **10:21-10:24(3`)** **Haptic Texture Authoring: A Demonstration**
Waseem Hassan, Arsen Abdulali, and Seokhee Jeon
Kyung Hee University, Korea

D2A09 **10:24-10:27(3`)** **SwarmGlove: A Wearable Tactile Device for Navigation of Swarm of Drones in VR Environment**
Luiza Labazanova, Akerke Tleugazy, Evgeny Tsykunov, and Dzmitry Tsetserukou
Skolkovo Institute of Science and Technology, Russian Federation

D2A10 **10:27-10:30(3`)** **Tactile Transfer Glove Using Vibration Motor**
Sang Hun Jung[1,2] and Bummo Ahn[1,3]
[1]Korea Institute of Industrial Technology, Korea, [2]Incheon National University, Korea, [3]University of Science and Technology, Korea

D2A11 **10:30-10:33(3`)** **LiquidVR - Wetness Sensations for Immersive Virtual Reality Experiences**
Kenichiro Shirota[1], Makoto Uju[1], Roshan Peiris[1], and Kouta Minamizawa[1]
Keio University Graduate School of Media Design, Japan

D2A12 **10:33-10:36(3`)** **Dental Simulator with Increased Z-Width of Haptic Rendering**
Hyojoon Park, Myungsin Kim, and Dongjun Lee
Seoul National University, Korea

D2A13 **10:36-10:39(3`)** **Random Forest for Modeling and Rendering of Viscoelastic Deformable Objects**
Hojun Cha, Amit Bhardwaj, Chaeyong Park, and Seungmoon Choi
Pohang University of Science and Technology, Korea

D2A14 **10:39-10:42(3`)** **A Teleoperation System for Reproducing Tactile Perception Using Frequency Channel Segregation**
Po-Hung Lin and Shana Smith
National Taiwan University, Taiwan

D2A15 **10:42-10:45(3`)** **Extended AirPiano: Visuohaptic Virtual Piano with Multiple Ultrasonic Array Modules**
Inwook Hwang and Sungryul Yun
Electronics and Telecommunications Research Institute, Korea

D2A16 **10:45-10:48(3`)** **Rigid-body Collaborative Manipulation Among Remote Users with Wearable Cutaneous Haptic Interfaces**
Myungsin Kim, WonHa Lee, Hyojoon Park, Junghan Kwon, Yong-Lae Park, and Dongjun Lee
Seoul National University, Korea

D2A17 **10:48-10:51(3`)** **Hapto-Band: Wristband Haptic Device Conveying Information**
Makiko Azuma, Takuya Handa, Toshihiro Shimizu, and Satoru Kondo
NHK (Japan Broadcasting Corporation), Japan

D2A18 **10:51-10:54(3`)** **Enhancing Haptic Experience in a Seat with Two-DoF Buttock Skin Stretch**
Arata Horie, Akito Nomura, Kenjiro Tadakuma, Masashi Konyo, Hikaru Nagano, and Satoshi Tadokoro
Tohoku University, Japan

D2A19 **10:54-10:57(3`)** **Spatiotemporal Tactile Display with Tangential Force and Normal Skin Vibration Generated by Shaft End-Effectors**
Takumi Shimada[1], Yo Kamishohara[1], Vibol Yem[1], Tomohiro Amemiya[2], Yasushi Ikei[1], Makoto Sato[1], and Michiteru Kitazaki[3]
[1]Tokyo Metropolitan University, Japan, [2]NTT Communications Science Laboratories, Japan, [3]Toyohashi University of Technology, Japan

D2A20 **10:57-11:00(3`)** **A Large-Scale Fabric-based Tactile Sensor Using Electrical Resistance Tomography**
Hyosang Lee[1], Kyungseo Park[2], Jung Kim[2], and Katherine J. Kuchenbecker[1]
[1]Max Planck Institute for Intelligent Systems, Germany, [2]Korea Advanced Institute of Science and Technology, Korea

D2A21 **11:00-11:03(3`)** **Haptic Eye: A Contactless Material Classification System**
Tamas Aujeszky, Georgios Korres, and Mohamad Eid
New York University Abu Dhabi, UAE

D2A22 **11:03-11:06(3`)** **Seesaw Type Actuator For Haptic Application**
Kahye Song, Jung-Min Park, and Youngsu Cha
Korea Institute of Science and Technology, Korea

D2A23 **11:06-11:09(3`)** **Conceptual Design of Soft and Transprent Vibrotactile Actuator**
Dong-Soo Choi and Sang-Youn Kim
Korea University of Technology and Education, Korea

D2A24 **11:09-11:12(3`)** **Baby Touch: Quantifying Visual-Haptic Exploratory Behaviors in Infants of Sensory-Motor Development**
Kazuki Sakurada[1], Akari Oka[1], Ritsuko Kiso[1], Leina Shimabukuro[1] Aoba Ueno[1], and Masashi Nakatani[1,2]
[1]Keio University, Japan, [2]JST PRESTO, Japan

D2A25 **11:12-11:15(3`)** **Exciting but Comfortable: Applying Haptic Feedback to Stabilized Action-Cam Videos**
Daniel Gongora, Hikaru Nagano, Masashi Konyo, and Satoshi Tadokoro
Tohoku University, Japan

Video Presentation (D2V1~D2V15)

Premier Ballroom A+B

Session Chair	Yasutoshi Makino (University of Tokyo, Japan)
Date	November 16, 2018 (Friday)
Time	13:30~14:00

D2V01 **13:30-13:32(2')** **Light Touch Postural Guidance Through a Robotic System**
Karna Potwar[1], Leif Johannsen[2], Matteo Saveriano[1,3], Martin Langer[1], and Dongheui Lee[1,3]
[1]Technical University Munich, Germany, [2]University of East Anglia, UK, [3]German Aerospace Center, Germany

D2V02 **13:32-13:34(2')** **Time Order Error vs Inter-Stimulus Interval and Stimulus Level During Force Comparison**
Amit Bhardwaj and Seungmoon Choi
Pohang University of Science and Technology, Korea

D2V03 **13:34-13:36(2')** **Design and Control of Vibration Feedback Display Using a Pneumatic Air-Jet**
Junghoon Park, Sangjoon J. Kim, and Jung Kim
Korea Advanced Institute of Science and Technology, Korea

D2V04 **13:36-13:38(2')** **Haptic Assistance Using Neural Networks for Driving Skill Enhancement and Training**
Hojin Lee, Hyoungkyun Kim, and Seungmoon Choi
Pohang University of Science and Technology, Korea

D2V05 **13:38-13:40(2')** **Recognition of Alphabet Objects by Sensing the Object Surface Using a Flexible Ferroelectric Sensor and Classifying the Sensor Signals Using a Neural Network**
Jaehun Kim, Minkook Choi, Taeyang Yang, Jisung Park, Ji-Hyun Kim, Jonghwa Park, Hyunhyub Ko, and Sung-Phil kim
Ulsan National Institute of Science and Technology, Korea

D2V06 **13:40-13:42(2')** **A Graphical Tactile Display for the Visually Impaired**
Yang Jiao, Xiaobo Lu and Yingqing Xu
Tsinghua University, China

D2V07 **13:42-13:44(2')** **Generalizing Pneumatic-Based Augmented Haptics Palpation Training Simulator**
Aishwari Talhan and Seokhee Jeon
Kyung Hee University, Korea

D2V08 **13:44-13:46(2')** **A Novel Shape Deforming Tactile Sensor for Safe Driving**
Sanghun Jung and Yeongjin Kim
Incheon National University, Korea

D2V09	13:46-13:48(2')	**How We Interact with Virtual Reality Drones?** *Sangyun Shin, Yong-Won Kang, Yong-Guk Kim* Sejong University, Korea
D2V10	13:48-13:50(2')	**A Movable Humanoid Robot for Presenting Walking Sensation of a Giant** *Shintaro Koiwa, Daisuke Morita, Yuki Enzaki and Hiroo Iwata* University of Tsukuba, Japan
D2V11	13:50-13:52(2')	**360° VR Fishing with Multimodal Interaction** *Byung-Wook Park, Do-Gyun Kim, and Soo-Mi Choi* Sejong University, Korea
D2V12	13:52-13:54(2')	**Increased Immersion Through Interacting with VR Players** *Min-soo Choi and Jun Park* Hongik University, Korea
D2V13	13:54-13:56(2')	**Rendering Virtual Window for Mobile Augmented Reality** *Jun Sol Oh and Jong Weon Lee* Sejong University, Korea
D2V14	13:56-13:58(2')	**Dismantling Simulation of Nuclear Power Plant Structures Based on Virtual Reality** *Myoung-Bae Seo* Korea Institute of Civil Engineering and Building Technology, Korea
D2V15	13:58-14:00(2')	**A Conceptual Design of a Haptic Glove with Soft Vibrotactile Actuators** *Won-Hyeong Park[1], Seokhee Jeon[2] and Sang-Youn Kim[1]* [1]Korea University of Technology and Education, Korea, [2]Kyung Hee University, Korea

IX. Abstract

Session 1 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

10:00-10:03 **D1A01**

Drone Based Kinesthetic Haptic Interface for Virtual Reality Application

Muhammad Abdullah, Ahsan Raza, Yoshihiro Kuroda*, and Seokhee Jeon

Department of Computer Science and Engineering, Kyung Hee University, Republic of Korea * Graduate School of Engineering Science, Osaka University, Japan
{abdullah, ahsanraza, jeon}@khu.ac.kr, ykuroda@bpe.es.osaka-u.ac.jp

A drone is capable of actively generating kinetic energy and can apply force in a required direction. If a drone can interact physically with a user in a well-controlled manner, it can be used as a force reflecting haptic interface. In this demonstration we will highlight the capabilities of a drone based haptic device through a bouncing ball application. Here the user can play with a virtual ball and the drone renders the impact force of the ball on the user's hand. For the scope of this demonstration during free fall, the ball is assumed in ideal 1D motion and only the force of gravity acts on the ball. The ground impact is calculated for an immovable surface and the rebound force is based on the energy conservation factor.

Keywords: Haptic Interfaces, Encountered-type, Drone, Kinesthetic, Virtual Reality

Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:03-10:06 D1A02

Encounter-type Haptic Feedback System Using an Acoustically Manipulated Floating Object

Takuro Furumoto[1], Yutaro Toide[1], Masahiro Fujiwara[1], Yasutoshi Makino[1], and Hiroyuki Shinoda[1]

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{toide, furumoto}@hapis.k.u-tokyo.ac.jp,Masahiro_Fujiwara@ipc.i.u-tokyo.ac.jp,
{yasutoshi_makino, hiroyuki_shinoda}@k.u-tokyo.ac.jp

This paper proposes a novel encounter-type haptic feedback system for virtual reality (VR) utilizing a balloon that can move around in three dimensional space. By locating a balloon at a position corresponding to that of virtual object, the user wearing a head mounted display feels a contact sensation when his or her hand touches a virtual object. The balloon is remotely actuated by ap-plying acoustic radiation pressure. The users can touch a VR object directly by their hands or via controllers or rods. We constructed a prototype system and conducted a preliminary experiment.

Keywords: Encounter-type Haptic Feedback, Airborne Ultrasound, Floating Object, Virtual Reality.

Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:06-10:09 D1A03

A Surface Texture Display for Flexible Virtual Objects

Lei Lu, Yuru Zhang, Xingwei Guo and Dangxiao Wang

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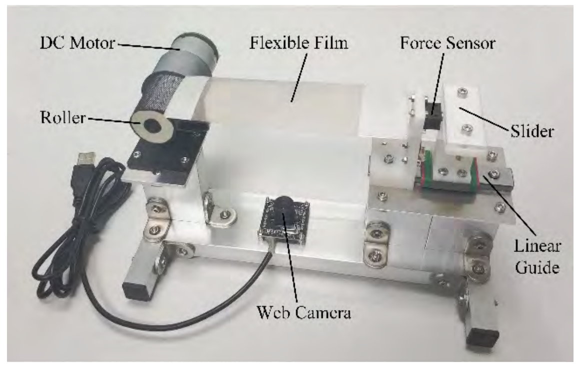
Beijing Advanced Innovation Center for Biomedical Engineering, Beihang University, Beijing 100191, China
hapticwang@buaa.edu.cn

This paper presents a tactile device for displaying surface texture of flexible virtual objects. The texture is simulated using electrovibration effect produced by a flexible film. The deformation of the film is controlled by a DC motor to generate desired softness according to applied finger force. A proto-type of the device is developed and integrated with a virtual environment. We show the application of the display using an online shopping scenario.

Keywords: Tactile Device, Electrovibration, Flexible Object, Texture Display, Softness Display.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:09-10:12 D1A04

Tactile Perception Effects of Shear Force Feedback and Vibrotactile Feedback on Virtual Texture Representations

Chia-Wei Lin and Shana Smith

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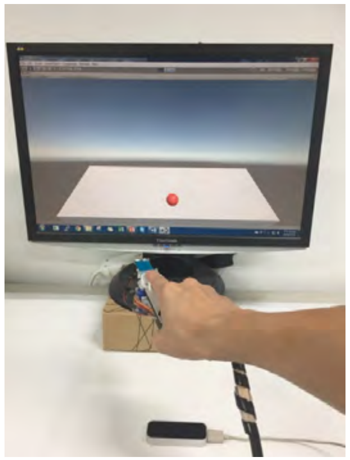
Nowadays, haptic feedback technology has been applied to many applications to help users acquiring more information concerning surrounding environments. In this research, a haptic feedback device was developed to combine shear force feedback and vibrotactile feedback to create realistic lateral stroking sensations to user's index fingerpad in virtual reality environments. The shear force feedback simulates the friction force which stretches the skin of the fingerpad during stroking on an object's surface, and the vibrotactile feedback simulates the surface texture information of the object in the real world. The user test shows that adding shear force feedback can increase the realism and accuracy of the virtual texture discrimination, compared with only vibrotactile feedback presented.

Keywords: Haptic Feedback, Shear Force Feedback, Vibrotactile Feedback



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:24-11:27 D1A05

Whole Body Haptic Experience Using 2D Communication Wear

Kohki Serizawa[1], Yuichi Masuda[1], Shun Suzuki[1], Masahiro Fujiwara[1], Akihito Noda[2], Yasutoshi Makino[1],and Hiroyuki Shinoda[1]

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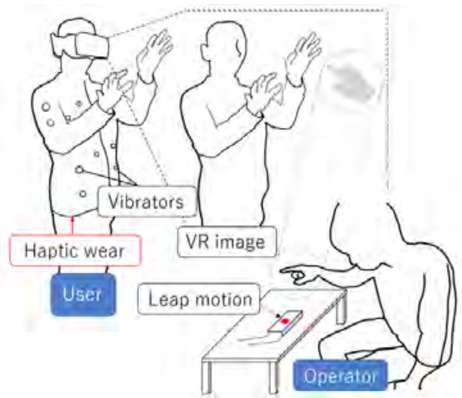
[2] Department of Mechatronics, Nanzan University
{serizawa, masuda, suzuki, yosutoshi_makino, hiroyuki_shinoda}@k.u-tokyo.ac.jp, Masahiro_Fujiwara@ipc.i.u-tokyo.ac.jp, anoda@nanzan-u.ac.jp

In recent years, a two-dimensional communication (2DC) technology has been proposed which performs communication and power supply with a large number of functional sensor/actuator units attached on cloth without individual connection. It is easy to make wearable system by using the 2DC cloth. Many vibrators can be attached at any place on the sheet to realize whole body tactile displaying wear. Various tactile expressions can be achieved on the whole body such as being stroked, pressed, grabbed, and so on. In this research, we propose a VR system which enables a user to be touched his/her body synchronized with VR images by using the whole body haptic wear. Users can experience various tactile sensations to their whole body through easily wearable garment device.

Keywords: Virtual Reality, Wearable Device, Whole Body Ttactile Display, Two-dimensional Communication.



Session 1 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

10:15-10:18 **D1A06**

A Haptic Feedback Touch Panel

Seung Mo Jeong[1], Dongbum Pyo[2], Ki-Uk Kyung[1], and Sungryul Yun[2]

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[2] Electronics and Telecommunications Research Institute, Daejeon, Republic of Korea
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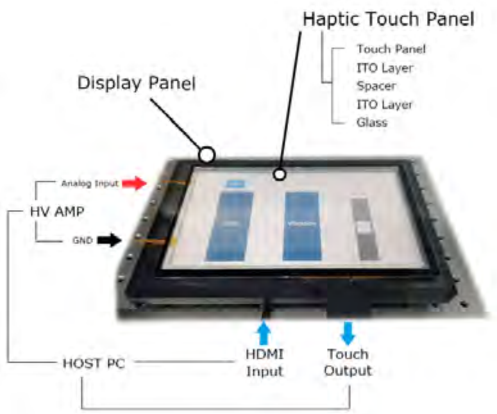
We present a haptic feedback touch panel. This actuator is capable of generating haptic stimulations, and thus can be used as a vibrotactile display. It is composed of two layers, a touch panel and a glass panel, each coated with ITO electrode. Unlike conventional vibration motors, it does not require an additional mass. The application of voltage induces electrostatic forces and consequently creates vibration. Through voltage control, vibration patterns of varying intensity and frequency can be generated. The demonstrated actuator exhibits stimulations of fast response time, and strong vibration acceleration of 5 G and normal dis-placement of 100μm.

Keywords: Haptics, Vibrotactile Display, Electrostatic Actuator, Touch Panel



Session 1 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

10:18-10:21 **D1A07**

LinkGlide: A Wearable Haptic Display with Inverted Five-Bar Linkages for Delivering Multi-contact and Multi-modal Tactile Stimuli

Miguel Altamirano Cabrera and Dzmitry Tsetserukou

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LinkGlide is a novel wearable palm-worn tactile display to deliver multicontact and multimodal stimuli at the user's palm. The array of inverted five-bar linkages generate three independent contact points to cover the whole palm area. The independent contact points allow to control different patterns in each of the points and provide multimodal tactile feedback, such as slippage, force vector, pressure, temperature, and vibration. With this novel haptic device, we can potentially achieve a highly immersive VR experience and make it more interactive.

Keywords: Haptic Device, Multimodal Stimuli, Multicontact Stimuli, Virtual Reality, Wearable Display.

Session 1 Live Demo

Premier Ballroom A+B | Thu, October 15, 2018, 10:00-11:30

10:21-10:24 D1A08

Pneumatic Actuated Haptic Glove to Interact with the Virtual Human

Aishwari Talhan[1]*, Hwangil Kim[1]**, Sanjeet Kumar[1]**, Ahsan Raza[1]*, and Seokhee Jeon[1]*

[1] Department of Computer Science and Engineering, Kyung Hee University, Deogyeong-daero, Giheung-gu, Yongin-si, Gyeonggi-do, Republic of Korea

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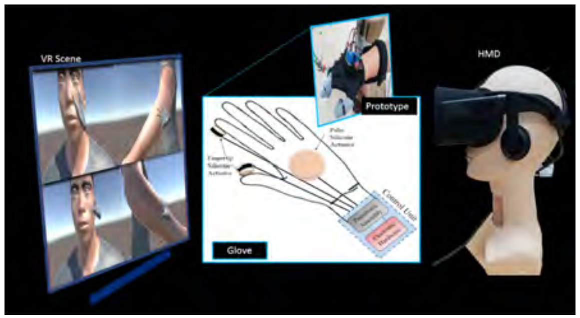
Realistic haptic feedback of virtual human avatars would make the virtual world more alive. In the direction of this goal, we focused on making pneumatic actuated haptic glove to augment the perception of human skin response. We have designed a pneumatic controlled actuation with silicone-made cavities (end-effectors), which are situated at the fingertips and the center of the palm embedded within the glove. Various positive air pressure is used to inflate the chambers to perceive soft skins with different shape, stiffness, and homogeneity. The palm actuator is to provide feedback for a grasping interaction, whereas the fingertip actuators are used to generate finger-based touch, e.g., pinching with two fingers. The VR environment with the HMD is designed to improve the immersive experience. Altogether, the system is controlled wirelessly. In this work, we will demonstrate the various scenario of human body parts in which the user can interact with and touch the human to perceive the natural haptic feedback from the skin.

Keywords: Pneumatic Glove, Soft Haptics, Skin Display, Augmented Reality, Wearable Interfaces.



Session 1 Live Demo

Premier Ballroom A+B | Thu, October 15, 2018, 10:00-11:30

10:24-10:27 D1A09

Wearable Haptic Device that Presents the Haptics Sensation of a Finger Pad to the Forearm and Fingertip

Taha Moriyama and Hiroyuki Kajimoto

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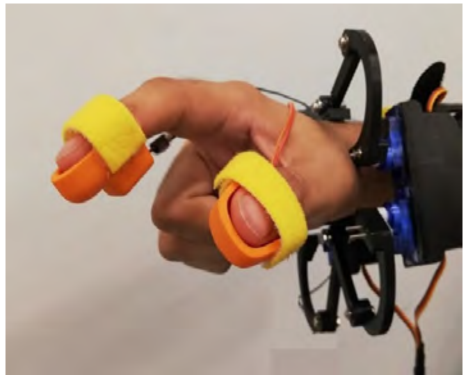
Many methods have been proposed for presenting the tactile sensations of objects in a virtual reality environment. In particular, many wearable tactile displays for the fingers such as fingertip-mounted haptics display and glove-type haptics displays have been developed. We developed a device for a new haptic presentation method that presents the haptic sensations of the fingertip on the fingers and forearm rather than only the fingertip. The device adopts a vibrator on the fingertip to present positional and collisional information, and a five-bar linkage mechanism on the arm to present the strength and direction of the force. In contrast to fingertip-mounted haptic displays, the combination of the two de-vices enables the direction of force to be expressed using only a small device at the fingertip. Our preliminary test revealed that it is easy for users to associate the haptics sensation provided to the forearm with the sensations of their own fingertip.

Keywords: Virtual Reality, Tactile Displays, 5 Bar-link Mechanism, Vibration.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:27-10:30 **D1A10**

Thermal-Radiation-Based Haptic Display

- Laser-Emission-Based Radiation System -

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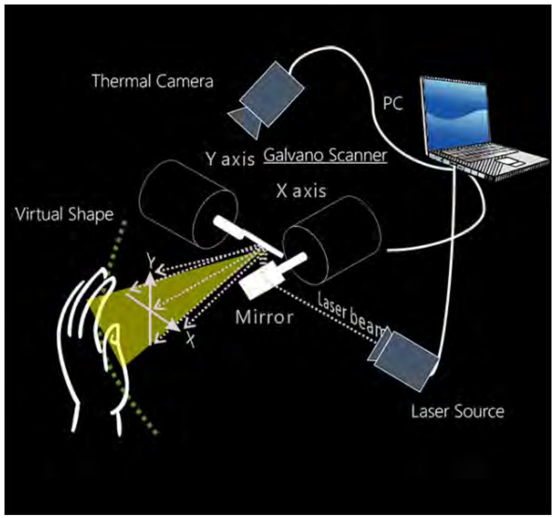
When a human places his/her hands over a source of heat, his/her hands become warm owing to thermal radiation. We employ spatially controlled thermal radiation to display a virtual shape. At a temperature near the nociceptive temperature, a person tends to avoid a heated region. Using this region, our proposed system displays the virtual 3-dimensional region. In this paper, we propose the laser-emission-based thermal radiation system for farther range and precise projection.

Keywords: Thermal Radiation, Haptic Display, Laser Projector.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:30-10:33 **D1A11**

Spatial Haptic Feedback Virtual Reality Controller for Manipulator Teleoperation Using Unreal Engine

Jae Min Lee[1], Dong Yeop Kim[1], and Jung-Hoon Hwang[1]

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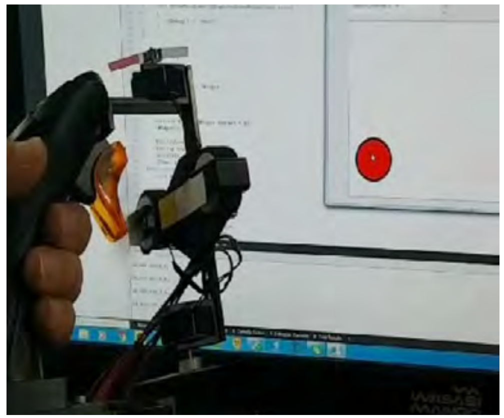
Virtual reality (VR) gives immersion to operators in teleoperated robot system, and many researchers have studied its possibility for better performance. We have studied the vision system for teleoperation, and tried to transfer visual information to the operators. In this paper, we suggested other information channel methodologies. One is haptic feedback for pinching of human operator. It presents the force of the slave robot gripper. The other is vibration motors on our hand set and elbow orthesis. They give spatial information incorporating with virtual walls. We merges these haptic feedbacks with VR Tracker, and every information is integrated to Unreal Engine for virtual reality.

Keywords: Virtual Reality, Haptic Feedback, Vibration cue, Teleoperation, Master(Controller).



Session 1 Live Demo

Premier Ballroom A+B | Thu, October 15, 2018, 10:00-11:30

10:33-10:36 | **D1A12**

A Two-DOF Impact Actuator for Haptic Interaction

Sangyoon Kim[1], Bukun Son[1], Yongheon Lee[2], Hyunwoong Choi[1], Woochan Lee[3] and Jaeyoung Park[2]

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[3] wlee@inu.ac.kr

This paper presents a new actuator mechanism that can create a planar two-DOF impact and vibrotactile stimuli with wide frequency bandwidth. The proposed device utilizes one permanent magnet and two different sets of solenoids, direction controlling solenoids and a central solenoid. The direction controlling solenoids are two sets of facing solenoid pair, which attract the permanent magnet from a neutral position toward the housing, to create an impact. The central solenoid increases the magnet's potential energy, resulting in a faster movement toward the outside of the neutral position and thus increasing the amount of impact. The central solenoid can be utilized to create an attractive force to move the magnet back to the neutral position after the impact. When creating an impact in an arbitrary orientation, two sets of solenoid pair are used to decide the initial force direction, which is parallel to the magnet's trajectory until an impact. The actuator can be used as a tactor by controlling the impact cycle.

Keywords: Two DOF, Impact Actuator, Solenoid.

Session 1 Live Demo

Premier Ballroom A+B | Thu, October 15, 2018, 10:00-11:30

10:36-10:39 | **D1A13**

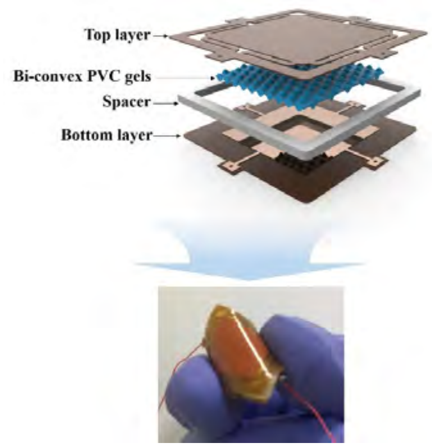
Conceptual Design of Soft Thin Self-sensing Vibrotactile Actuator

SiHo Ryu[1], Dong-Soo Choi[1] and Sang-Youn Kim[1]

[1] Interaction Laboratory of Advanced Technology Research Center, Korea University of Tech-nology and Education, Cheonan, South Korea
sykim@koreatech.ac.kr

This paper proposed a conceptual design of a soft, thin self-sensing vibrotactile actuator, which can measure applied pressure and can generate haptic information. The proposed self-sensing actuator is composed of two electrodes and a bi-convex patterned PVC gel. A PVC gel, which is one of the dielectric electro-active polymers (EAPs), was fabricated by solution-casting with a wavy-patterned mold to improve sensing and vibrotactile actuation performances. The results show that the proposed self-sensing actuator effectively measures applied pressure, and generates vibration force to stimulate human mechanoreceptors.

Keywords: Multi-functional Elastomer, Wearable Device, Transducer.



Session 1 Live Demo

Premier Ballroom A+B — Thu, October 15, 2018, 10:00-11:30

10:39-10:42 — D1A14

A Novel Haptic Interface for the Simulation of Endovascular Interventions

Hafiz Ramli[1], M. Iqbal Saripan[1] and Fernando Bello[2]

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[2] Center for Engagement and Simulation Science, Imperial College London, London SW10 9NH, United Kingdom

Endovascular interventions are minimally invasive surgical procedures that are performed to diagnose and treat vascular diseases using flexible instruments known as guidewire and catheter. A popular method of developing the skills required to manipulate the instruments successfully is through the use of virtual reality (VR) simulators. However, the interfaces of current VR simulators have several shortcomings due to limitations in the instrument tracking and haptic feedback design. A major challenge in developing training simulators for endovascular interventional procedures is to unobtrusively access the central, co-axial guidewire for tracking and haptics. In this work, we designed a haptic interface using novel approaches to both. Instrument tracking is performed using a combination of an optical sensor and a transparent catheter. Haptic feedback is supplied by both off-the-shelf actuators and a bespoke electromagnetic actuator embedded within the catheter hub. Initial test results by expert interventionists have shown positive responses and further development is ongoing.

Keywords: Haptic Interface, Endovascular Interventions, Simulator Training

Session 1 Live Demo

Premier Ballroom A+B — Thu, October 15, 2018, 10:00-11:30

10:42-10:45 — D1A15

Collaborating through Magic Pens: Grounded forces in large, overlappable workspaces

Soheil Kianzad[1] and Karon E. MacLean[1]

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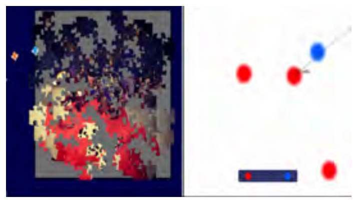
We demonstrate a grounded, planar force feedback device (the Magic Pen) via applications in collaborative task coordination and learning. The pen's ballpoint drive achieves force-feedback grounding through rolling frictional contact on an arbitrary 2D surface. Its current tether provides communications and power, to be replaced in the near future with wireless and battery respectively. The ballpoint drive can render virtual features such as constraints and active guidance with no restriction on 2D workspace size or location. Together, these features give Magic Pens unique capabilities: multiple users can use them flexibly in either co-located or remote collaboration, e.g., reaching in and around one another to access the same point; and (untethered) they will be fully nomadic force feedback devices.

We will demonstrate a pair of Magic Pens in two collaborative scenarios:

- **Virtual Jigsaw Puzzle:** Working together to complete a task, users experience constraints (e.g., board edge; repelled from a partner's piece); and guidance (e.g., one user can direct a partner's attention to another piece).
- **Virtual Electrostatic Lab:** The Pen conveys electrostatic forces between charges. Multiple users can place and drag point charges in the same field, and feel the changing attractive repulsive forces to understand their inverse square relation to separation.

Keywords: Grounded Force Feedback, Large Workspace, Haptic Stylus, Computersupported Collaborative Work, Ballpoint Drive, Nomadic Interface.



Premier Ballroom A+B | **Thu, October 15, 2018, 10:00-11:30**

10:45-10:48 | **D1A16**

A Ball-type Haptic Interface to Enjoy Sports Games

Takuya Handa[1], Makiko Azuma[1], Toshihiro Shimizu[1] and Satoru Kondo[1]

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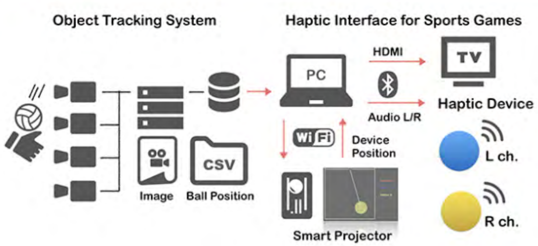
handa.t-es@nhk.or.jp

We have developed a ball-type haptic interface that enables users to enjoy watching sports games more actively. For a game such as beach volleyball, the viewer manipulates the ball-type device on the surface of a table where the court is displayed. The ball impact is presented as a vibration when he/she moves the device to where the player is hitting the ball. In this demonstration, we pro-pose a viewing style to enjoy the speed and impact of sports games more actively.

Keywords: Haptics, Impact Vibration, Human Interface, Sports.



Premier Ballroom A+B | **Thu, October 15, 2018, 10:00-11:30**

10:48-10:51 | **D1A17**

Highly Stretchable Optical Strain Sensor for Human Motion Detection

Jaeyeon Jeong[1], Taeyeon Kim[1] and Ki-Uk Kyung[1]

[1] Korea Advanced Institute of Science and Technology (KAIST), Yuseong-Gu, Daejeon, Re-public of Korea
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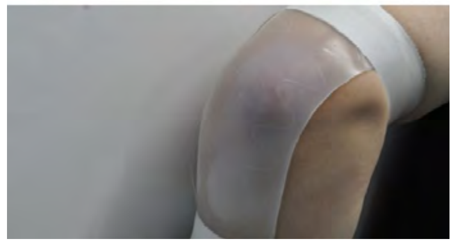
Soft sensors have been highlighted in human motion estimation due to its high flexibility and stretchability. This paper proposes a polymer-based optical strain sensor that has large stretchability over 100% strain to estimate human motion. We have designed the stretchable strain sensor by embedding a waved optical fiber into soft polymer substrates. Changing intensity of light passes through the optical fiber by applying variation of bending curvature, the sensor can estimate its strain from the magnitude of light intensity. The sensor can be easily mounted on human skin and can estimate pose of wrists or elbows.

Keywords: Soft Sensor, Optical Fiber, Polymer, Human Motion Detection.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:51-10:54 D1A18

Improvement of Walking Motivation by Vibratory Display Powered by an Ankle-Worn Generation Device

Minatsu Sugimoto, Hiroo Iwata, and Hiroya Igarashi

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We propose an ankle-worn power generation device that supplies power to a vibration speaker to improve walking motivation. With the walking motion of the user, the vibration speaker is driven. In this paper, we propose an interface of a wearable generator that obtains electric power from ankle movement during walking by means of attaching a device with power generation functions to the ankle, and we report the performance evaluation result of the ankle-worn power generation device. In addition, as a part of investigating factors that improve walking motivation, we also describe the results of a questionnaire on walking and its considerations, and the approach to the design-oriented aspects assuming scenarios for future use.

Keywords: Vibration Speaker, Wearable Harvester, Walking Motivation.

Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:54-10:57 D1A19

Deformation and Friction: 3D Haptic Asset Enhancement in E-Commerce for the Visually Impaired

Hong Jian Wong[1], Kian Meng Yap[1], Wei Kang Kuan[1], Andrew Jian Yue Chan[1], Sam-uel John Omamalin[1], Alyssa Yen-Lyn Ding[1], Mei Ling Soh[1], and Ahmad Ismat Bin Abdul Rahim[2]

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The availability of Internet resources is currently restricted for the visually impaired (VI) due to the primarily visual-based information transfer methods afforded by modern connectivity devices. A haptic device was suggested in enabling the VI to feel the shape of the assets with a stylus, gaining a more concrete perception of formerly purely visual depictions of said assets. This paper describes the trials of an e-commerce website, which enables the use of this hap-tic technology to feel products of which VI users intend to purchase. Additional features that were recently implemented include the ability to deform products where appropriate, and frictional surfaces depending on the surface material. A majority of VI testers provided positive impressions towards the direction of development with fine-tuning necessary to improve asset deform and friction quality, while giving additional feedback for further improvements to the website.

Keywords: Visually Impaired, E-Commerce, Instant Force Feedback, Haptics, Deformation, Friction, H3D.

Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

10:57-11:00 D1A20

Controlling Robot Vehicle Using Hand-Gesture with Mid-Air Haptic Feedback

Tao Morisaki[1], Masahiro Fujiwara[1], Yasutoshi Makino[1] and Hiroyuki Shinoda[1]

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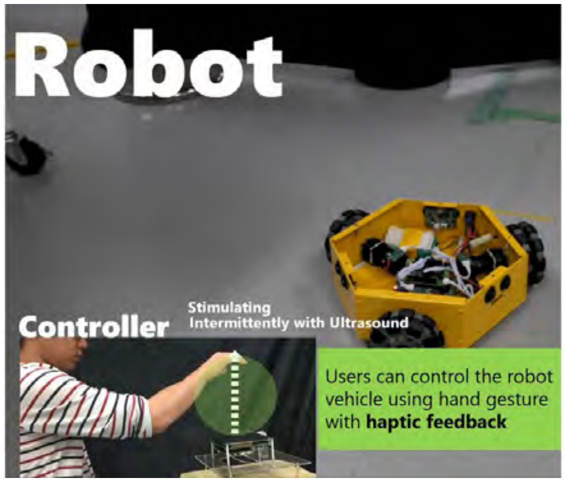
In this paper, we improve the usability of hand-gesture control system of robot vehicle using mid-air haptic feedback. The system notifies a user of three states of the system with haptic feedback: A) the user's hands exists in a recognition range of the system, B) the robot vehicle is controllable and C) the user is controlling the robot vehicle. As a result, haptic feedback improved the usability and the variation of haptic feedback was not perceived completely.

Keywords: Mid-Air Haptic Feedback, Hand-Gesture Control, Usability.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:00-11:03 D1A21

Gravity Ball: A Virtual Trackball with Ultrasonic Haptic Feedback

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This paper presents a virtual trackball named Gravity Ball. By touching, grabbing, pushing, dragging, swiping, and scrolling the Gravity Ball, a user can conduct multi-mode manipulations on a 3D object via a single interaction medium. Physics-based haptic feedback is provided through ultrasonic-based mid-air haptic device, enabling the user more immersive interaction and more precise manipulation. Potential of the concept is demonstrated through a gun shooting video game.

Keywords: AR, VR, Trackball, UltraHaptics.

Session 1 **Live Demo**

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

11:03-11:06 **D1A22**

Data-driven Multi-modal Haptic Rendering Combining Force, Tactile, and Thermal Feedback

Seongwon Cho[1], Hyejin Choi[1], Sunghwan Shin[1], and Seungmoon Choi[1]

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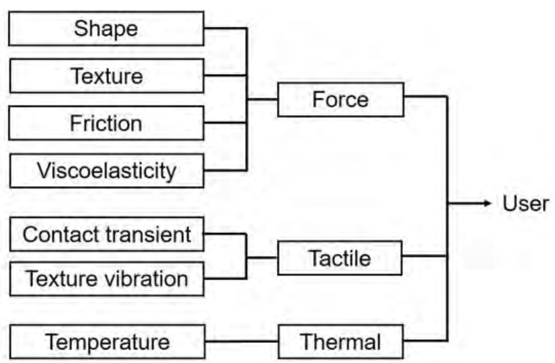
We introduce a data-driven multi-modal haptic rendering system which simultaneously presents force, tactile, and thermal feedback. To handle force, tactile, and thermal feedback together, a vibration actuator and a peltier module are attached to a force-feedback device. Several haptic properties of an object shape, texture, friction, and viscoelasticity are considered as components of force rendering. About tactile feedback, we combine contact transient and texture vibration when the user contacts and explores a surface. Thermal sensation between skin and an object rendered by considering both heat flux and the initial temperatures of the object and skin. Rendering models for all the modalities are collected from real interaction and modeled in a data-driven manner. We expect that our multi-modal rendering system improves realism of haptic sensation in the virtual environment.

Keywords: Multi-modal Rendering, Data-driven Model, Haptic Feedback, Rendering.



Session 1 **Live Demo**

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

11:06-11:09 **D1A23**

Painting Skill Transfer Through Haptic Channel

Ahsan Raza, Muhammad Abdullah, Waseem Hassan, Arsen Abdulali, Aishwari Talhan, and Seokhee Jeon

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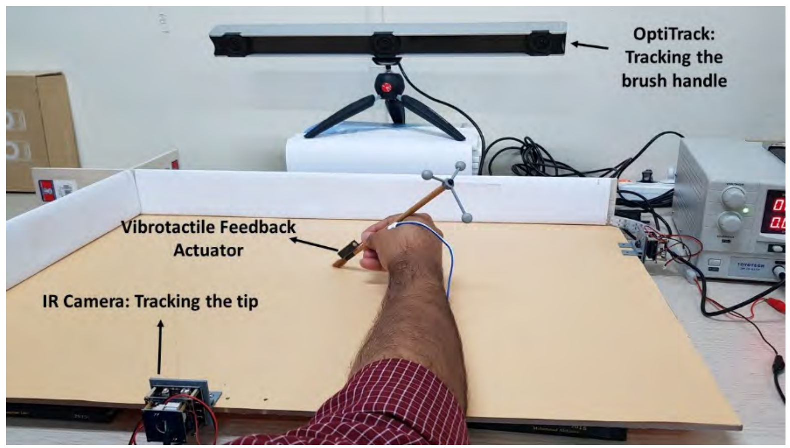
In this paper, we focused on designing a system that can guide and train a user in painting an art work. Initially, we aim to develop a system which can guide a user with basic strokes of Korean language calligraphy. The proposed system is implemented in a sequence of three steps. Firstly, we collected the data from the surfaces of the canvas and different orientations of a painting brush. Then based on the data, a relationship is established among the collected parameters by building a machine learning model. Finally, actuators attached with the handle of the brush provides the vibrotactile and force feedback based on the built model. The actuator guides the user in order to paint the required object.

Keywords: Haptic Painting, Painting Skill, Haptic Guidance, Deep Learning, Haptic Rendering.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:09-11:12 D1A24

A Hand Wearable Device Used in Local Curvature Recovery

Tao Zeng[1,2] and Shizhen Huang[1,2]

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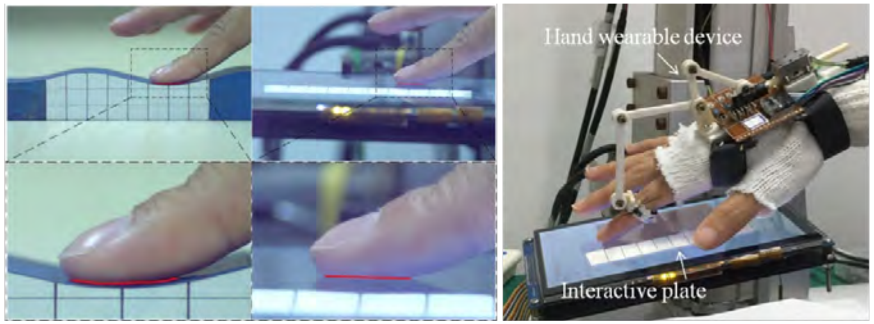
In virtual curvature perception, extrusion-type curvature reproduction that refers to extruding the fingertip by a plate to render skin and muscle deformation so as to obtain the sense of curvature, is the way that with favorable effects. However, as the extrusion stimulus is always a rigid plate, the contact surface between the finger and the plate is a plane, only height difference and attitude difference are considered but not the local curvature. This work presents a hand wearable device which is used to recover local curvature by lifting up or pressing down the finger according to touch position in the process of exploring, which is a supplement to traditional extrusion-type curvature reproduction.

Keywords: Curvature Reproduction, Local Curvature, Hand Wearable Device.



(a) (b)

Fig. 1. (a) Difference of second-order information between touching on physical sinusoidal model and touching on interactive plate. (b) The hand wearable device and its application.

Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:12-11:15 D1A25

Signal Generation for Vibrotactile Display by Generative Adversarial Network

Shotaro Agatsuma[1], Junya Kurogi[2], Satoshi Saga[2], Simona Vasilache[1], and Shin Takahashi[1]

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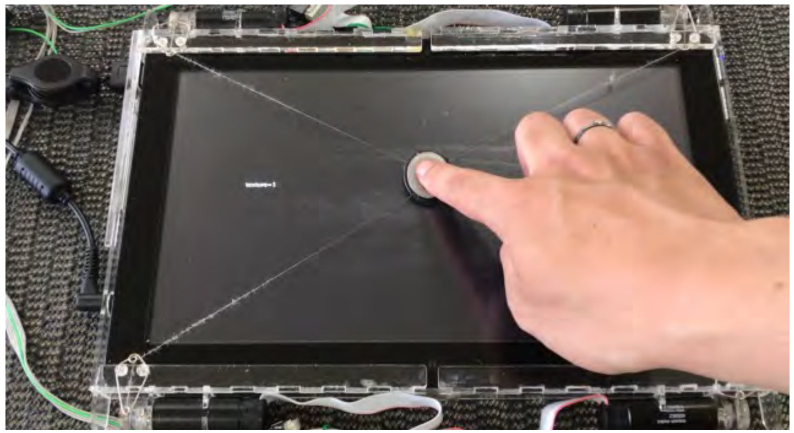
Various methods have been proposed for collecting vibrotactile information. However, the collection procedure requires manual scanning of texture, collection of vast information may be difficult. Owing to the fast progress of machine learning technologies, even with little information, there is a possibility to generate further virtual data from existing collected data by using Generative Advisory Network (GAN). In this paper, we proposed a generation model of vibrotactile information by Deep Convolutional GAN (DCGAN) from the collected acceleration data. We generated various vibrotactile information by using the proposed DCGAN, and compared the tactile stimulation based on the generated data with the actual texture.

Keywords: Vibrotactile Information, Acceleration, DCGAN.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:15-11:18 D1A26

Shape and Stiffness Sensation Feedback with Electro-tactile and Pseudo-Force Presentation When Grasping a Virtual Object

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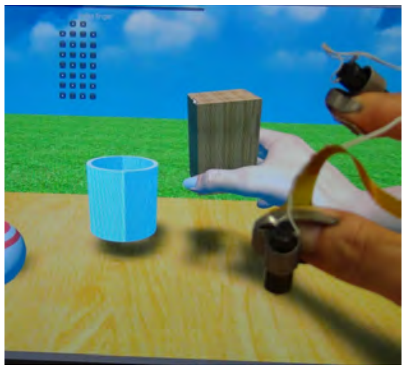
We developed a 3D virtual reality system with electro-tactile and pseudo force stimulation for presenting sensation of shape and stiffness of an object to the tips of thumb and index finger. Our system comprises two fingertip gloves and a finger-motion capture device. Each glove provides a shape sensation via an electrode array of the electro-tactile display and pseudo-force sensation via asymmetric vibration of a DC motor. In our demo experience, participants can grasp a 3D virtual object and perceive both tactile feedback on the fingertips and visual feedback of rigid or deformable shape of the objects showing on the monitor. Our previous study confirmed that the initial vibration amplitude, which represents the reaction force when the thumb and the index finger initially contact the surface of an object, effects to the intensity of stiffness perception. In the demo, we design several kinds of initial vibration amplitude, shape, and shape deformation for different perception of shape and stiffness.

Keywords: Stiffness, Shape Sensation, Pseudo Force, Motor-Rotational Acceleration, VR Interaction.



Session 1 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 10:00-11:30

11:18-11:21 D1A27

Presenting a Pseudo-force Sensation Using a Clothespin

Masahiro Miyakami[1] and Hiroyuki Kajimoto[1]

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Here, we describe a phenomenon in which a pseudo-force sensation can be elicited by pinching the finger of a participant using a clothespin. When the clothespin pinches the finger from the palm side, a pseudo-force is felt in the direction in which the hand naturally bends, and when the clothespin pinches the finger from the back of the hand, the pseudo-force is felt in the extension direction. We investigated the occurrence frequency of this phenomenon and assessed the possibilities for use as a human interface. We examined the relationship between the location/pinch direction and force/posture elicited. As a result, we confirmed that a pseudo-force sensation occurred in the extension and bending directions, except for when the distal phalanx was pinched from the back side of the hand. In future work, we plan to investigate the cause of this phenomenon by developing skin deformation-based or compression based devices, with the goal of application in VR environments.

Keywords: Clothespin, Pseudo Force, Human Interface, Virtual Reality.

Session 1 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

11:21-11:24	D1A28

Presentation of Stepping Up and Down by Pneumatic Balloon Shoes Device

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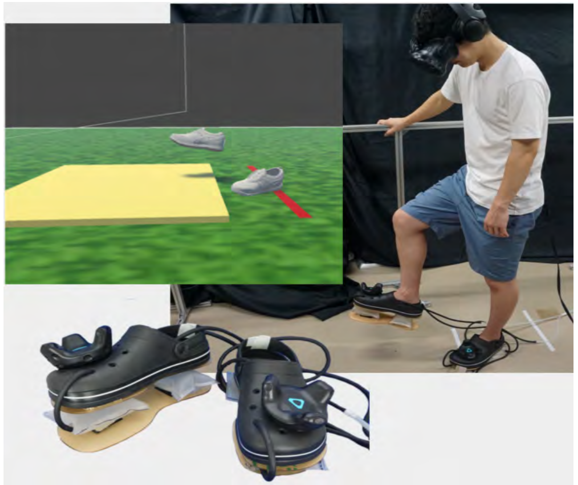
In recent years, to have a realistic experience in the VR space, various study and contents employed the sense of walking. In this study, we developed a light weight shoe-type VR device for uneven height presentation using pneumatically driven balloons. While previous shoe-type walking simulation device becomes heavy, the balloon enabled light-weight wearable device. The weight of the presenting device was about 430g on one foot and the thickness of the shoe sole when non-operation was about 1.0cm. We report the method of presenting stepping on the stage by the shoes device.

Keywords: Locomotion Device, Pneumatic Balloon, Height Presentation, Shoes Device, VR Device.



Session 1 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 10:00-11:30**

10:12-10:15	D1A29

Analysis and design of surgical instruments for the development of a shoulder joint arthroscopic surgery simulator

Tae-Keun Kim[1], Geon Won[1], Jong-bum Park[1], Saehan Kim[1], Byung-jin Jung[1], Jung-Hoon Hwang[1*], Jaeuk Ahn[2], Minju Song[2] and Chang Nho Cho[3]

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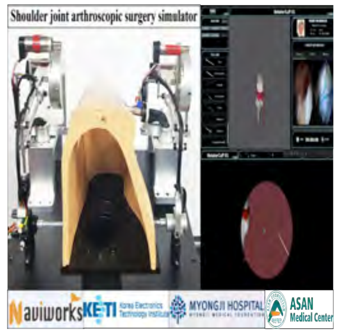
Arthroscopic surgery is a minimally invasive surgery which provides a number of benefits, such as faster recovery and minimal incision. However, due to the limited field of view caused by the use of an arthroscope and the difficulties associated with maneuvering surgical instruments through a narrow portal, a highly skilled surgeon is often required. To cope with this, various surgical training simulators have been developed. This study proposes novel designs for the surgical instruments to be used for a shoulder joint arthroscopic surgery simulator. In-depth analysis on the surgical instruments used in the shoulder joint arthroscopic surgery training has been conducted, and novel surgical instruments for a training simulator is developed. The developed surgical instrument is equipped with sensors and actuators to deliver haptic sensation to the users.

Keywords: Haptic Device, Arthroscopic Surgery, Surgery Simulator, Surgical Instrument, Haptic Simulator



Session 1 Live Demo

Premier Ballroom A+B — Thu, October 15, 2018, 10:00-11:30

11:27-11:30 — D1A30

Development of Virtual Diving Interface by Flutter Kick Motion

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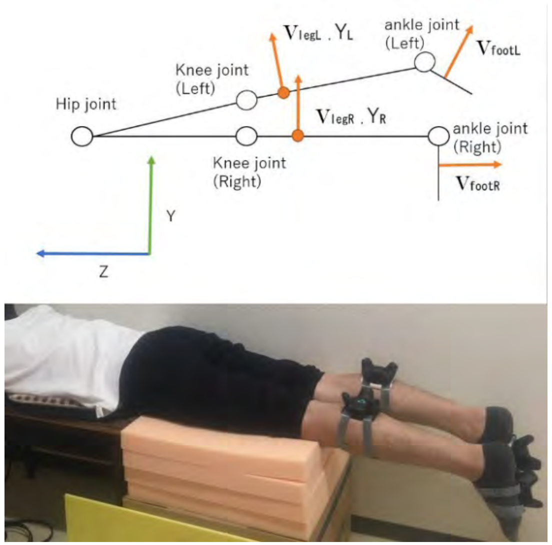
We propose an interface which user can move in virtual reality (VR) space. User equips four vive trackers for tracking position and rotation of foot and leg. If user move legs strongly, VR avatar move forward and if user bend ankles, VR avatar receive resistant force. Thereby the system allows the user to feel like swimming underwater by flutter kick.

Keywords: Virtual Reality, Locomotion Interface, Swimming Sensation, Flutter Kick.



Session 2 Live Demo

Premier Ballroom A+B — Thu, October 15, 2018, 14:30-16:00

14:30-14:35 — D1P01

Stiffness Perception of Virtual Objects Using FOLDAWAY-Touch

Marco Salerno[1], Stefano Mintchev[1], Alexandre Cherpillod[1], Simone Scaduto[1], Jamie Paik[1]

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Haptic human interfaces are nowadays becoming more and more diffused also thanks to their combined use with Virtual Reality & Augmented Reality (VR & AR). Although many research platforms explore kinesthetic interaction with virtual objects, the only feedback available in widespread commercial devices is a rather simple vibration. In this paper we introduce “FOLDWAY-Touch” a novel portable kinesthetic haptic interface whose technology can be easily integrated into hand-held devices. The key technological aspect is the miniaturization of the haptic mechanism achieved through the use of origami design and manufacturing principles. Another achievement of this paper is the use of FOLDAWAY-Touch in a virtual simulation to grasp objects with different levels of stiffness.

Keywords: Force Feedback, Virtual Reality, Origami.

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:35-14:40 D1P02

Smart Bracelets to Represent Direction of Social Touch with Tactile Apparent Motion

Taku Hachisu and Kenji Suzuki

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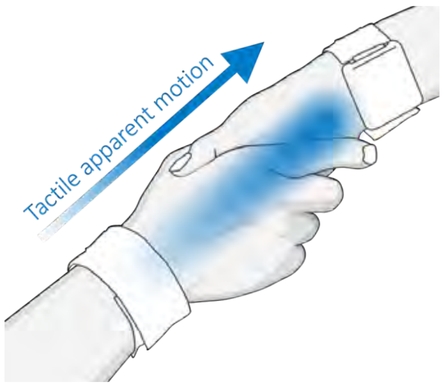
We present a novel haptic interaction which represents a direction of social touch with a tactile apparent motion using a pair of smart bracelet devices. We dene the direction as being from the hand actively touching to the hand passively touched. The device consists of a microcontroller, an acceleration sensor, an intra-body network module, and a vibrator. First, one device sends own acceleration data at the moment of physical contact with the other over wearers' hands (intra-body network). The other compares it to the own data, decides which one is actively touching or passively being touched, and sends the result to the partner device. Then, the devices drive the vibrators synchronizing the timing of the vibrations with each other according to our previously built model through the intra-body network. As a result, a tactile apparent motion is induced from the active to the passive. We aim that representing the direction provides awareness of the direction, which we expect to correct unilateral touch behavior.

Keywords: EnhancedTouch, Social Touch, Tactile Apparent Motion, Vibrotactile feedback, Wearables.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:40-14:45 D1P03

“HaptiComm”, a Tactile Communicator Device for Deafblind Communication

Basil Duvernoy[1], Sven Topp[2], and Vincent Hayward[3]

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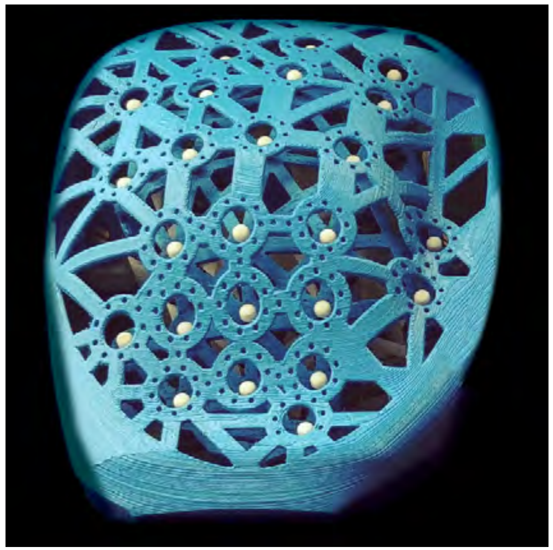
When people are deaf and blind, daily life is made difficult owing to the lack of linguistic communication that is normally mediated by sight and hearing. The project described herein aims at helping deafblind individual overcome this communication barrier. We describe a tactile communication apparatus that is capable of rich and efficient reproduction of the tactile signs employed by several tactile deafblind languages.

Keywords: Haptic Device, Deafblind, Communication, Tactile, Actuators.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:45-14:50 D1P04

A Novel Fingertip Tactile Display for Concurrently Displaying Texture and Orientation

Harsimran Singh[1], Sang-Goo Jeong[2], Syed Zain[2], and Jee-Hwan Ryu[2]

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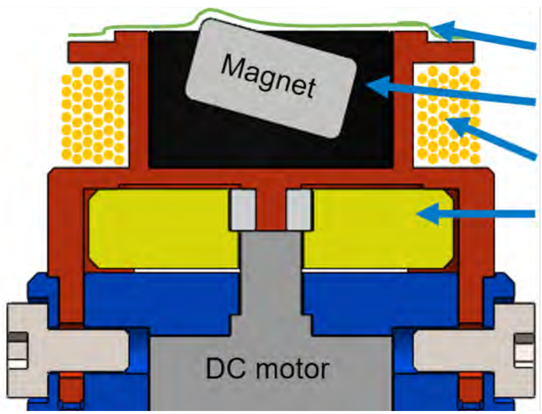
http://robot.kut.ac.kr

Although there have been numerous researches recently on tactile device, unfortunately, research on small size finger-tip tactile device has been limited, and researches on the device that simultaneously transmit texture and orientation information of rendered objects has been even more limited. The wearable tactile device presented in this paper can transmit rotational and vibrational cues at the same time and can alleviate the spatial limitations.

Keywords: Finger-tip Haptic, Tactile Device, Ferrouid, Solenoid, Neodymium Magnet, Wearable.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:50-14:55 D1P05

Estimation of Racket Grip Vibration from Tennis Video by Using Neural Network

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In this paper, vibrotactile perception of a person in a video is automatically estimated from the visual and audio information. We limit the video scene to the back view of a tennis player rallying, but other factors such as locations, a player's clothes, sound environments are arbitrary. We use tennis videos taken in three locations for neural network learning of the relation between the video and measured acceleration of the racket grip. Then we show the grip sensation can be successfully estimated from an unknown video. The quality of the produced vibrotactile sensation is evaluated by a subject experiment. The system is based on a similar concept to VibVid proposed by the authors. In this paper, we examine more general case than the previous research.

Keywords:

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:55-14:58 D1P06

Skin Vibration-Based Tactile Tele-sharing

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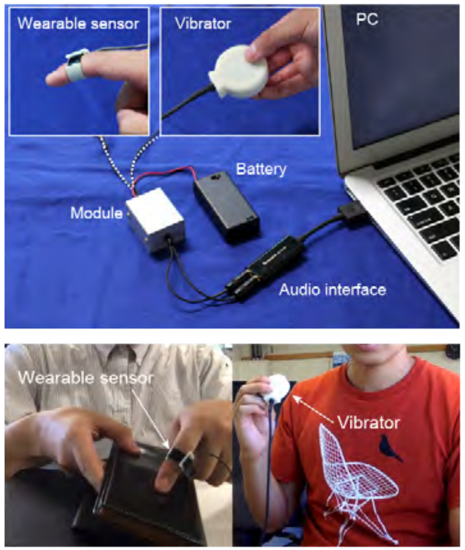
This paper presents the sharing of tactile experiences between distant locations. A wearable sensor using a PVDF (polyvinylidene difluoride) film was used to detect the skin vibration on the finger, and the audio channel of computers was used to transmit the vibration information bidirectionally. We developed a prototype module having functions of inputting the sensor output as an audio signal and of driving a vibrator according to the audio signal. It was confirmed that the tactile information during various tasks could be transmitted via the Internet by using conventional videophone software.

Keywords: Tele-sharing, Skin-propagated vibration, Audio channel.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

14:58-15:01 D1P07

An Attempt of Displaying Softness Feeling Using Multi-Electrodes-Based Electrostatic Tactile Display

Hirobumi Tomita[1], Satoshi Saga[2], Hiroyuki Kajimoto[3], Simona Vasilache[1], and Shin Takahashi[1]

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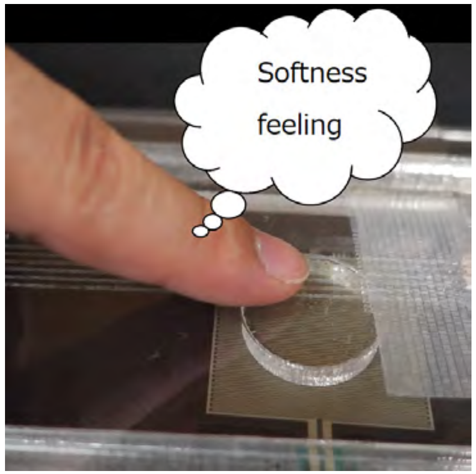
Touchscreen interfaces have become increasingly popular worldwide. However, few commercial touchscreens enable reactive tactile signals. We use lateral-force-based tactile feedback devices that employ electrostatic force. In this research, we attempted to display softness feeling by using multi-electrodes and a pressure sensor. When using our system, we observed that the user can feel change of the display area on the fingertip when his pressure toward the surface is changed.

Keywords: Haptic Display, Electrostatic Force, Multi-Electrodes.



Session 2 **Live Demo**

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:01-15:04 **D1P08**

Development of a Teleoperation Precision Grasping System with a Haptic Feedback Sensation on the User's Fingertip

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[2] Department of Medicine and Surgery, Umm Al-Qura University, Makkah, Saudi Arabia
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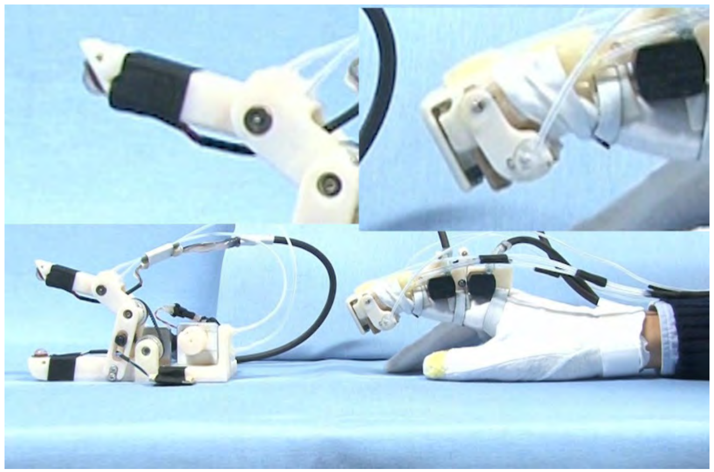
Tactile feedback sensation is an important factor in the surgical and medical application. A simple gripper is developed to perform precision grasping using teleoperation technology. The system provides the user with the tactile feedback sensation through a haptic device that applies forces on the user's fin-gertip based on the measured force at the gripper's fingertip.

Keywords: Precision Grasping, Haptic Feedback Sensation, Teleoperation.



Session 2 **Live Demo**

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:04-15:07 **D1P09**

Interactive Virtual Fixture Generation for Shared Teleoperation in Unstructured Environments

Vitalii Pruks and Jee-Hwan Ryu

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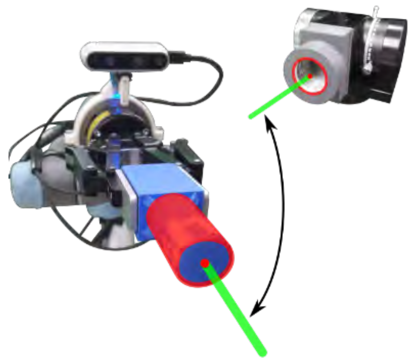
We present a method of virtual fixture generation for shared teleoperation. The method is based on an interactive selection of 2d image features obtained from a 3d camera. The preferred features are then automatically transformed into several possible 3d geometries which the human operator chooses to dene the virtual fixture. The generated virtual fixtures are utilized in the teleoperator's control system to render haptic assistance on the master device. The proposed method is intuitive, easy to use, and applies to unstructured environments. The proposed method is implemented as a graphical user interface that enables virtual fixture-based control of a robotic manipulator located at a remote site.

Keywords: Virtual Fixture, Shared Teleoperation, Unstructured Environment, Virtual Fixture Generation, Computer Vision.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:07-15:10 D1P10

Preliminary Study On Gap Detection Threshold of Textured Durface

Seitaro Kaneko[1], Kohei Matumori[2], Naoki Saito[2], and Hiroyuki Kajimoto[1]

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One indicator of the tactile spatial resolution is the gap detection threshold when a person touches or traces their finger along a concave liner gap. While the gap detection threshold has previously been measured using a flat surface, such as an iron plate, we measured the gap detection threshold for four textured surfaces. The participant traced his finger along the gap proximally and answered by choosing from two alternatives whether felt the gap or not. The gap detection threshold was found to increase as the surface texture became rougher. This is larger than the threshold for smooth surface and smaller than that for a more irregular surface. This suggests that there is a constant relationship between texture roughness and the ability to perceive gap. We discussed two explanations of the phenomenon for the large gap detection thresholds for coarse textures.

Keywords: Psychophysics Measurement, Gap Detection Threshold, Roughness, Texture

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:10-15:13 D1P11

VR training system of step timing for baseball batter using force stimulus

Wataru Sakoda[1], Toshio Tsuji[1], and Yuichi Kurita[1,2]

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http://www.jst.go.jp/kisoken/presto/en/index.html

Conventionally, correct motion in sports training and rehabilitation has been taught directly from a trainer. However, oral or gesture presentations are difficult based on what the trainer considers to be the accurate motion. We propose a motion timing presentation method using force stimulus, which has high relevance to the target motion. In this study, we developed a timing presentation training system for a baseball batter using force stimulus. The force stimulus is presented according to the pitching motion reproduced on a virtual reality (VR) system to present the timing stimulus repeatedly. The stimulus is used for presenting the timing of the initial foot step motion, which is the first phase of batting. For verification of the timing presentation effect of the training system, we measured the initial batting timing of the baseball beginner. As a result, it was found that the foot step could be started very close to the target timing using force stimulus presentation.

Keywords: Force Stimulus, Motion Timing Presentation, VR Training System, Baseball, Pneumatic Gel Muscle.

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:13-15:16 D1P12

Reducing 3D Vibrations to 1D in Real Time

Gunhyuk Park and Katherine J. Kuchenbecker

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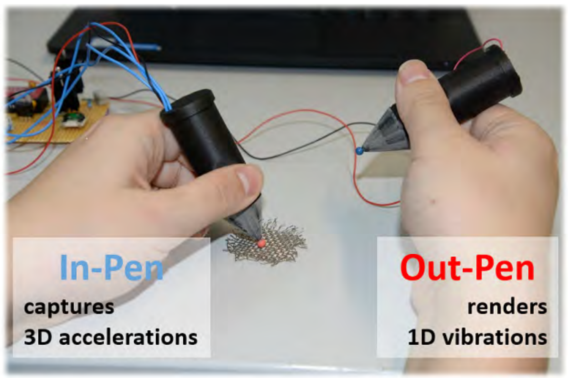
For simple and realistic vibrotactile feedback, 3D accelerations from real contact interactions are usually rendered using a single axis vibration actuator; this dimensional reduction can be performed in many ways. This demonstration implements a real-time conversion system that simultaneously measures 3D accelerations and renders corresponding 1D vibrations using a two-pen interface. In the demonstration, a user freely interacts with various objects using an In-Pen that contains a 3-axis accelerometer. The captured accelerations are converted to a single-axis signal, and an Out-Pen renders the reduced signal for the user to feel. We prepared seven conversion methods from the simple use of a single-axis signal to applying principal component analysis (PCA) so that users can compare the performance of each conversion method in this demonstration.

Keywords: Vibrotactile Feedback, Signal Processing, Dimensional Reduction, User Interface, Realistic Vibration.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:16-15:19 D1P13

A Soft Tactile Display Using Dielectric Elastomer Actuator for Fingertip Interaction

Jung-Hwan Youn[1], Seung-Mo Jeong[1], Young-Seok Choi[1] and Ki-Uk Kyung[1]

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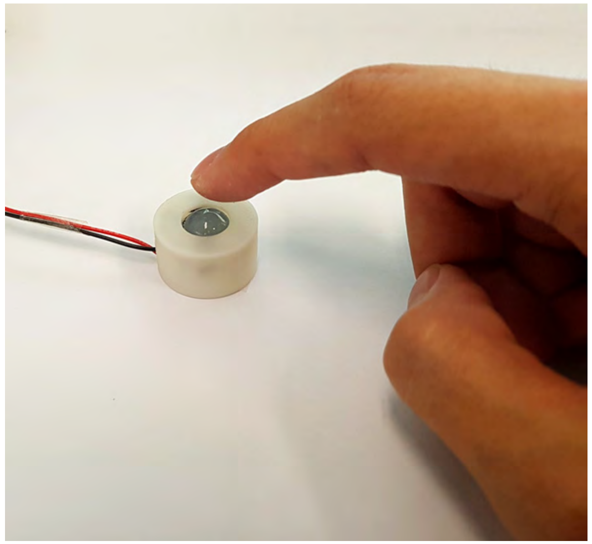
In this paper, we demonstrate a soft tactile display composed of a thin dielectric elastomer (DE) actuator coupled with silicone gel in a bubble shape, which can provide tactile stimulation to the skin. The design of the tactile display is referred from hydrostatically coupled DEA structures. We could observe the maximum force of the tactile actuator as 378mN. In addition, the actuating module could provide exerting force higher than 250mN in overall range of perceivable frequencies.

Keywords: Dielectric Elastomer Actuator, Soft, Tactile Display, Haptic, HC-DEA.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:19-15:22 D1P14

Configuration of Haptic Feedback Based Relief Robot System

Byung-jin Jung[1], Tae-Keun Kim[1], Geon Won[1], Dong Sub Kim[1], Jung-Hoon Hwang[1*] and Jee-Hwan Ryu[2]

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This paper deals with the development of a relief robot system that can provide first aid to the injured person by remote control in disaster environment and battlefield. To perform safe first aid, relief robot has hardware and controller that can feed back the contact force while following the command of remote controller. In addition, a controller capable of maintaining system stability under the influence of time delay and packet loss due to communication state during remote control is mounted. The developed relief robot system is evaluated through experiments simulating actual first aid procedures.

Keywords: Relief Robot, Haptic Feedback, Remote Control, Series Elastic Actuator, Virtual Spring Damper.

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:22-15:25 D1P15

TouchPhoto: Enabling Independent Picture-taking and Understanding of Photos for Visually-Impaired Users

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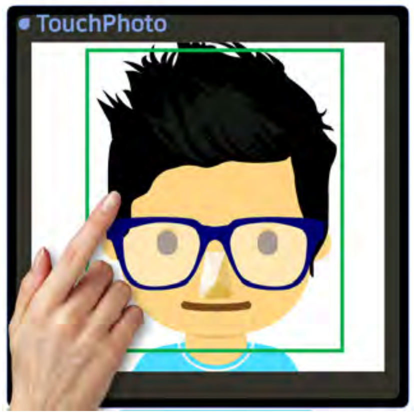
Photographs are a powerful medium for recording moments and sharing them with others. However, visually-impaired users have quite limited access to photograph's benefits. In this paper, we present an integrated system TouchPhoto, which provides visual-audio-tactile assistive features to allow visually-impaired users to take and understand photographs independently. A user can take photographs with auditory guidance and record several audio tags to aid recall of the photograph's content. For comprehension, a user can listen to the audio tags embedded in a photograph and also touch the photograph using an electrostatic friction display. The latter is done after salient features in the photograph, e.g., human faces, are extracted to facilitate tactile recognition.

Keywords: Blind Photography, Assistive Technology, Multimodal Interaction, Electrovibration.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:25-15:28 D1P16

Human-Agent Shared Teleoperation: A Case Study Utilizing Haptic Feedback

Affan Pervez[1], Hiba Latifee[2], Jee-Hwan Ryu[2], and Dongheui Lee[1,3]

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[2] Department of Mechanical Engineering, Korea University of Technology and Education, South Korea.
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Even though teleoperation has been widely used in many application areas including nuclear waste handling, underwater manipulation and outer space applications, the required mental workload from human operator still remains high. Some delicate and complex tasks even require multiple operators. Learning from Demonstration (LfD) through teleoperation can provide a solution for repetitive tasks, but in many cases, one task can be a combination of repetitive and varying motion. This paper introduces a shared teleoperation method between human and agent, trained by LfD though teleoperation. In the proposed method, human takes charge of uncertain or critical motion, whereas more mundane and repetitive motion could be carried out through the assistance of the agent. The proposed method has exhibited superior performance as compared to the human-only teleoperation for a peg-in-hole task.

Keywords: Teleoperation, Human-Agent Shared Teleoperation, Cooperative Teleoperation, Dynamic Movement Primitive, Learning from Demonstrations, Haptic Feedback.

Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:28-15:31 D1P17

Induced Pulling Sensation by Synthesis of Frequency Component for Voice-Coil Type Vibrators

Takeshi Tanabe[1], Hiroaki Yano[1], and Hiroo Iwata[1]

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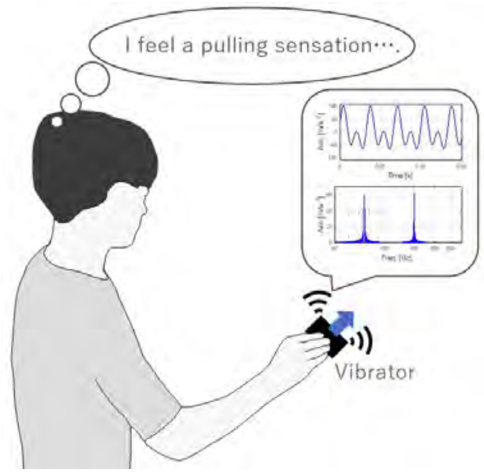
It is known that humans experience a kinesthetic illusion, such as a pulling sensation in a particular direction, when asymmetric vibrations are presented. In our previous experiment, it was suggested that the fundamental wave and the second harmonic of asymmetric vibration may contribute to this illusion. In this study, we verified whether this illusion can be induced by combining frequency components using three kinds of commercial vibrators through psychophysical experiments. The results confirmed that participants could perceive the correct direction of the pulling force with a correct answer rate of 83.3%.

Keywords: Illusory Force Perception, Asymmetric Vibration, Nongrounded Haptic Interface.



Session 2 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:31-15:34 **D1P18**

Hands-on Demonstration of Heterogeneous Haptic Texturing of Mesh Models Based on Image Textures

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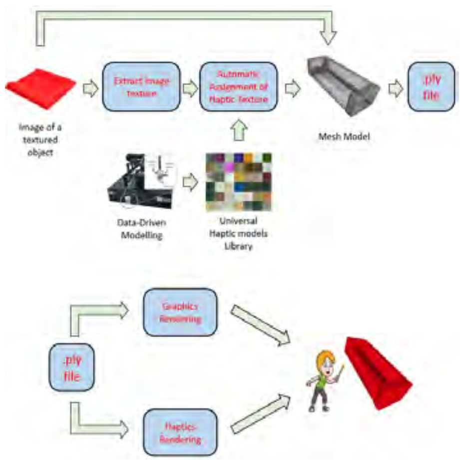
In this article, we introduce a framework for heterogeneous assignment of multiple haptic textures to mesh objects based on image textures. The framework consists of two applications, i.e., texture assignment and rendering programs. A user-friendly interface of the framework allows to assign and render textured mesh models in four steps. First, the user provides an image texturele to the algorithm that automatically selects perceptually closest haptic texture from the library. Then, the user is offered to texture object faces by stroking over an object surface with a virtual brush. Several haptic textures can be assigned to different object surfaces of a single mesh model. The haptic information for each face is embedded to mesh object and stored in a generic *.plyfile. Finally, a textured mesh object is loaded by rendering application.

Keywords: Haptic Texture Assignment, Rendering



Session 2 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:34-15:37 **D1P19**

Real-time Mapping of Sensed Textures into Vibrotactile Signals for Sensory Substitution

Jaeyoung Park, Woo-seong Choi and Keehoon Kim

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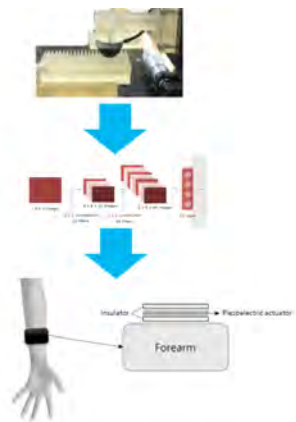
This paper presents a method to transform a surface texture sample sensed with a force-torque sensor into a vibrotactile stimulus in real time, as a technique to let a hand amputee feel the surface of objects. We built a convolution neural network with the contact force for real-time texture classification and haptic rendering. The neural network was constructed from the contact force between the force-torque sensor and sliding physical texture samples with three wavelengths. Once the classifier is constructed and if the force-torque sensor moves over a texture, the classified texture is mapped to a sinusoidal source signal generated with a DAQ board. We mapped the textures with the wavelengths of 3.14, 6.28, and 9.42 mm into sinusoids with the frequency of 150, 100 and 50 Hz. Then, the source signal is amplified and drives a piezoelectric actuator installed on a user's forearm, to provide a vibrotactile stimulus corresponding to the sensed texture.

Keywords: Texture Classification, Convolutional Neural Network, Lateral Sliding.



Session 2 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:37-15:40 **D1P20**

Towards Automatic Synthesis of Motion Effects

Sangyoon Han[1], Jaebong Lee[2], and Seungmoon Choi[1]

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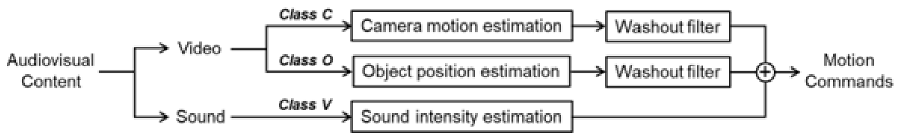
Motion effects are a key component for improving users' immersiveness in 4D content and virtual reality. However, the production of motion effects is still very labor-intensive and time-consuming. In this demonstration, we present synthesis algorithms which generate motion effects by analyzing the audiovisual content of 4D ride and films. Our synthesis algorithms provide compelling multimedia experiences to viewers while greatly improving the productivity.

Keywords: 4D Film, Multi-sensory Theater, Motion Simulator, Motion Cueing, Motion Effects, Synthesis, Automatic Generation.



Session 2 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:40-15:43 **D1P21**

Development of a Rigidity and Volume Control Module Using a Balloon Filled with Dilatant Fluid

Saizoh Kojima, Hiroaki Yano, and Hiroo Iwata

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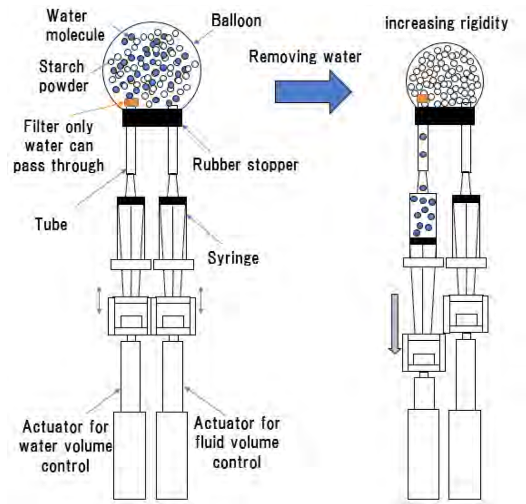
In this paper, a rigidity and volume-changing device is proposed for presenting the shape and rigidity of a virtual object in the real world. This device comprises a balloon filled with a dilatant fluid and two syringes connected to electric linear actuators. The electric linear actuators enables controlling the volume of the balloon by allowing the user to change the amount of dilatant fluid in the balloon. Moreover, when the amount of fluid (water) contained in the balloon changes, the rigidity of the balloon changes in proportion to the composition of the fluid (ratio of the amount of water and starch). In this study, a prototype system was developed, and the performance of the system was evaluated by measuring the rigidity of the balloon at different volumes.

Keywords: Virtual Reality, Haptic Display, Dilatant Fluid.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:43-15:46 D1P22

Using Wearable Haptics for Thermal Discrimination in Virtual Reality Scenarios

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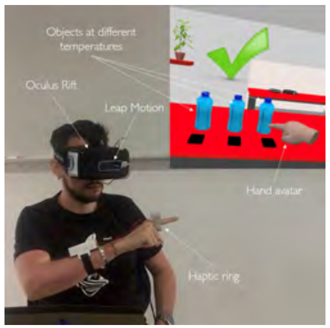
https://www.iit.it/research/lines/advanced-robotics

Towards a more realistic feeling of interacting with virtual and remote objects, we developed a wearable cutaneous device for the proximal finger phalanx able to provide skin deformations and thermal cues on the user skin. A servomotor is used to move a belt applying a pressure on the user finger, while a Peltier cell renders thermal cues. In the proposed hands-on demonstration, a user wears such haptic ring and a VR headset, and interacts with a virtual environment. In the virtual scenario, objects with different temperatures are displayed and the user is asked to find the coldest or the hottest. During the interaction, the movements of the user hand are tracked by a Leap Motion sensor, while the haptic ring renders interaction forces and thermal cues, providing the user with the sensation of touching objects in the scene at different temperatures.

Keywords: Thermal Feedback, Wearable Haptics, Virtual Reality, Haptic Ring



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:46-15:49 D1P23

A Wearable Hand Haptic Interface to Provide Skin Stretch Feedback to the Dorsum of a Hand

Hyunwoong Choi[1], Bukun Son[1], Sangyoon Kim[1], Yonghwan Oh[2] and Jaeyoung Park[2]

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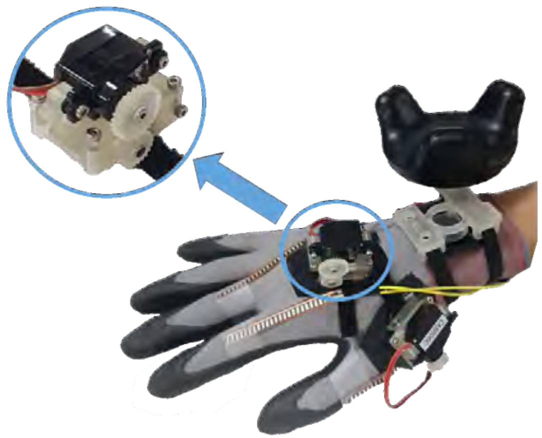
This paper presents a glove type haptic interface that can provide cutaneous feedback to the dorsum of a user's hand. The interface consists of flex sensors, a position tracker and skin stretch modules which gives tactile feedback to the hand. Global position of the wrist is tracked with the position tracker, and the flex sensors estimate the finger posture. Two skin-stretch modules are in-stalled on the dorsum of the hand behind the MCP joint of the thumb, and the middle of the index and middle fingers' MCP joints. Whenever there is a contact between a fingertip and a virtual object, the skin-stretch module provides cutaneous feedback by rotating a contact element toward the wrist. The skin-stretch emulates the strain of the skin occurring when a finger is pushed away by touching a real object.

Keywords: Skin Stretch, Wearable, Haptic Interface, Dorsum.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:49-15:52 D1P24

The Thermal Feedback Influencer: Wearable Thermal Display for Enhancing the Experience of Music Listening

Yuri Ishikawa[1]*, Anzu Kawazoe[2]*, George Chernyshov[3], Shinya Fujii[4], and Masashi Nakatani[4, 5]
*both authors equally contributed to this study

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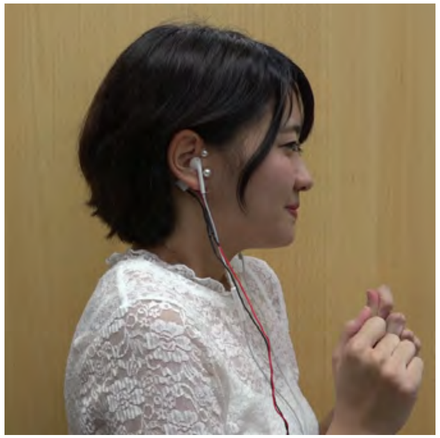
This paper describes a new wearable thermal display, the Thermal Feedback Influencer, that can provide chilling stimuli to the skin in order to enhance emotional experiences of music listening. We developed a prototype device that can be attached to behind the ear. The device is designed to be small and lightweight enough to be worn comfortably. In this work, we describe basic concepts of this research, preliminary test results, details and evaluation of the developed prototype. We also summarize methods to provide thermal feedback with music and discuss the possible applications and future research plans.

Keywords: Thermal Display, Musical Interface, Wearable Device, Frisson, Chill.



Session 2 Live Demo

Premier Ballroom A+B Thu, October 15, 2018, 14:30-16:00

15:52-15:55 D1P25

Midair Ultrasound Haptic Display with Large Workspace

Shun Suzuki, Masahiro Fujiwara, Yasutoshi Makino and Hiroyuki Shinoda

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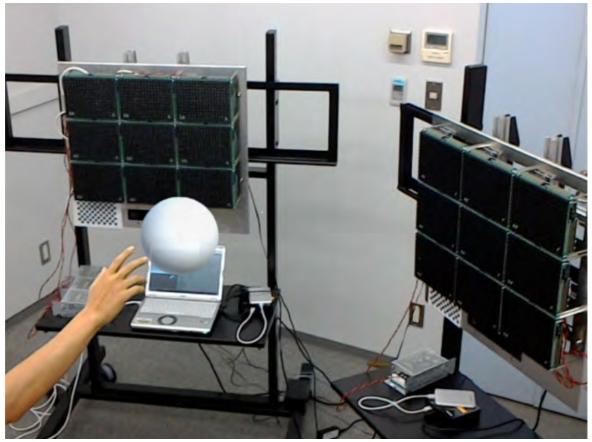
Midair haptic display using airborne ultrasound enables to give tactile feedback to a human body without wearing any devices. In the conventional ultrasound midair haptics system, the workspace was limited to the space of about 30 cm cube. In this paper, we integrate multiple ultrasound display units to achieve a large workspace. Our prototype system enables visuo-tactile interaction with AR images in a space of about 2m cube.

Keywords: Midair Haptics, Visuo-haptic Interaction, Mixed Reality.



Session 2 Live Demo

Premier Ballroom A+B **Thu, October 15, 2018, 14:30-16:00**

15:55-15:58 **D1P26**

Haptopus : HMD with Built-in Pressure Sense Presentation Device by Suction Stimulus

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With the surging popularity of VR systems using HMD, many efforts have been made to improve the user experience by providing tactile information to the fingertips. However, there are a few problems with the current system, such as difficulty attaching and detaching the devices and hindrances to free finger movement. To resolve these issues, we developed "Haptopus," which embeds a suction tactile display in the HMD and presents tactile sensations of the finger to the face. In this work, we investigated whether the suction stimulus is perceived as a suction or pressure sensation and found that the two sensations can be switched by changing the suction pressure.

Keywords: Haptopus, Suction Stimulus, Haptics HMD, Virtual Reality.

Session 3 Live Demo

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

10:00-10:03 **D2A01**

Human Rendezvous via Haptic Suggestion

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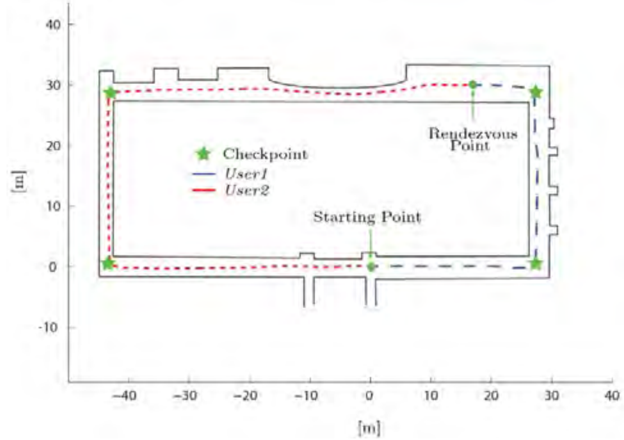
[2] Istituto Italiano di Tecnologia, Department of Advanced Robotics, Via Morego 30, 16163 Genova, Italy.

In this work we propose a wearable system to guide humans in structured or unstructured environments, with the aim of reaching simultaneously a rendezvous point. Directional and rhythmic cues are provided using wearable haptic interfaces placed at the subject's ankles. The walking pace guidance is achieved through the synchronization of the user's step cadence with the rhythm suggested by tactile cues. Directional hints are provided using different vibro-tactile patterns when reaching predefined locations called checkpoints. Here the estimated walking parameters are updated. The user retains complete access to audio and visual information from the environment, thus he/she is ready to react to unexpected events (e.g., moving obstacles). Exploitation of the proposed approach are assistive and rescue scenarios, human-human collaboration, as well as rehabilitation.

Keywords: Human Guidance, Haptic Communication, Cadence Suggestion.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:03-10:06 D2A02

Circular Lateral Modulation in Airborne Ultrasound Tactile Display

Ryoko Takahashi, Saya Mizutani, Keisuke Hasegawa, Masahiro Fujiwara, and Hiroyuki Shinoda

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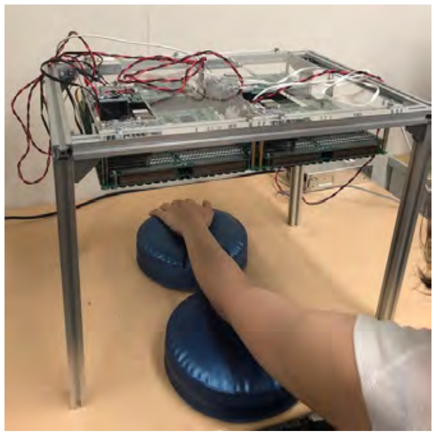
Hiroyuki Shinoda@k.u-tokyo.ac.jp

Airborne Ultrasound Tactile Display (AUTD) can present tactile stimulus on the skin, but the generated pressure is too small in many cases to be perceived on the hairy part. In a previous paper, we proposed a lateral modulation (LM) method where the ultrasound focus was reciprocated along the skin surface instead of amplitude modulation (AM). LM provided clear vibrotactile stimuli even on the hairy skin. In this research, we examine a new modulation named LMc where the ultrasound focus follows a circumference on the skin. In this method, the frequency of the pressure received by each skin receptor is constant regardless of the position. The conference participants experience the difference among AM, LM, and LMc.

Keywords: Midair Haptics, Haptic Display



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:06-10:09 D2A03

2D Braille Display Module using Rotating Latch Structured Voice Coil Actuator

Joonyeong Kim, Byung-Kil Han and Dong-Soo Kwon

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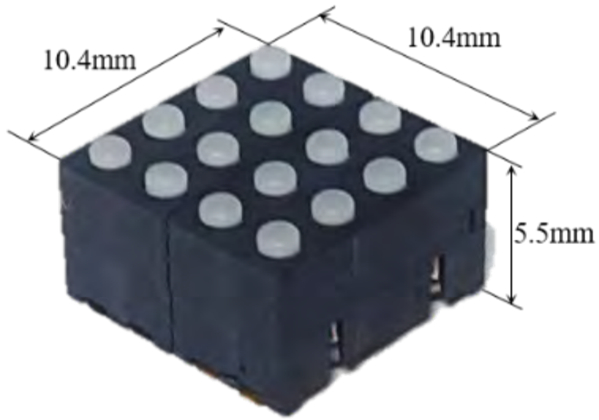
A braille system for visually impaired people is valuable for acquiring information by using only tactile sense of the fingertips. However, the in-formation can be expressed by braille is limited as characters, it's difficult to display two-dimensional information or more. In this paper, we propose a braille display module based on electromagnetism principle, and propose possibility as a portable braille pad. The module has minimized size compared to the conventional braille actuator. While satisfying dimensions of braille standards, the braille pins are arranged at equidistant intervals to be able to express two-dimensional information. In addition, the proposed module has a rotating latch structure, which minimizes the power consumption and can be applied to portable device.

Keywords: Portable Braille Device, 2D Scalability, Miniaturization, Latch Structure



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:09-10:12 D2A04

Remotely Displaying Cooling Sensation Using Ultrasound Mist Beam

Mitsuru Nakajima[1], Keisuke Hasegawa[2], Yasutoshi Makino[1], and Hiroyuki Shinoda[1]

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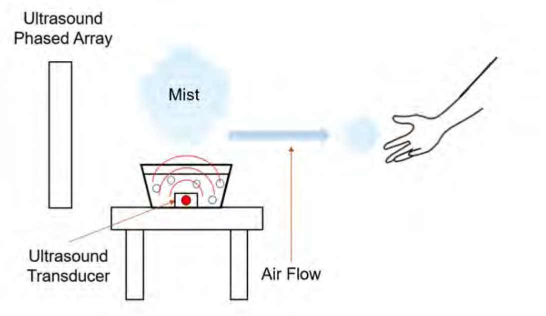
This study describes a midair haptic display that provides a cooling sensation using ultrasound-driven cold air flow cooled by mist vaporization. Non-contact thermal display using ultrasound-driven cold air flow has been reported, but the system uses dry ice as the cold-air source, which limits the range of practical applications. In this study, we propose a method using mist vaporization instead of dry ice to extend the application. Using this system, we demonstrate transporting cold air to a localized spot on a user's skin.

Keywords: Cooling Sensation, Ultrasound Beam, Acoustic Sir Flow, Bessel Beam, Mist.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:12-10:15 D2A05

Efficiency of haptic search facilitated by the scale division

Hirotsugu Kaga[1] and Tetsuya Watanabe[1]

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An experiment was conducted to reveal the efficiency of haptic search facilitated by the division of the searchable area. Tactile maps with five different numbers of divisions were presented to 16 blind participants and they were in-structed to find the target. The results show that the search time became minimal at the 4 × 5 condition, but there was no significant difference between any pair of conditions.

Keywords: Haptic Search, Scale Division, Search Time, Tactile Map, Blind People.

Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:15-10:18 D2A06

Body-ownership Illusion by Gazing at a Blurred Fake Hand Image

Hikaru Hasegawa[1], Shogo Okamoto[1], Nader Rajaei[1], Masayuki Hara[2], Noriaki Kanayama[3], Yasuhiro Akiyama[1], and Yoji Yamada[1]

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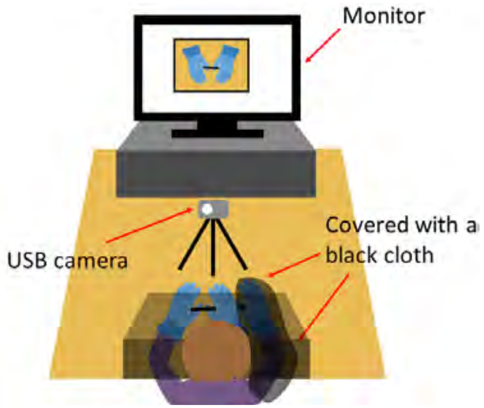
[3] Human Informatics Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

Feeling body ownership over a fake body image in video games or virtual environments may enhance the immersion and feeling of presence in them. In these situation, the sharpness of the image may influence the induction of the body-ownership illusion. In this study, we investigated the effect of blurring the image on the rubber hand illusion experience under seven levels of blur intensity. The results showed that blurring the image within the limits of hand recognizability may induce stronger body ownership of the fake hand but may not influence agency. This indicates that body ownership of a body image can be controlled by the sharpness of the presented image.

Keywords: Body Ownership, Agency, Rubber Hand Illusion, Blurred Image



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:18-10:21 D2A07

Allowable Range of Consistency Between the Visual and Tactile Presentations of a Linear Grating Texture

Shun Yamaguchi[1], Seitaro Kaneko[1] and Hiroyuki Kajimoto[1]

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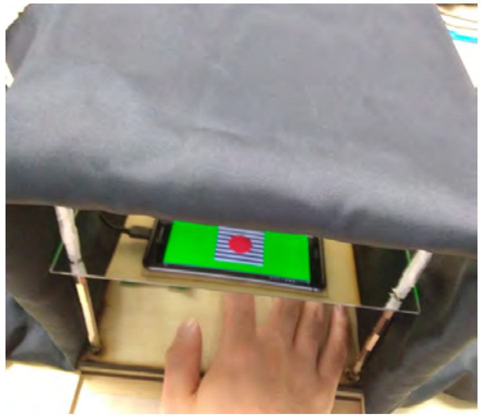
To impart a tactile sense to the virtual reality experience, a method has been proposed in which the user actually touches an object of the same material as the object in the virtual reality scene. However, in this method, it is necessary to prepare the same number of objects for touching as those that are visually presented. The purpose of this research is to clarify the conditions under which the two modalities are perceived as subjectively matched, thereby reducing the number of tactile textures that must be prepared. In this paper, we studied the range of allowable spatial frequencies of tactile stimuli that a user feels to be consistent with the visual stimuli in the case of line gratings. The results indicate that the discrimination threshold monotonically increases with respect to visual texture width, implying that Weber’s law holds true in this range.

Keywords: Cross Modal, Texture Perception, Visual Tactile Sense, Virtual Re-ality.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:21-10:24 D2A08

Haptic Texture Authoring: A Demonstration

Waseem Hassan, Arsen Abdulali, and Seokhee Jeon

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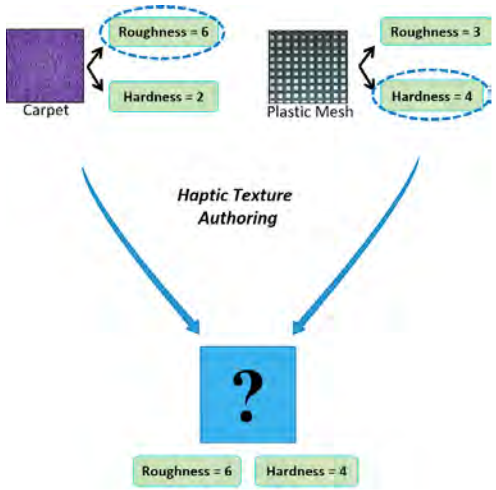
We present a haptic texture authoring algorithm for synthesizing new virtual textures by manipulating affective properties of existing real textures. Two different spaces are established: “affective space" built from a series of psychophysical experiments and “haptic model space" built on features from tool-surface contact vibrations. Another space, called “authoring space" is formed by merging the two spaces, whereby, features of model space that were highly correlated with affective space become axes of the space. Thus, new texture signal corresponding to any point in authoring space can be synthesized by weighted interpolation of nearest real surfaces in perceptually correct manner.

Keywords: Haptic Texture, Interpolation, Texture Perception, Texture Rendering, Psychophysics.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:24-10:27 D2A09

SwarmGlove: A Wearable Tactile Device for Navigation of Swarm of Drones in VR Environment

Luiza Labazanova, Akerke Tleugazy, Evgeny Tsykunov and Dzmitry Tsetserukou

Skolkovo Institute of Science and Technology, Moscow, Russian Federation
{Luiza.Labazanova, Akerke.Tleugazy, Evgeny.Tsykunov, D.Tsetserukou}@skoltech.ru

Navigation of the quadcopters with tactile feedback has been extensively studied for the cases of single drone. However, the operation of the swarm is a complex task, which requires intuitive interaction. We introduce wearable tactile device aimed at control of the formation with impedance interlinks. Tactile patterns representing dynamics of the swarm (extension or con-traction) are proposed. The user feels the state of the swarm at the fingertips and receives valuable information, which, coupled with visual feedback, improves the controllability of the complex life-like formation. In order to demonstrate capabilities of the technology, we developed VR applications in Unity, in which user guides the swarm in the virtual city and village environments through both static and dynamic obstacles to avoid collisions.

Keywords: Human-Swarm Interaction, Vibrotactile Glove, Swarm Navigation.

Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:27-10:30 D2A10

Tactile Transfer Glove Using Vibration Motor

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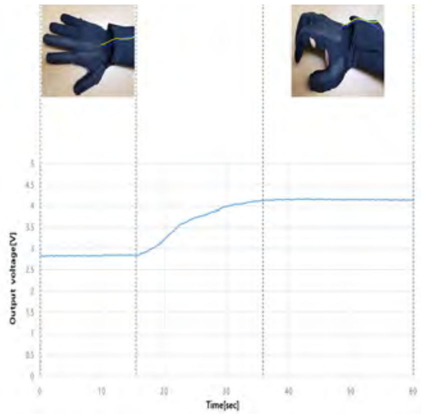
Virtual reality environment gives a variety of realistic experience to users. To provide realistic information to the users in virtual reality, several devices are necessary. The visual and auditory information is transferred by VR goggle. The tactile information can be provided by tactile transfer device. In this research, we, therefore, suggest tactile transfer gloves that can be used with VR goggle. The glove is consisted of flex sensor, vibration motor, fabric glove, and electrical circuit. The resistance sensor, which changes with the degree of flexion, controls intension and frequency of the vibration motor. Consequently the glove give tactile feedback to users by regulating intension and frequency of motor depending on degree of flexion of finger. The developed tactile transfer glove can be used to provide realistic information for users in virtual reality environment.

Keywords: Virtual Reality, Tactile Transfer Glove, Vibration Feedback, Flex Sensor, Finger Bending Motion



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:30-11:15

10:30-10:33 D2A11

LiquidVR - Wetness Sensations for Immersive Virtual Reality Experiences

Kenichiro Shirota[1], Makoto Uju[1], Roshan Peiris[1], and Kouta Minamizawa[1]

Keio University Graduate School of Media Design
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We propose LiquidVR, a system that simulates wetness and liquid sensations for the whole body by providing a combination of thermal and vibrotactile stimuli from the users face and across the upper body to the lower body. A head mounted display with thermal and vibrotactile modules simulates the wetness sensations on the face with the displayed visuals. These sensations are carried through out the body by using an array of vibrotactile modules placed on the collarbones and the feet actuated to simulate moving phantom sensations. We demonstrate this experience through virtual reality application scenarios such as being in a shower or being in side a glass of liquid.

Keywords: Wetness, Virtual Reality, Liquid, HMD Haptics, Full Body Haptics

Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:33-10:36 **D2A12**

Dental Simulator with Increased Z-width of Haptic Rendering

Hyojoon Park, Myungsin Kim, and Dongjun Lee

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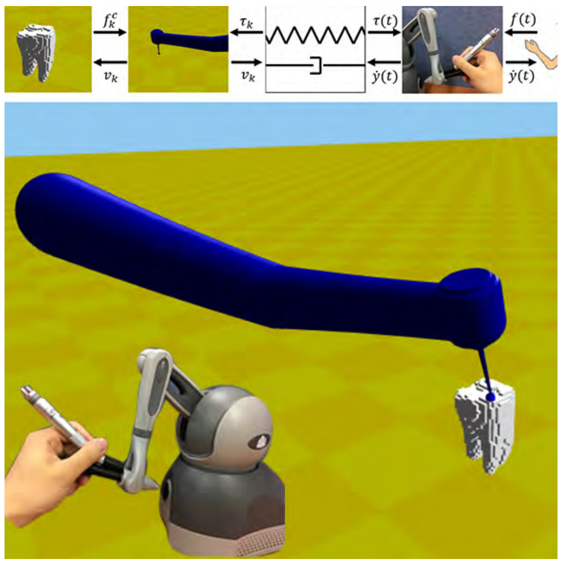
We demonstrate a dental simulator with haptic feedback which can render stiff virtual objects (i.e., tooth) with commercially available haptic devices. In particular, we adopt the passivity-based real-time simulation, virtual coupling with passive decomposition, and momentum-based disturbance observer. Our dental simulator demonstrates that the proposed method can increase Z-width of haptic renderings significantly while maintaining stability.

Keywords: Passive Midpoint Integrator, Passive Decomposition, Momentumbased Disturbance Observer, Z-width, Dental Simulator



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:36-10:39 **D2A13**

Random Forest for Modeling and Rendering of Viscoelastic Deformable Objects

Hojun Cha, Amit Bhardwaj, Chaeyong Park, and Seungmoon Choi

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In the recent past, data-driven approaches have gained importance for modeling and rendering of haptic properties of deformable objects. In this paper, we propose a new data-driven approach based on a well-known machine learning technique: random forest. We train the random forest for regression for estimating the input-output mapping between discrete-time interaction data (position/displacement and force) collected on a homogeneous deformable object. Unlike currently existing data-driven approaches, we use at most 1% of the recorded interaction data for the training of the random forest. Even then, the trained random forest model reproduces all the interactions used for the training with a good accuracy. This also provides promising results on unseen data. When employed for haptic rendering, the model estimates smooth and stable interaction forces at an update rate more than 650 Hz.

Keywords: Viscoelasticity, Haptic Modeling and Rendering, Random Forest.

Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:39-10:42 D2A14

A Teleoperation System for Reproducing Tactile Perception Using Frequency Channel Segregation

Po-Hung Lin and Shana Smith

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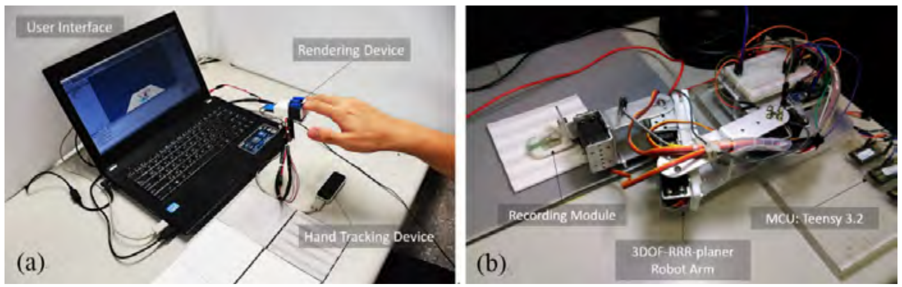
Nowadays, haptic feedback technology has been applied to many applications to help users acquiring more information concerning surrounding environments. In this research, a real-time teleoperation system was developed to bring vibrotactile sensation concerning object surface texture from a remote location to the local users. A force sensor and a PVDF sensor were used to design a data recording device, which was attached to a remote slave robot arm, for recording physical surface texture information. Based on the different sensitivity frequency ranges of the mechanoreceptors in human glabrous skin, a novel tactile rendering device was designed to trigger frequency-channel-segregated vibrotactile stimuli in the master's side. Two bending piezoelectric actuators were used to trigger different stimulation intensities with different frequency ranges. To examine the efficacy of the teleoperation system, a tactile discrimination test was conducted. Users were asked to match the simulated surface textures with physical surface textures. The correctness of the discrimination test was about 87.5%. The results also showed that the developed system can produce realistic remote surface textures in real time.

Keywords: Vibrotactile Feedback, Teleoperation, Surface Texture Reproduction, Frequency Channel Segregation, Haptics Feedback, Piezoelectric Actuators.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:42-10:45 D2A15

Extended AirPiano: Visuohaptic Virtual Piano with Multiple Ultrasonic Array Modules

Inwook Hwang[1] and Sungryul Yun[1]

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We developed an improved version of midair visuohaptic virtual piano utilizing multiple ultrasonic array modules. We implemented scheduling algorithm for simultaneous generation of haptic points to increase the output efficiency. Our algorithm is based on temporal switching of modulated ultrasonic signals and player draft system on multiple ultrasonic modules. With the ex-tended AirPiano, a user can play the virtual piano in a scene shown via the HMD and can feel the haptic points on their whole fingers while touching the keys.

Keywords: Midair Haptics, Virtual Environment, Haptic Point Scheduling.

Session 3 Live Demo

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

10:45-10:48 **D2A16**

Rigid-body Collaborative Manipulation among Remote Users with Wearable Cutaneous Haptic Interfaces

Myungsin Kim, WonHa Lee, Hyojoon Park, Junghan Kwon, Yong-Lae Park, and Dongjun Lee

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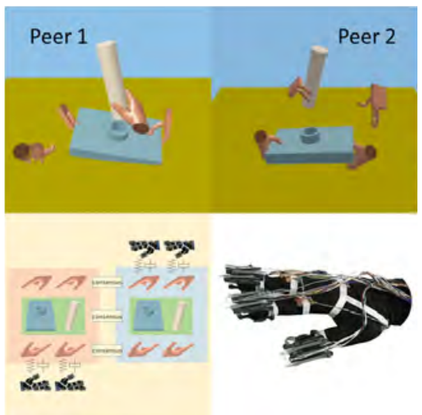
We present a novel system architecture and its constituent components for multiuser haptic interaction, where geographically distributed multiple users collaboratively manipulate a shared virtual rigid-body evolving in SE(3). Wearable Cutaneous Haptic Interface (WCHI) and passivity-based real-time simulation and consensus control are employed for dexterous hand motion tracking with fingertip cutaneous haptic feedback and stable shared rigid-body manipulation on partially-connected imperfect communication network. Experiments of two users cooperatively handling a virtual rigid bodies are performed to validate the feasibility of the proposed system architecture.

Keywords: Remote Multiuser Interaction, Rigid-body Peg-in-Hole Manipulation, Wearable Cutaneous Haptic Interface, Multi-DOFs Finger Tracking, Cutaneous Haptic Feedback.



Session 3 Live Demo

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

10:48-10:51 **D2A17**

Hapto-band: Wristband Haptic Device Conveying Information

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We have developed a wristband haptic device called Hapto-band to intuitively convey various pieces of information such as ball direction and player actions in sports. Hapto-band has the advantage that it keeps both hands free and puts less burden on the user's body even when enjoying content for a long time. This device has four vibration actuators that are controlled wirelessly. When the user wears Hapto-band on the wrist, the four vibration actuators are in contact with four positions of the wrist, and various pieces of information can be conveyed by changing the vibration position and the vibration type. In this study, we developed a demonstration system to communicate information about player actions, such as serving / receiving, and the trajectory of the ball in volleyball games to the user via tactile sense by using Hapto-band, and we conducted an experiment to evaluate the effectiveness of using this device to convey player actions in sports.

Keywords: Haptic, Vibration, Universal Design, Wearable.

Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:51-10:54 D2A18

Enhancing Haptic Experience in a Seat with Two-DoF Buttock Skin Stretch

Arata Horie, Akito Nomura, Kenjiro Tadakuma, Masashi Konyo, Hikaru Nagano, and Satoshi Tadokoro

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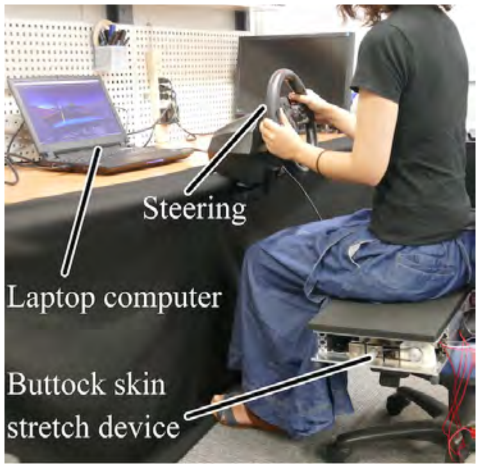
We propose a buttock skin stretch device that adopts a two-degree-of-freedom horizontal movement mechanism. We have confirmed that an acceleration sensation of self-motion can be induced by a buttock skin stretch device with one degree of freedom. In this paper, we propose a two-degree-of-freedom buttock skin deforming device that extends the direction of skin deformation, which was only in the left and right directions, to the forward and backward directions. We focused on the range of motion, position accuracy, and driving speed, and evaluated the performance of the device as a buttock skin-deforming device.

Keywords: Skin Stretch Device, Force Perception, Self-motion Perception, Buttock Skin.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

10:54-10:57 D2A19

Spatiotemporal Tactile Display with Tangential Force and Normal Skin Vibration Generated by Shaft End-effectors

Takumi Shimada[1], Yo Kamishohara1, Vibol Yem[1], Tomohiro Amemiya[2], Yasushi Ikei[1], Makoto Sato[1], and Michiteru Kitazaki[3]

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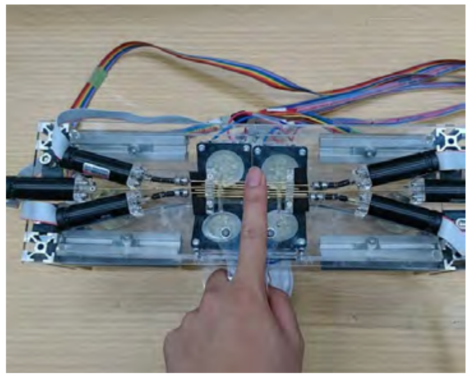
While rubbing a material, both shear force and vibration spatiotemporally occur on the skin of our finger pad. To reproduce various kind of rubbing sensation, we developed a tactile display using shaft end-effectors to spatiotemporally drive the skin of finger pad. Each shaft was connected to a DC motor and to a voice coil. When the shaft is rotated by a DC motor, the friction of the shaft tangentially move the skin. In addition, the voice coil was used to vibrate the shaft perpendicularly to the skin. There are six shafts in our present study. We conducted preliminary test to reproduce rubbing sensation of three sample materials, hemp, leather and Teflon. In the demo, participants can experience our dis-play reproducing these material sensation. They also can adjust the amplitudes and the frequencies of tangential and normal skin vibration by comparing to the sensation of the real materials.

Keywords: Tactile Display, Shaft End-effector, Tangential Force, Normal Vibration.



Session 3 Live Demo

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

10:57-11:00	D2A20

A Large-scale Fabric-based Tactile Sensor Using Electrical Resistance Tomography

Hyosang Lee[†1], Kyungseo Park[†2], Jung Kim[2], and Katherine J. Kuchenbecker[1]

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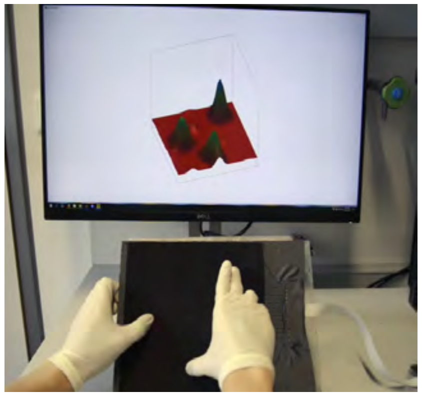
Large-scale tactile sensing is important for household robots and human-robot interaction because contacts can occur all over a robot's body sur-face. This paper presents a new fabric-based tactile sensor that is straightforward to manufacture and can cover a large area. The tactile sensor is made of conductive and non-conductive fabric layers, and the electrodes are stitched with conductive thread, so the resulting device is flexible and stretchable. The sensor utilizes internal array electrodes and a reconstruction method called electrical resistance tomography (ERT) to achieve a high spatial resolution with a small number of electrodes. The developed sensor shows that only 16 electrodes can accurately estimate single and multiple contacts over a square that measures 20 cm by 20 cm.

Keywords: Fabric-based Tactile Sensor, Electrical Resistance Tomography, Large-scale Tactile sensing.



Session 3 Live Demo

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

11:00-11:03	D2A21

Haptic Eye: A Contactless Material Classification System

Tamas Aujeszky, Georgios Korres, and Mohamad Eid

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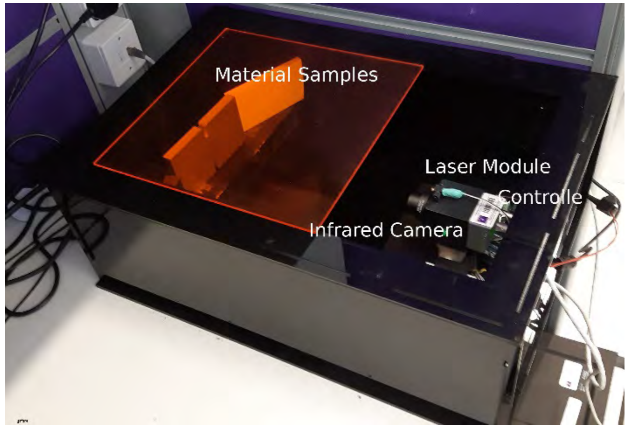
In this paper we demonstrate a system capable of classifying different types of materials in a contactless fashion by using active infrared thermography and machine learning algorithms. A laser diode heats the materials and the infrared camera records the thermal dissipation signature of each material. These data are then fed to machine learning algorithms to classify the materials. This system can potentially be used in teleoperation applications for robots that operate in unknown scenes.

Keywords:



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

11:03-11:06 D2A22

Seesaw Type Actuator for Haptic Application

Kahye Song[1], Jung-Min Park[1], and Youngsu Cha[1]

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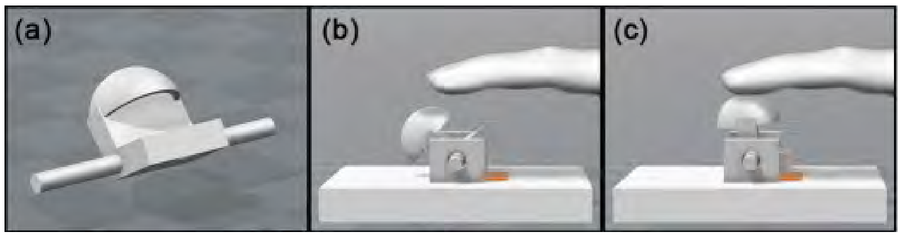
In this study, we propose a seesaw type actuator, and we investigate its actuation to determine the most efficient structure. When a high voltage input is applied between the L-shaped actuator and metal plate at the bottom substrate, another panel rises due to reaction of the electrostatic attraction. And it leads to tactile stimulation. In addition, we add a round cap to the edge of the panel of the actuator for more effective stimulation delivery. Various types of actuators experiments showed that the actuator with the largest radius of motion was an actuator with a narrow angle and a long length, and the axis of rotation coincided with the axis of gravity. This is because narrower angles between actuators increase the movable radius of motion and longer actuators can induce electrostatic attraction of larger forces and lose balance if the center of gravity axis does not match. Both gravity and electrostatic attraction are utilized for the operation of the actuator, and this actuator generates strong tactile stimulation without the risk of electric shock to users by separating the user contact part from the electrostatic force region. We expect that this new actuation mechanism is adapted to various haptic devices in the future to help the human-computer interaction.

Keywords: Seesaw Type Actuator, Electrostatic Attraction, L-shaped Actuator.



Session 3 Live Demo

Premier Ballroom A+B Thu, October 16, 2018, 10:00-11:15

11:06-11:09 D2A23

Conceptual Design of Soft and Transprent Vibrotactile Actuator

Dong-Soo Choi[1] and Sang-Youn Kim[1]

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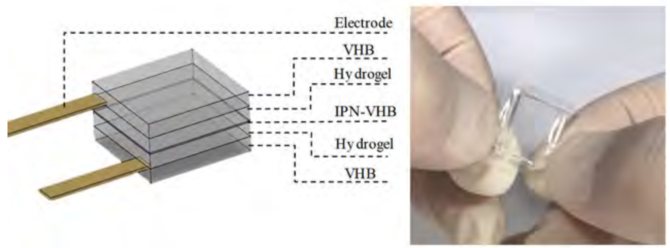
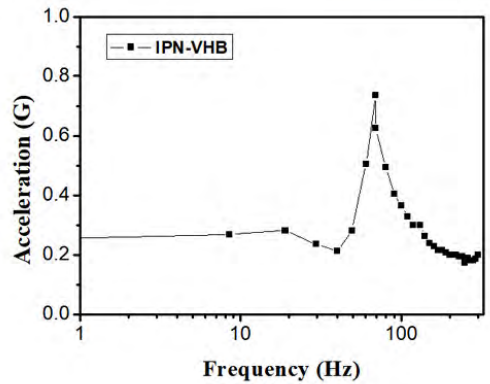
This paper reports a soft and transparent vibrotactile actuator which can be easily embedded into small wearable devices. When AC voltage is applied to the actuator, the electroactive polymer gets charged and then generates vibration. Vibration mechanism and experiment results for suggested vibrotactile actuator are explained.

Keywords: Dielectric Elastomer, Wearable Device, Electroactive Polymer.





Session 3 **Live Demo**

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

11:09-11:12 **D2A24**

Baby Touch: Quantifying Visual-haptic Exploratory Behaviors in Infants of Sensory-motor Development

Kazuki Sakurada[1], Akari Oka[1], Ritsuko Kiso[1], Leina Shimabukuro[1], Aoba Ueno[1] and Masashi Nakatani[1,2]

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We propose a method to quantify an infant's exploratory behavior by taking a video of his/her actions and analyzing them. Exploratory behaviors of infants are known to be necessary for the development of cognitive functions and language acquisition. Multiple studies on exploratory behaviors have been conducted; however, exploratory behaviors of infants have been commonly classified and quantified manually, requiring ample efforts. Advances in computer vision research using machine learning in recent years have made it possible to automatically analyze captured videos and register movements of the human body. In this study, we developed a measurement system that enables the quantification of exploratory behaviors of infants by combining OpenPose, OpenFace, and a computer vision library. First, we created a video-capturing environment suitable for capturing an infant's behavior. Second, we integrated the computer vision library to analyze infants fixating on and touching objects placed in front of them. As a result, we are now able to quantify some aspects of infants' exploratory behavior. Our measurement system will be useful for investigating the exploratory behavior of six to fifteen-month old children using visual-haptic modalities, and also it will also be valuable in comprehending the developmental stages of each child.

Keywords: Exploratory Procedures, Child Psychology, OpenPose, OpenFace.

Session 3 **Live Demo**

Premier Ballroom A+B **Thu, October 16, 2018, 10:00-11:15**

11:12-11:15 **D2A25**

Exciting but Comfortable: Applying Haptic Feedback to Stabilized Action-Cam Videos

Daniel Gongora[1], Hikaru Nagano[1], Masashi Konyo[1], and Satoshi Tadokoro[1]

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Videos recorded with action cameras let viewers experience extreme activities from a safe environment. Unfortunately, these videos can be uncomfortable to watch due to intense camera shaking, and video stabilization limits the experience of motion. Here we propose using vibrotactile feedback to preserve the feeling of motion in first-person view videos that have been stabilized. First, we created vibrations from camera motion estimates for two vibrotactile actuators that emphasize the feelings of turns and jumps. Then, we conducted a pilot user study to assess viewers perception of motion in stabilized videos with and without vibrotactile feedback. We observed that motion vibrations added to a stable video did not preserve the motion intensity ratings of a raw video without vibrations. We also observed that motion vibrations had a significant effect on comfort and satisfaction, and that video stabilization did not have a signicant effect on the perceived synchronization between a stable video and vibrations generated from the original video.

Keywords: Vibrotactile, Video Stabilization, Camera Motion.

Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:30-13:32 D2V01

Light Touch Postural Guidance Through a Robotic System

Karna Potwar[1*], Leif Johannsen[2], Matteo Saveriano[1,3], Martin Langer[4] and Dongheui Lee[1,3]

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[2] School of Health Sciences, University of East Anglia, Norwich, United Kingdom
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Deliberately light interpersonal touch (IPT) in between two humans has been shown to reduce postural sway and stabilize the body in standing and walking. The principle of IPT support could therefore be translated in the development of balance assistive devices for dynamic motions. During IPT both the participants in a pair, the contact provider (CP) as well as the contact receiver (CR), are likely to contribute towards the haptic interaction and implicitly adjust their posture according to the current social context and situational demands. Can this beneficial phenomenon of IPT support be replicated in a human-robot interaction with the robot as the contact provider? In this proof-of-principle study, we instructed participants to perform a maximum forward reach task with the right arm and hand outstretched to push an object placed in front on a low friction glass surface. While doing so, mechanically non-supportive IPT was provided at the wrist of the participant by a KUKA LWR4 robot which acted as a contact provider. The participant's motion was captured through a motion capture system, which was then used by the robot to track the wrist of the participant. The position of the end effector and the interaction force were actively controlled using a hybrid force-position controller. The control system made sure that force was close to 1N along the medio-lateral direction. A Linear Kalman Filter (LKF) was used to up-sample the participant's wrist trajectory on-line or to predict the wrist position in future time instants. These capabilities of the LKF helped us in developing the two robot modalities: Follower and Anticipator mode. In the Follower mode, the robot followed the wrist passively with a delay of 10ms. While, in the Anticipator mode, the robot anticipated the movement by one sample (10ms) and led the task execution. The robots during both the modalities portrayed precise responsiveness, which a human being would lack. The participants were not able to distinguish between the anticipatory and the follower mode and would not change their behavior voluntarily. As compared to the human-human light touch, robotic light touch showed improvement in postural stability during the forward reach, i.e., decrease in sway in the medio-lateral and anterior-posterior direction. Though the robotic light touch has shown promise in postural balance, its feasibility in balance-impaired population is still to be assessed.

Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:32-13:34 D2V02

Time Order Error vs Inter-stimulus Interval and Stimulus Level During Force Comparison

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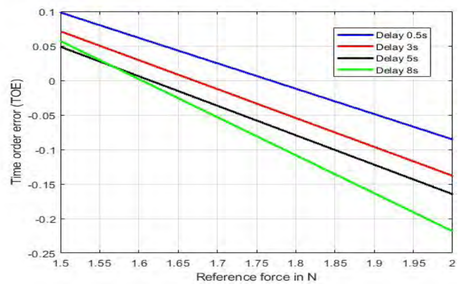
Fechner (1860) discovered that in psychophysical experiments involving the comparison of paired stimuli, presented sequentially (i.e., separated by a finite time interval called as inter-stimulus interval), time-order errors (TOEs) defined as the difference between the point of subjective equality (PSE) and standard stimulus, kept entering the findings: thus signifying the importance of temporal order of stimuli. In many of the studies, the TOE is generally found negative (i.e., the first stimulus is underestimated with respect to the second), and is explained as some kind of response bias [1]. In accurate determinations of the just-noticeable difference (JND), the TOE is controlled by counter-balancing the temporal order of reference and comparison stimuli. However, in applications where stimuli are to be compared in real time, the TOE is bound to happen, thus needs to be taken care of before making final decisions.

There are numerous studies in the literature investigating the factors affecting the TOE. In particular, the TOEs are found to vary with ISIs and stimulus level. It is observed that the TOE is often negative with longer inter-stimulus intervals (ISIs) and positive (or less negative) with shorter ISIs [1], and it's more negative with higher stimulus magnitude level [2]. The above observations are validated on sound and vision stimuli comparison. To the best of our knowledge, these observations have not been verified on haptic stimulus comparison. In this work, we take up this study.



For that purpose, we design an experiment where two successive force stimuli are compared. The first stimulus (i.e., standard stimulus) takes value from 1.5 to 2.0 N, and the second force stimulus (test) is in the range of +(-) 30 % of the first stimulus. Each stimulus is held constant for 2 seconds before reset to zero. The experiment is performed with four ISIs: 0.5, 3, 5 and 8s. For each ISI, 500 runs of the experiment are performed by each user. The user perceives both the stimuli with the help of a force feedback device Phantom Omni, and responds which interval has larger force. The stimuli perceived larger are labeled as +1 and -1, otherwise. We employ a state-of-the-art machine learning technique SVM to estimate the boundary between the labeled responses. The estimated boundary defines the PSE as a function of the standard stimulus, thus the TOE can be computed for each stimulus. We find that the TOEs are more negative with longer ISIs, and larger stimulus magnitude. Thus, our preliminary results corroborate with the studies on auditory loudness and visual comparison. In future, we would like to perform this study in detail and determine how significant the variation of TOEs is with ISIs and stimulus level.

Session 4 Video Demo

Premier Ballroom A+B   Thu, October 16, 2018, 13:30-14:00

13:34-13:36   D2V03

Design and Control of Vibration Feedback Display Using a Pneumatic Air-jet

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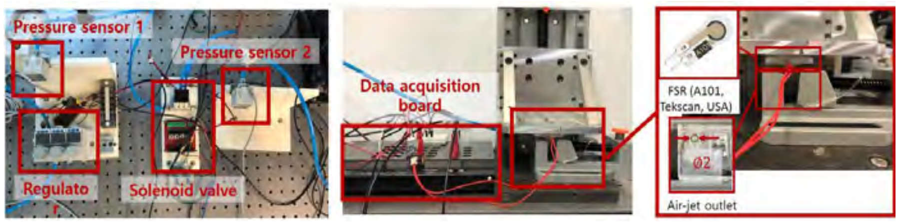
Haptic feedback generally involves a physical contact that is followed by the perception of objects. Haptic interaction has been widely used in various fields, such as virtual reality (VR) and robot teleoperation. Most haptic interfaces are mounted on the ground, and portable haptic interfaces have been limited to the vibrators in telephones and pagers. Only recently, wearable type haptic interfaces are being developed for a portable haptic interface. In particular, wearable hand haptic interfaces have been developed and they can provide haptic feedback to the fingers.

Wearable haptic interfaces have limitations in size and weight unlike the traditional grounded haptic interfaces. If the interfaces display the kinesthetic feedback, the structure of the interfaces becomes complex because it is necessary to move the ground of the system closer to the point of the stimulus. To make the system simple and light, the kinesthetic component of the interaction is gradually lost and only the cutaneous part of the interaction is remained. Therefore, cutaneous feedback component is suitable for wearable interfaces because it has more information than kinesthetic feedback in surface curvature and fine manipulation.

Researchers have developed cutaneous-only interfaces, which are comfortable, compact, and inexpensive. However, these studies can only provide cutaneous feedback by pressure and are not able to provide vibration, which is typical cutaneous displaying way. Shimoga et al. proposed a pneumatic air-jet interface as a way to provide both pressure and vibration feedback for wearable applications. The complexity of air-jet interface is lower than other methods (visual, electrotactile, piezoelectric) and it is safer than other methods, but suitability for more degree of freedoms (dofs) are poor and the weight of system using air-jet method is quite high. There have been some researches about developing air-jet displays for VR and robot-assisted minimally invasive surgery (RMIS), however, they simply provided pressure feedback and did not provide vibration feedback.

In this paper, we propose a design and control of the vibro-tactile feedback using pneumatic air-jet method, which can stimuli the mechanoreceptors that can detect the vibration according to various frequencies. A control method that can provide a constant pressure for various frequency ranges is presented.



Session 4 Video Demo

Premier Ballroom A+B   Thu, October 16, 2018, 13:30-14:00

13:36-13:38   D2V04

Haptic Assistance Using Neural Networks for Driving Skill Enhancement and Training

Hojin Lee[1*], Hyoungkyun Kim[2], and Seungmoon Choi[1**]

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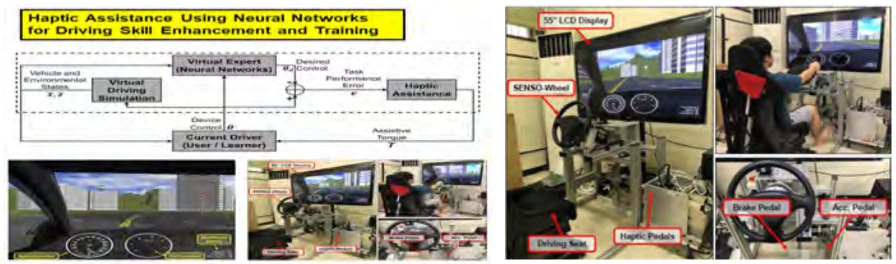
This work addresses our research for sensorimotor skill enhancement and training by presenting a driving training simulator with performance-based, error-corrective haptic feedback, i.e. haptic assistance (Figure 1). A driving task requires coordinated motions of limbs. Since haptic (kinesthetic) feedback can deliver mechanical momentum and moves the limbs of interest, providing direct and continuous information, many studies examined the effectiveness of haptic assistance to arms or legs for a steering task or a pedaling task. However, in those studies, the task and the skill model to learn steering or pedaling were manually abstracted into simple deterministic forms. This abstraction of tasks was usually different from real driving which requires simultaneous manipulation of the steering wheel and pedals for lane-keeping and velocity control. We face an immediate demand for reasonable modeling methods of complicated driving skills, which is a prerequisite of competent haptic assistance systems.

To this end, we introduce a novel modeling approach which learns an optimized driving skill model from the driving data of expert drivers (See our driving simulator in Figure 2) using artificial neural networks. Artificial neural networks are generally used to find a nonlinear function that explains input/output relationships and identify structures beneath complex dynamic systems. We obtain a model utilizing neural networks to assimilate a desired movement of a steering wheel and an accelerator pedal from the experts' prediction. Then, we can deliver haptic assistance (haptic guidance) based on a driver's performance error, which is a difference between the current and the desired movement. We validate the subjective scores of effectiveness and comfort via a user experiment which compares our method with the conventional haptic assistance (predictive haptic guidance). In results, our method showed an equivalent score for effectiveness and an improved score for comfort compared to the conventional haptic guidance.



Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:38-13:40 D2V05

Recognition of Alphabet Objects by Sensing the Object Surface Using a Flexible Ferroelectric Sensor and Classifying the Sensor Signals Using a Neural Network

Jaehun Kim[1*], Minkook Choi[1], Taeyang Yang[1], Jisung Park[1], Ji-Hyun Kim[1], Jonghwa Park[2], Hyunhyub Ko[2], and Sung-Phil kim[**]

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We developed a alphabet objects recognition system by using wearable sensing environment with General regression neural network(GRNN) which is a viration to radial basis neural network. Flexible pressure sensors with ultrahigh pressure sensitivity with multilayer interlocked microdome geometry was used for tactile sensing system. This data acquisition system enables uniform data collection for various types of stimulus by attaching the tactile sensor at the microstage, which performs horizontal movement with constant pressure and speed. For the alphabet object recognition, we extract tactiel data from A to Z alphabet letters($1\times1cm$). The one-way motion of the sensor was applied equally to all alphabets, and the horizontal observation from left to right at a speed of 1mm/s. We used a GRNN,which is frequently used for classification in MATLAB software, as a classifier to discriminate letters from tactile sensing signals. The system is implemented through the MATLAB envirionment and runs in realtime. This demonstration shows that the system can recognize uppercase alphabet letters with highly reliable accuracy more than 99%.

Keywords: Tactile Sensing, Neural Network, Human-Inspired, Electronic Skin, Online-Classification

Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:40-13:42 D2V06

A Graphical Tactile Display for the Visually Impaired

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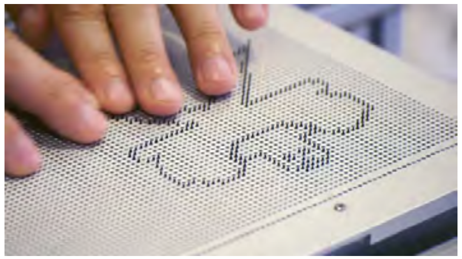
According to WHO latest statistics in 2017, there are approximately 253 million people suffering visually impaired in the world, including 36 million totally blind individuals, 90% of which living in developing countries. It is known that the blind people are able to learn and understand texts by Braille, such as Braille books, or make use of voice-assisted software such as screen reader to surf the Internet by voice, but there is very limited tool to help the blind people learn and understand graphical information.

Current large pin-matrix graphical displays employ thousands of piezoelectric actuators, which are very expensive, and hinder popularization. We design and implement a new type of graphical tactile display: Graille. This 60 by 120 pin-matrix device is made up of economical push-push structure actuated by a customized electromagnet matrix, achieving the significantly lower cost than other tactile displays. Meanwhile, Graille has a touch guidance interface. This interactive interface aims to enhance the usability of tactile graphics and dynamic tactile displays by introducing both haptic and audio experience.

The innovative device is able to achieve good haptic perception experience and a relative cost balance. It can render rich graphical tactile images as well as Braille, which can be widely used as educational resources in schools, public places and blind families. We hope our product-quality tactile graphical display can open new perspectives for the visually impaired people.



Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:42-13:44 **D2V07**

Generalizing Pneumatic-Based Augmented Haptics Palpation Training Simulator

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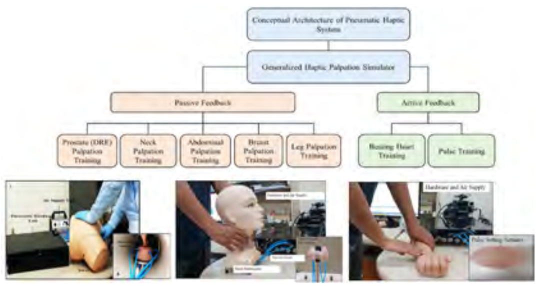
Augmented haptics (AH) enables us to experience in enhanced reality with high fidelity via combining the real and virtual environment. The numerous applications of this technology have been around in medical, telemedicine, entertainment, telerobotics, and education fields. Among them, medical palpation simulator is one of the prominent application areas of AH. This is due to the inherent benefit of AH; it can achieve extremely high realism without expensive HW/SW by utilizing a real environment itself in the interaction. We have extensively examined the potential of AH in this area and established a generalized approach for efficiently building a palpation simulator using AH. To this end, we established categories of palpation in terms of the characteristic of feedback in palpation; passive feedback where the physician palpates localized abnormalities that previously occurred at the location(e.g., tumor, lumpy tissues, etc) and active feedback where feedback actively changes in real-time(e.g., pulse, heartbeats, etc).This paper presents two example systems in each category; AH-based neck palpation simulator for passive feedback and a wrist pulse palpation simulator for active feedback. These systems are extensions of our previous prostate palpation (DRE) simulator (lower left figure) using pneumatic actuation. The complete system consists of original electro-pneumatic hardware, various silicone-made actuators, body mannequins, and a supportive library of related abnormalities of multiple body parts and organs. In a video demonstration, we will show active and passive feedback scenarios related to three types of palpation training simulators.



Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:44-13:46 **D2V08**

A Novel Shape Deforming Tactile Sensor for Safe Driving

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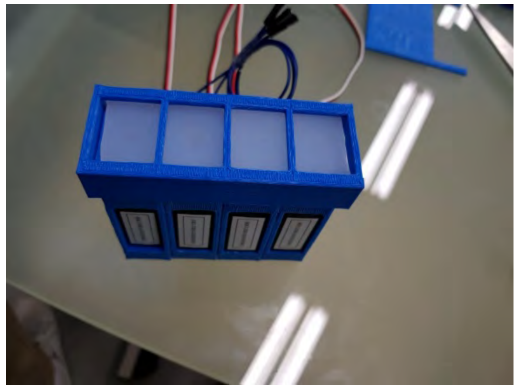
This paper presents a shape deforming large-scale flexible sensor for tactile display. We proposed the sensor which includes a linear actuator array and a flexible large-scale sensor. Thus, the sensor can deform its own shape and many linear resonant actuators (LRAs) under the large flexible sensor are arranged regularly. The LRAs below the sensor protrude and then control surface shapes. When a user touches the sensor, the user can feel the shape. Once the user presses the protruded shape, the user can operate specific functions without vision. The proposed display can decrease distractions by vision during driving.

Keywords: Large-scale Flexible Tactile Sensor, Shape Deformable Display, and Haptic Display.



Session 4 Video Demo

Premier Ballroom A+B — Thu, October 16, 2018, 13:30-14:00

13:46-13:48 — **D2V09**

How We Interact With Virtual Reality Drones?

Sangyun Shin[1], Yong-Won Kanng[1], Yong-Guk Kim[1*]

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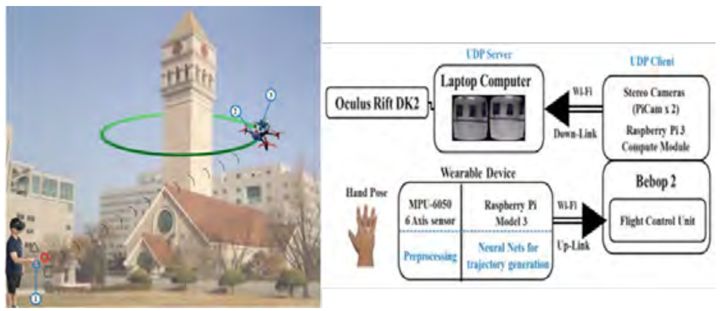
Although Radio Control (RC) has been a dominant device for controlling the UAV (or drone), it is known that a fair amount of training period is required too master it. A potential way to sidestep such an RC-based control scheme would be utilizing either Kinect or Leap Motion sensor by which the user interacts with a drone more naturally. In doing so o, however, he has to hang around the sensor since the operating distance of such sensors is rather short. In this study, we propose a new Human-Drone Interface (HDI) embedded on a wearable device, with which even a novice can let the drone take-off, fly and land safely using only his hand-pose gestures without any physic al constraint. There are two control modes: the first is the direct control by which one can control the direction of the drone whatever directions he wants to move it; the second is the figural trajectory control by which one can generate diverse figural drone trajectories such ass circle, square and spiral, which is very difficult to doo even by an expert drone pilot. In demo, we will show how a drone can navigate against diverse obstacles. In addition, when the drone has aa stereoscopic sensor installed in front of it, the user who wears a Head Mounted Display (HMD) can receive streaming video from the flying drone.

This research was supported by the MSITT (Ministry of Science , ICT), Korea, under the ITRC (Information Technology Research Center) support program (IITP20018-2016-0-000312) supervised by the IITP((Institute for Information & communications Technology Promotion)



Session 4 Video Demo

Premier Ballroom A+B — Thu, October 16, 2018, 13:30-14:00

13:48-13:50 — **D2V10**

A Movable Humanoid Robot for Presenting Walking Sensation of a Giant

Shintaro Koiwa[1*], Daisuke Morita[2], Yuki Enzaki[3] and Hiroo Iwata[3**]

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[2] Graduate School of Systems and Information Engineering, University of Tsukuba-shi, Tsukuba, Japan
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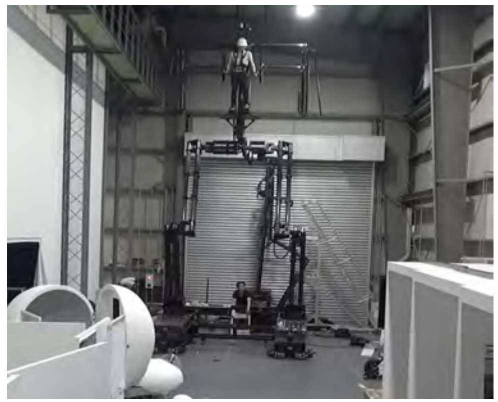
BigRobot Mk.2 is a giant humanoid robot that enables a user to experience the feeling of walking as a giant (Figure 1a). When the pilot operating the robot performs walking movements, the sliding feet of the robot also “walk” accordingly. The pilot can experience the feeling of walking as a giant. Figure 1b shows the configuration of the robot. Joint actuators are used to support and move the robot’s body. Drive wheels make it possible for the robot to slide its feet. Using these, our robot “walks” by sliding its feet. The locomotion interface is located on the upper part of the robot such that the pilot's head is in the same level as the giant's head (Figure 1b,1c). Therefore, the pilot can thus experience the same viewpoint as an 8 m-tall giant. As the pilot walks using the interface, the robot also walks with a correspondingly larger stride. Thus, the pilot feels as if he/she were 8m giant.

Keywords: Locomotion, Mobile Robot



Session 4 **Video Demo**

Premier Ballroom A+B **Thu, October 16, 2018, 13:30-14:00**

13:50-13:52 **D2V11**

360 VR Fishing with Multimodal Interaction

Byung-Wook Park*, Do-Gyun Kim, Soo-Mi Choi**

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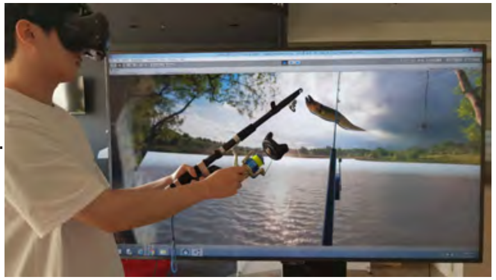
In recent years, user-created virtual reality (VR) contents have been rapidly increasing with the advancement in low-cost image or video-capturing equipment. However, VR contents that use images or videos suffer from limitations with the lack of interactivity by only providing passive information. This paper presents an interactive VR fishing game using 360° photographs or videos. To create engaging interactions in the surrounding scenes, we introduce a multi-layer representation where each layer can have different types of interactions including deformable objects, moving objects, and water simulation. Initially, the original input image can be segmented by its context such as sky, water, and land by using image tools, and the segmented regions are assigned to different layers. Then, images, animated images, and videos can be added to the original image as separate layers. Different interaction properties can be assigned to these multiple layers based on image semantics or user intention. Finally, all the layers are mapped onto each individual sphere for 360° panoramic view. To verify the effectiveness of the presented framework, we developed fishing scenarios where users can catch a fish on a boat and near the coast. When the users cast a fishing rod, the movement of surface water is simulated, producing realistic visual and spatial sound effects. To make the game more realistic, we implemented a physical controller which integrates a fishing rod and reel with a VR controller. Such a physical controller increases a tangible experience of fishing by allowing them to rotate the handle of the reel while drawing a fish. Through realistic scenes and a tangible user interface, the users can experience catching a fish as if they catch in the real world.



Session 4 **Video Demo**

Premier Ballroom A+B **Thu, October 16, 2018, 13:30-14:00**

13:52-13:54 **D2V12**

Increased Immersion Through Interacting with VR Players

Min-soo Choi*, Jun Park**

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Among the important factors in using virtual reality(VR), there is immersion and environment that experiences VR. In order to enhance the immersion feeling for the VR contents, interaction with the actual motion or high graphic quality is required, but when it is applied excessively, the visual stimulation may cause the motion sickness. In this paper, we introduce a method to increase the immersion feeling of VR contents while minimizing the side effects such as motion sickness through interaction with player movement on VR. Generally, when a person gazes at a specific object, the user does not focus on the remaining portion except the scene within the viewing angle, and when the user is in a high-speed state such as a playground, the viewing angle becomes smaller. However, in most VR contents, all scenes are displayed with high graphic quality without considering these parts, which causes inconvenience such as motion sickness as mentioned above. So we designed to reduce the visual stimulation coming from the scene beyond the viewing angle through the blur effect according to the movement of the player on the VR. As a result, it was possible to see the effect of increasing the amount of water for VR contents and the effect of reducing cyber nuisance in VR. This result shows that constructing the VR screen through the interaction with the player's movement on the VR can be more realistic and can contribute to the stable VR content production.

Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:54-13:56 D2V13

Rendering Virtual Window for Mobile Augmented Reality

Jun Sol Oh and Jong Weon Lee**

Department of Computer Science and Engineering, Sejong University, Seoul, Korea
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This paper introduces the algorithm that renders virtual windows in a mobile augmented reality environment. Rendered virtual windows that can be viewed from any angle without wasting a lot of resources.

Keywords: Augmented Reality, Virtual Window, Rendering, Mobile, Panoramic image.

AsiaHaptics 2018

Session 4 Video Demo

Premier Ballroom A+B Thu, October 16, 2018, 13:30-14:00

13:56-13:58 D2V14

Dismantling Simulation of Nuclear Power Plant Structures Based on Virtual Reality

Myoung-Bae Seo*

Department of Future Technology and Convergence Research, KICT, Korea
*smb@kict.re.kr

The domestic and overseas construction sector sees an increasing use of 3-dimensional information model technology, BIM (Building Information Modeling), and a rapid development of VR/AR/MR-linked virtual construction technologies based on BIM. Since the construction sector, given its industrial characteristics, gathers the diverse stakeholders such as the client, designer and constructor, before execution of construction to review the business feasibility, design, construction, etc., if diverse prior virtual simulations are conducted, it will minimize errors and reduce costs. This presentation thus produced a 3D model of a nuclear power plant structure so as to implement the simulation by which the worker links VR equipment in the multi-screen environment to dismantle the structure in a VR environment. Since the nuclear power plant structure is exposed to radiation, it is very important to determine the optimal structure dismantling scenario with minimum manpower. Thus the workers can experience the simulation of installation of temporary facilities for the dismantling of the structure, the simulation of installation of dismantling equipment, the simulation of the dismantling of blocks using cranes, etc., and this enables the determination of the optimal dismantling scenario. If this simulation is applied, it will enable the experience of VR construction not only for the nuclear power plant structure, but in diverse construction environments.

Session 4 **Video Demo**

Premier Ballroom A+B **Thu, October 16, 2018, 13:30-14:00**

13:58-14:00	D2V15

A Conceptual Design of a Haptic Glove with Soft Vibrotactile Actuators

Won-Hyeong Park[1*], Seokhee Jeon[2] and Sang-Youn Kim[1**]

[1] Interaction Laboratory of Advanced Technology Research Center, KOREATECH, CHeonan, South Korea
[2] Kyung Hee University, Youngin, South Korea
*ipo1001@koreatech.ac.kr, **sykim@koreatech.ac.kr

Although various haptic gloves with rigid vibrotactile actuators have been used for increasing immersion of virtual reality (VR) through providing haptic sensations to a user, a rigid feeling by attaching the rigid actuators onto user's fingertip disturbs to feel the textures of an interacted virtual object. Therefore, this paper proposes a conceptual design of a haptic glove with soft vibrotactile actuators and demonstrates the haptic glove with a simple VR application based on a gesture user interface. In the application, a user can create and can modify music cubes by gesture inputs, and can play music by touching the music cubes. A user can feel various haptic sensations during gestures without any rigid and unexpected feelings in VR.

X. Exhibition Information

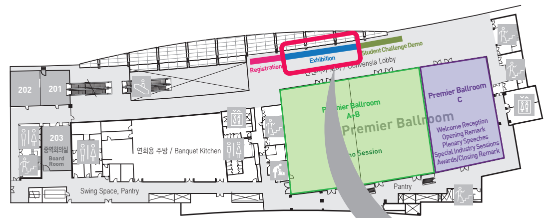
AsiaHaptics 2018

XII. Exhibition Information

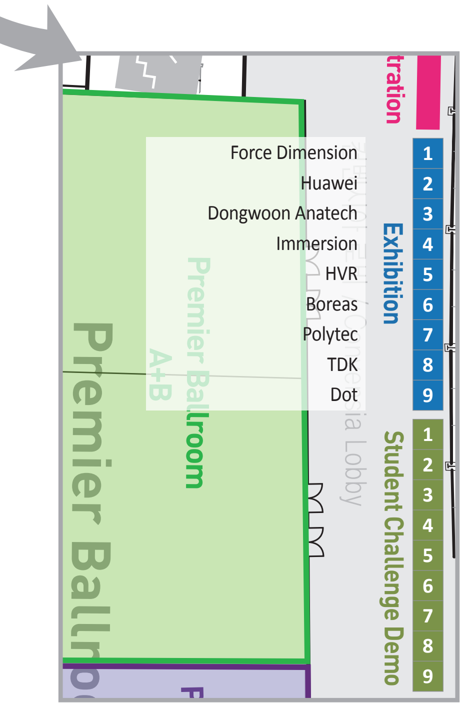
• Overview

- **Date/Time:** November 15, Thursday / 09:00-18:00
  November 16, Friday / 09:00-16:00
- **Venue:** Premier Ballroom Lobby, 2F, Songdo Convensia

• Booth Layout



Place : 2F, Song-do Convensia
(In front of Premier Ballroom)



Exhibition

Booth No.	Company
1	Force Dimension
2	Huawei
3	Dongwoon Anatech
4	Immersion
5	HVR
6	Boreas
7	Polytec
8	TDK
9	Dot

Booth No. 1	Company Name	Force Demension
	President	Sebastien Grange
	Address	Route de Saint-Cergue 295, CH-1260 Nyon, Switzerland
	Tel/Fax	+41 22 362 6570 / +41 22 362 6571
	Email	sales@forcedimension.com
	Website	http://www.forcedimension.com
	Contents of Exhibit	Omega / Delta / Sigma

Introduction

Founded in 2001 with the support and expertise of Switzerland's leading R&D facilities, Force Dimension has more than a decade of first-hand haptic technology expertise. | Close partnerships with leaders in R&D, high-tech manufacturing and marketing enable the company to stay constantly at the cutting edge of haptic design.

Force Dimension has earned international recognition for designing and manufacturing high precision haptic interfaces operating industrial and medical robotic systems. Our flagship products, the delta and omega family of haptic devices, provide best-in-class solutions that enable human operators to instinctively and safely operate critical systems.

Booth No. 2	Company Name	Huawei Technologies Co.,Ltd.
	President	Zhu Xiaolei
	Address	No.156, Beiqing Road, Haidian District, Beijing, 100095, P.R.China.
	Tel/Fax	+86-18345155406
	Email	zhuxiaolei@huawei.com
	Website	http://www.huawei.com
	Contents of Exhibit	3D gesture game

Introduction

We are AR&VR engineering department from Huawei 2012 labs. We have delivered Huawei AR Engine for Huawei flagship mobile phones, including Motion Tracking, Plane Detection, Light Estimation, Hit Testing, Body/Hand Skeleton, Hand Gesture Recognition, and haptics feedback features. Our goal is to bring Visual-Auditory-Tactile Multimodality Interaction to Huawei Mobile & Wearable Products. We are open for university collaboration to co-work with leading research groups, and we offer internship & job opportunities in Huawei Global Research Centers.

Booth No. 3	Company Name	Dongwoon Anatech Co., Ltd.
DONGWOON ANATECH	President	DongCheol Kim
	Address	9FL, Arirang Tower, Nambusnhwan-Ro 2351 Sechogu Seoul Korea
	Tel/Fax	+82-2-3465-8765 / +82-2-3465-8779 (HQ, Korea) +86-18566257674(Shenzhen) / +86-18616303961(Shanghai) / +886-958009028(Taiwan) +813-5512-5760(Japan)
	Email	sales@dwanatech.com
	Website	https://www.dwanatech.com
	Contents of Exhibit	Haptic Motor Driver IC, A2V Demo System, Haptic Control Board

Introduction

Booth No. 4	Company Name	Immersion
immersion	President	Mr. Tom Lacey
	Address	50 Rio Robles, San Jose, CA 95134
	Tel/Fax	1.408.467.1900
	Email	marketing@immersion.com
	Website	https://www.immersion.com
	Contents of Exhibit	Mobile Haptic UI and AR experiences, Haptic Design Tools

Introduction

For over 25 years, Immersion has led the development of haptic technology in mobile, gaming, automotive, wearables, and other commercial consumer devices. Immersion's technology is in more than 3 billion digital devices worldwide and holds 3,200 issued and pending patents. The company, headquartered in Silicon Valley, works with leading device manufacturers across the world.

Booth No. 5	Company Name	HVR Co., Ltd.
	President	Dae-Sung, Jang
	Address	543-1. Gasan-Dong, Geumcheon-Gu, Daesung D-Polis B-Dong #2405, Seoul, 153-719, Korea
	Tel/Fax	+82-2-861-9278
	Email	3dif@3dif.co.kr
	Website	http://www.hvr.co.kr
	Contents of Exhibit	Haptic Device, Software

Introduction

HVR has contributed to the knowledge industry through research and development for the core technology of the future-oriented IT technology haptic interface, 3D scientific data visualization, 3D graphics library development.

- Haptics Device(3D Systems Geomagic / ForceDimension)
- Software Development Toolkit for Medical application(Open Inventor)

Booth No. 6	Company Name	Boréas Technologies Inc
	President	Simon Chaput
	Address	45, Bld Aéroport Bromont Québec Canada, J2L 1S8
	Tel/Fax	+1 450 534 8000 ext.1525 or 1529
	Email	info@boreas.ca
	Website	https://www.boreas.ca
	Contents of Exhibit	Development Kits, Integrated Circuits, Demo Kits.

Introduction

Boréas Technologies Inc. is a fabless semiconductor company commercializing product-differentiating integrated circuits for haptic applications in consumer and industrial markets. With origins in research conducted at Harvard University, Boréas was founded in 2016 in Bromont, Québec, Canada. Its proprietary piezoelectric actuator driver technology platform, CapDrive^{TM}, enables the rapid design of low-power HD haptic feedback in wearables, smartphones, game controllers and other devices. For more information, visit website www.boreas.ca

Booth No. 7	Company Name	TDK Corporation
TDK	President	Shigenao Ishiguro
	Address	Shibaura Renasite Tower, 3-9-1 Shibaura, Minato-ku, Tokyo
	Tel/Fax	Please check https://product.tdk.com/info/en/contact/ for the contact of your area/country
	Email	Please check https://product.tdk.com/info/en/contact/ for the contact of your area/country
	Website	https://www.global.tdk.com/
	Contents of Exhibit	Piezo Haptic Actuators - PowerHap™, PiezoHapt™

Introduction

TDK Corporation is a leading electronics company based in Tokyo, Japan. It was established in 1935 to commercialize ferrite, a key material in electronic and magnetic products. TDK's comprehensive portfolio features passive components such as ceramic, aluminum electrolytic and film capacitors, as well as magnetics, high-frequency, and piezo and protection devices. The product spectrum also includes sensors and sensor systems such as temperature and pressure, magnetic, and MEMS sensors. In addition, TDK provides power supplies and energy devices, magnetic heads and more. These products are marketed under the product brands TDK, EPCOS, InvenSense, Micronas, Tronics and TDK-Lambda. TDK focuses on demanding markets in the areas of information and communication technology and automotive, industrial and consumer electronics. The company has a network of design and manufacturing locations and sales offices in Asia, Europe, and in North and South America.

Booth No. 8	Company Name	Polytec GmbH
Polytec	President	Dr. Helmut Selbach
	Address	Polytec-Platz 1-7 76337 Waldbronn. Germany
	Tel/Fax	+49 (0) 7243 604-0 / +49 (0) 7243 604-0
	Email	info@polytec.de
	Website	https://www.polytec.com
	Contents of Exhibit	Psv-500-Xtra scanning vibrometer system, IVS-500 singlepoint vibrometer

Introduction

Polytec, with over 350 employees worldwide, has more than 40 years of experience developing, producing, and distributing optical measurement systems for industry and research.

Polytec's laser vibrometers have very likely played their part sensing those vibrations, allowing them to be modified or eradicated,or to validate finite element models used in their development.

We are specialists in the fields of optical measurement and are simultaneously the worldwide market leader in contactless vibration measurement.

Polytec's laser vibrometers continue to have an international reputation for quality and are recognized as the standard tool for reliably accurate non-contact vibration detection and measurement.

Booth No. 9	Company Name	Dot Incorporation
	President	Eric JuYoon Kim, Ki Kwang Sung
	Address	#2002 Ace High-End Tower 7th 67 Gasan Digital 2-ro, Geumcheon-gu, Seoul, Republic of Korea
	Tel/Fax	+82-2-864-1113 / +82-2-864-1989
	Email	dot@dotincorp.com
	Website	https://dotincorp.com
	Contents of Exhibit	Dot Watch, Dot Mini, 1st generation cells, 2nd generation cells, Dot Module

Introduction

Dot strives to be a pioneer in accessible and affordable innovations for the vision-impaired and the deafblind, to lead independent lives. Our mission is to make the world accessible, dot by dot.
To do this, we developed the world's first braille smartwatch, the Dot Watch. But Dot is more than just the watch. We are creating a whole new media universe for a previously unserved target group. We are launching the Dot Mini soon. This is the first smart media device for the visually impaired. It can be used in classrooms and library to get access to digital text content. But that's not all, with our second generation cells, we are working on the Dot Pad, a multi-layered braille display that will make graphics and images possible. Ultimately, we want technology to change the lives of the people, in their everyday lives. To do this, we will be working on the Dot Public, making even public infrastructures like transportation, public buildings, and others accessible.

Booth No.	Company Name	Hyundai Motor Company
	President	WON HEE LEE
	Address	12, Heolleung-ro, Seocho-gu, Seoul, Republic of Korea
	Tel/Fax	080-600-6000
	Email	group@hyundai.com
	Website	https://www.hyundai.com
	Contents of Exhibit	EQ900 & Veloster

Introduction

- Founded in 1967.
- Sold 4.51 million vehicles in 2017 (including 688,939 in Korea and 3,817,336 overseas)
- Won numerous awards (e.g. Elantra Eco 1.4L made the 2017 Ward's Ten Best Engines list)
- 2018 Interbrand ranking : 6th in automotive field and 36th in overall ranking
- Management Philosophy : "Realize the dream of mankind by creating a new future through ingenious thinking and continuously challenging new frontiers."
- Core Value : Customer, Challenge, Collaboration, People and Globality

XI. Author Index

AsiaHaptics 2018

IEEE Haptics Symposium 2020
Washington, DC, USA

March 28 - 31, 2020
Crystal Gateway Marriott

Held since 1992, the IEEE Haptics Symposium is a vibrant interdisciplinary forum of research in neuroscience, perception, engineering, and design, focused on sharing new advances in our understanding of the sense of touch, sparking new collaborations, and envisioning a future in which physical interactions are enriched through haptic technologies.

To stay informed about the 2020 conference, visit:
www.hapticssymposium.org

EUROHAPTICS 2020

17 - 20 June 2020
Leiden, The Netherlands

The Eurohaptics Society welcomes you to Leiden for Eurohaptics 2020. This beautiful, historical city will open its gates, streets and canals to this edition of the international conference on haptics and touch enabled computer applications.

Leiden is an easy-to-reach city (only 15 minutes from Amsterdam international airport), rich with cultural heritage and a vast wealth of history in art and science. Leiden University – the oldest in the Netherlands – was founded in 1575 in an environment where freedom was the highest good.

www.eurohaptics2020.org

We invite you to come to Leiden and to become enchanted by the city that inspired so many before you. Welcome to Leiden, City of Discoveries.

Add the sense of Touch to your digital world

3D Systems haptic devices provide true three-dimensional navigation and force feedback integrating a sense of touch into the Geomagic Freeform® and Geomagic® Sculpt™ 3D modeling software solutions as well as research and commercial applications. The 3D Systems haptic device can accurately measure the 3D spatial position (along the x-, y- and z-axis) and the orientation (roll, pitch and yaw) of its handheld stylus.

Intuitive Interaction

When haptics are used in design and virtual sculpting environments, designers can interact and fell the shape of the 3D model as if they were designing in physical clay. Interactive clay sculpting tools that perform just like the real world allow for a far more intuitive 3D design. These patented 3D Systems haptic devices ingeniously use motors to create forces that push back on the designer's hand to simulate touch when the cursor interacts with the 3D model in virtual space. Depending on the model, 3D Systems haptic devices provide either 3 or 6 Degrees of Freedom(DOF)

Touch to Create and Simulate

3D Systems haptic devices are used in every industry that requires accurate organic designs, using the sense of touch to build 3D models faster and with precision.

Designers turn to Geomagic Software and haptic devices to successfully create their designs for the following applications:

- 3D Modeling and Manufacturing
- Jewelry, Automotive, Toy, and Shoe Design
- Medical Surgery and Rehabilitation Simulations
- Artwork and Sculpting
- Forensic Reconstruction
- Training, Simulations, and Skills Assessment
- Gaming, Entertainment, and Virtual Reality
- Bakewear and Cookery Molds and Dies
- Teleoperation and Robotic Control
- Virtual Assembly and Collision detection
- Applications for the Visually Impaired
- Molecular Modeling
- Nano Manipulation

Touch™

The 3D Systems Touch offers the ability to precisely sculpt inside the Geomagic organic design software solutions. This haptic device offers robustness and stability for complex projects and designs.

Touch X™

With greater accuracy, the Touch X delivers the very best for professional designers and artists in terms of accuracy and ability to develop fine details. This haptic device delivers optimal stiffness and a high exertable force to assist with the process of design and production.

3D INTERFACE 에이치 브이알
HVR Co., Ltd

As pioneers of the haptic industry, our job is to inspire others and enable them to create amazing haptic experiences.

We do this by creating versatile enabling technologies for haptic development, delivery & playback.

What ideas do you have?

COME MEET WITH US

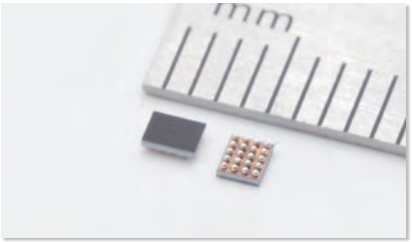
immersion.

DONGWOON
ANATECH

DW7912 , High Voltage Vibration Motor Driver

- Powerful touch feedback
- Overdrive up to 10V
- Flexible waveform creation
- Fast response time

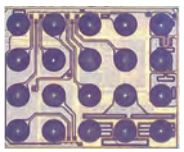
Strong Effect | Over drive | Wave form | Fast response



DW7912 is a high voltage vibration motor driver that delivers intensive vibration effects with high voltage boost converter and H-bridge driver. The Real-Time Playback mode is a simple 8-bit register interface where the user enters a register value over I2C. The internal memory and the memory playback mode using waveform sequencer reduce the burden imposed on the host processor including offloading processing requirements such as digital streaming, latency improvement and I2C traffic reduction. DW7912 features a full shutdown and an automatic go-to-standby state to reduce power consumption.
The optimum waveform is applied to customize the vibration power as well as the tactile sense.

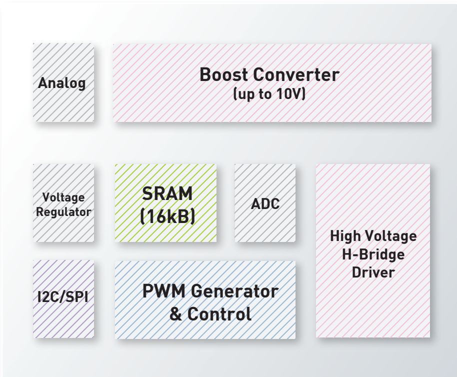
▶ Features

- High Voltage H-Bridge Driver
- I2C/SPI Controlled Digital Playback Engine
  - Real-Time Playback Mode / Memory Playback Mode
- Built-in SRAM(16KB) for Waveform Storage
- Built-in Boost Converter with Bypass Mode
  - Boost Output Voltage Range : 4.68V to 10.2V
  - Maximum Boost Current : 500mA @VBST=8.0V
  - Adaptive Boost Output Voltage Option
- Drive Compensation over Boost Output Voltage
- Hardware Trigger Input / Interrupt Output Option
- Automatic Transition to Standby State
- Protection : UVLO, TSD, OCP, SCP
- 2.9V to 4.5V Input Voltage Range



20-WLCSP Package
(1.65mm x 2.05mm)

▶ Functional Block Diagram



DONGWOON

force dimension

omega.x haptic devices

force feedback interfaces

omega.3

omega.6

omega.7

The **omega.x** family of haptic devices relies on a unique kinematic design that has been optimized for high-end force feedback. Its **high mechanical stiffness**, combined with its embedded **USB 2.0 controller**, enables the rendering of **crisp contact forces**.

The **omega.6** and **omega.7** designs provide **perfect decoupling** of translations and rotations. The combination of **full gravity compensation** and **driftless calibration** contributes to greater user comfort and accuracy.

With its unique **active grasping** extension, the **omega.7** is the most versatile haptic device available. Its end-effector covers the **natural range of motion** of the human hand and is compatible with **bi-manual teleoperation** console design.

The **omega.x** family of devices features a modular architecture that makes it possible to **replace one end-effector with another**. Conceived and manufactured in Switzerland, the **omega.x** range is specifically designed for demanding applications where **performance and reliability** are critical, including:

- medical and space robotics
- micro and nano manipulators
- teleoperation consoles
- virtual simulations
- training systems
- research

www.forcedimension.com
info@forcedimension.com