新製品
紹介

HAPTIC PLASTeR: Soft, Thin, Light and Flexible Haptic Display using DEA Composed of Slide-Ring Material for Daily Life

Tadatoshi Kurogi[*1], Yuji Yonehara[*2], Roshan Lalintha Peiris[*3]
Takeshi Fujiwara[*2], Kouta Minamizawa[*4]

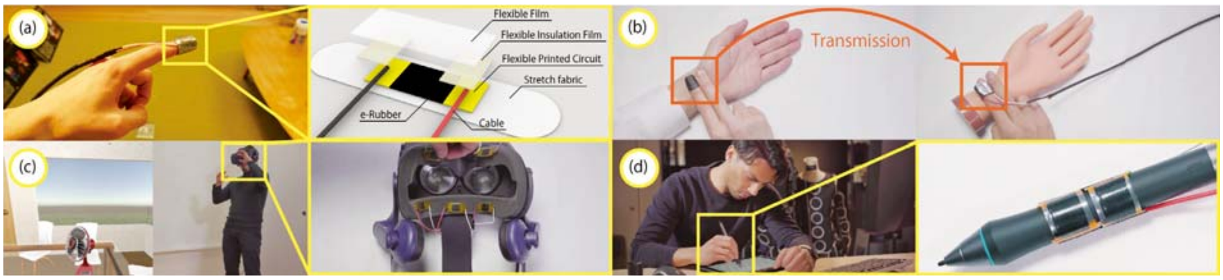

Figure 1: The HAPTIC PLASTeR system and applications: (a) The haptic display part of the HAPTIC PLASTeR and structure of the haptic display, (b) The haptic transmission system using the HAPTIC PLASTeR, (c) The HMD with the HAPTIC PLASTeR to present feeling the virtual wind, (d) The stylus with the HAPTIC PLASTeR to present feeling texture of materials

CCS CONCEPTS

•**Human-centered computing → Haptic devices;**

KEYWORDS

Haptic display, dielectric elastomer actuator, slide-ring material

ACM Reference format:
Tadatoshi Kurogi, Yuji Yonehara, Roshan Lalintha Peiris, Takeshi Fujiwara, and Kouta Minamizawa. 2019. HAPTIC PLASTeR: Soft, Thin, Light and Flexible Haptic Display using DEA Composed of Slide-Ring Material for Daily Life. In *Proceedings of SIGGRAPH '19 Emerging Technologies, Los Angeles, CA, USA, July 28 - August 01, 2019*, 2 pages.
https://doi.org/10.1145/3305367.3327983

[*1] Keio University Graduate School of Media Design, TOYODA GOSEI Co., Ltd.
[*2] TOYODA GOSEI Co., Ltd.
[*3] Keio University Graduate School of Media Design
[*4] Keio University Graduate School of Media Design JST ACCEL

1 INTRODUCTION

Recently, many wearable haptic displays have been widely explored aiming the enriched user experience through various application such as the virtual reality and Telexistence. Many such proposed wearable haptic displays so far are composed of rigid materials such as motors, voice coil actuators and speakers [Minamizawa et al. 2007]. Therefore, in recent years, haptic displays composed of soft materials such as dielectric elastomer actuators (DEAs) have been proposed [Koo et al. 2008; Park et al. 2015]. However, the polymers used in such DEAs have hysteresis-loss property as a main physical limitation, which results in different output displacement property during the actuation cycles. As such, this property requires

SIGGRAPH '19 Emerging Technologies, July 28 - August 01, 2019, Los Angeles, CA, USA

ACM ISBN 978-1-4503-6308-2/19/07.
https://doi.org/10.1145/3305367.3327983

specialized actuation mechanisms for DEAs to be widely used as haptic displays.

Following this trend, Ito proposed Slide-Ring polymer Material (SRM), which has property different from the other polymers [Ito 2007]. In contrast to the other polymers, SRM consist of 8-shaped cross-linking points that allow the SRM to freely move. Therefore, it has a unique property that allows small hysteresis-loss. As such, this property of the SRM makes it suitable as a haptic actuator compared with other DEAs.

Thus, in our work HAPTIC PLASTeR, we explore a soft, thin, light and flexible haptic display that uses DEA composed of SRM (**Figure 1(a)**). Due to the property of SRM, it can present an output waveform that approximately follows the input waveform as a desirable property for soft haptic displays. As such, by customizing the shape/size and/or the input signals, we can seamlessly integrate it with other objects as a haptic display that blends into our daily life.

2 HAPTIC PLASTER

Figure 2 shows the system overview of the HAPTIC PLASTeR which consists of the *haptic display*, the *control driver unit*, and the *actuation system*. The *haptic display* is equipped with "e-Rubber" which is a DEA composed of SRM (**Figure 3**), on a plaster-sized flexible material

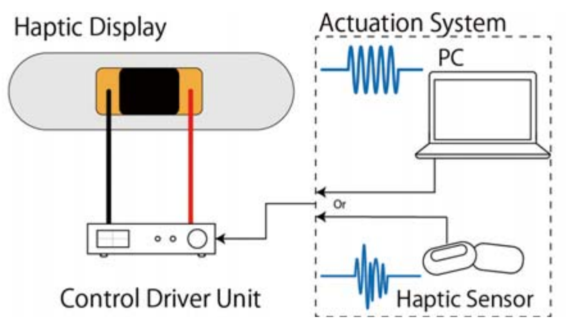

Figure 2: System Overview

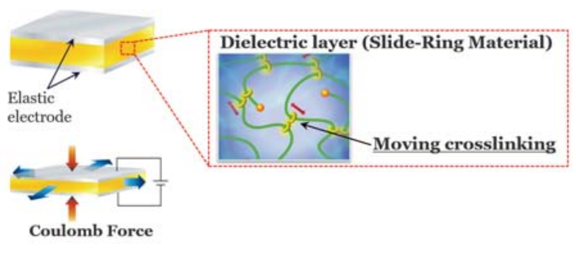

Figure 3: Structure of e-Rubber and SRM

that can be worn on a finger. A flexible insulation film is placed on top of the flexible electrodes of the actuator prevent the electrodes from touching the skin (**Figure 1(a)**). The e-Rubber works by the Coulomb Force principle, whereby the rubber shrinks when a voltage is applied to the two electrodes. Thus, by changing the applied signal, the e-Rubber can be actuated as a haptic display.

The *control driver unit* amplifies and offsets the input signal as required by the haptic display. As the e-Rubber requires 0-1.5kV for actuation (similar to other DEA), the input signal from various sources can be amplified using the amplifier of the control unit. In addition, the control unit offsets any negative values on the input signal as specified by property of the e-Rubber where the drive voltage is 0 - 1.5 kV with 750 V as the center.

We developed two kinds of actuation systems that allow input signals from the PC and an external haptic sensor. Input from the PC is used for VR applications or presenting textures on a tablet application, etc. Input from the haptic sensor is used as a haptic transmission application. Both these actuation systems can be directly attached to the control unit to present the input signal.

Note on safety: Since the actuator requires a high drive voltage, we have taken a few steps as safety measures. Firstly, as indicated, the haptic display is well insulated with two layers of films. Secondly, the haptic display consumes a minimal amount of current as it operates using the Coulomb principle (as a capacitor). Therefore, the control unit consists of an overcurrent detector that detects any current leakage and shuts down immediately. These safety measures were ensured with thorough procedures. As proof, the display was presented at a public exhibition (**Figure 4**) that was held for 3 days (8 hours a day) with over one hundred visitors who tried our prototype.

Figure 4: Public demonstration in business robot exhibition.

3 EVALUATION

Two technical evaluations were conducted to identify the property of the system.

In the input voltage waveform vs output displacement waveform evaluation, a voltage of 0-1.5kV (750V center) with 1Hz was presented as the drive signals to the HAPTIC PLASTeR, and the displacement was measured. The result indicates that the waveform of the output displacement approximately followed the waveform of the input signal (**Figure 5**). This property indicates the characteristics of the SRM of the e-Rubber used in the HAPTIC PLASTeR that denote small hysteresis-loss.

In the frequency characteristics evaluation, eleven types of sine waves with frequencies were presented as the input signals to HAPTIC PLASTeR, and the displacement was measured. As a result, the maximum displacement is 3.5um when input frequency is 0.1Hz, and the displacement decreases at higher frequencies (**Figure 6**) . This result indicates that the HAPTIC PLASTeR is suitable for low-frequency actuation which present a different property from conventional vibration motors, voice coils, and speakers.

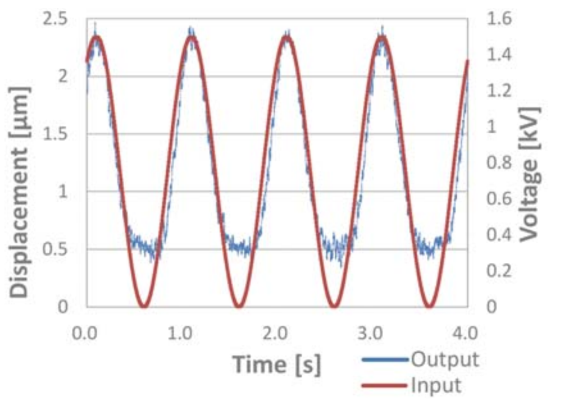

Figure 5: Input waveform vs output waveform

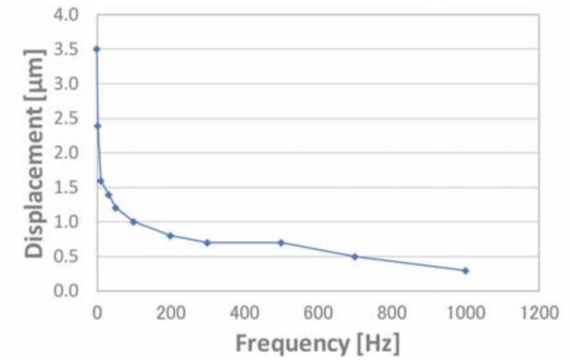

Figure 6: Frequency Charac-teristics

4 USER EXPERIENCE

At the SIGGRAPH 2019 E-Tech demonstrations, we will showcase the HAPTIC PLASTeR in various form factors such as wearable band-aid, integrated with a head-mounted display and smartwatches, table styluses etc. Mainly, the participants will be able to experience two main application scenarios the HAPTIC PLASTeR. First is a haptic transmission based experience that will allow the user to experience various transmission of haptic data such as the heartbeat of a remote user. Secondly, the participants will be able to experience various daily use applications such as being able to feel textures of materials on a tablet device with an integrated stylus, and various VR application scenarios such as feeling the virtual wind in VR through the soft haptic actuation of the display.

ACKNOWLEDGMENTS

This research is partly supported by JST-ACCEL Embodied Media Project Grant #JPMJAC1404.

REFERENCES

Kohzo Ito. 2007. Novel cross-linking concept of polymer network: synthesis, structure, and properties of slide-ring gels with freely movable junctions. *Polymer journal* 39, 6 (2007). https://doi.org/10.1295/polymj.PJ2006239

Ig Mo Koo, Kwangmok Jung, Ja Choon Koo, Jae-Do Nam, Young Kwan Lee, and Hyouk Ryeol Choi. 2008. Development of Soft-Actuator-Based Wearable Tactile Display. *IEEE Transactions on Robotics* 24, 3 (2008).

Kouta Minamizawa, Souichiro Fukamachi, Hiroyuki Kajimoto, Naoki Kawakami, and Susumu Tachi. 2007. Gravity Grabber: Wearable Haptic Display to present Virtual Mass Sensation. In *ACM SIGGRAPH*. ACM.

Won-Hyeong Park, Tae-Heon Yang, Yongjae Yoo, Seungmoon Choi, and Sang-Youn Kim. 2015. Flexible and Bendable Vibrotactile Actuator Using Electro-conductive Polyurethane. In *World Haptics Conference*. IEEE.