A Conceptual and Practical Exploration of Electrovibrating Wearables

Balkiss Friaa[1] and Vincent Lévesque[1]

***Abstract*— Electrovibration has been used extensively with touchscreens and other rigid objects. We propose extending electrovibration to wearables such as wristbands, jewelry and clothing, and present an exploration of the resulting design space and preliminary experimentation with haptic prototypes made of flexible materials and conductive textiles.**

I. Introduction

Electrovibration generates tactile sensations by modulating the friction between the skin and an insulated conductive surface driven with time-varying high-voltage signals [1]. This technology has been used extensively to produce sensations as a fingerpad slides on a touchscreen, and has also been applied to interactions with everyday objects (e.g., [2]).

We propose extending electrovibration to wearable objects such as wristbands, jewelry and clothing. We first explore the design space of electrovibrating wearables before presenting preliminary results of experimentation with electrovibration at different body locations using flexible materials.

II. Design Space Exploration

We consider two forms of interaction with electrovibrating wearables (Fig. 1). In the first, users deliberately interact with the wearable by running a finger against its electrovibrating outer surface. In the second, users accidentally interact with the wearable as they move naturally, brushing the skin of a part of their body against its electrovibrating inner surface.

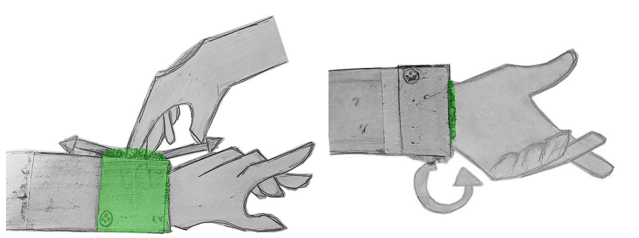

Fig. 1. Examples of (left) deliberate and (right) accidental interactions with an electrovibrating cuff. Electrovibrating surface is shown in green.

Both interaction forms may be supported by wearables such as wristbands, jewelry or clothing. Deliberate interactions are best suited for locations easily reachable with a hand, such as the wrist, the forearm or the thighs. Accidental interactions require friction against moving body parts, such as wrist against cuff, neck against collar, or thighs against pants. In many cases, interactions that are typically accidental can also be triggered by deliberate movements.

We believe that electrovibrating wearables could enable new forms of communication and information transmission, either alone or in combination with wearable input technologies such as touch-sensitive fabrics (e.g., [3]). Users could for example touch bracelets for directional cues while walking, feel a calm, non-obtrusive notification through the texture of their cuffs, or get confirmation feedback as they interact with a smart sleeve controlling their phone. Such interactions may notably be performed subtly or surreptitiously.

III. Preliminary Results

To experiment with these concepts, we developed prototypes with flexible conductive materials such as copper or aluminum foil and conductive textiles such as Velostat. We applied a thin layer of insulating paint and drove the materials with 100 V signals at frequencies of 15 to 250 Hz. Safety precautions included current-limiting circuits (<5 mA), break-away connections, and user switches. We experimented with these prototypes to understand the perception of electrovibration at different body locations.

Our preliminary results suggest that electrovibration is strongest and most noticeable on the palm and fingertips, and slightly weaker on the wrist. The arms, neck, and thighs produce a more subtle sensation and occasionally an unpleasant tingling, possibly due to the larger area of contact or the presence of hair. Moreover, we have found the sensations produced by natural movement of the body against an electrovibrating wearable (whether deliberate or accidental) to be difficult to distinguish from other tactile cues such as clothes brushing against the skin. We also faced issues in fabrication of the flexible sketches, and more specifically with the adhesion of the insulating paint to material such as Velostat over time.

IV. Conclusion

We introduced a new perspective on electrovibration through an exploration of its use in wearable devices. While promising, our results suggest that further work is necessary to understand how to fabricate electrovibrating wearables and which body locations and use case to target.

References

[1] Basdogan, C., Giraud, F., Levesque, V., Choi, S. (2020). A review of surface haptics: enabling tactile effects on touch surfaces. IEEE transactions on haptics, 13(3), 450-470.

[2] Bau, O., Poupyrev, I. (2012). REVEL: tactile feedback technology for augmented reality. ACM Transactions on Graphics 31(4), 1-11.

[3] Poupyrev, I., Gong, N. W., Fukuhara, S., Karagozler, M. E., Schwesig, C., Robinson, K. E. (2016). Project Jacquard: interactive digital textiles at scale. In Proc. CHI 2016, pp. 4216-4227.

*Research supported by NSERC and MITACS.

[1]The authors are with École de technologie supérieure, Montréal, Canada. e-mail: balkiss.friaa.1@ens.etsmtl.ca, vincent.levesque@etsmtl.ca