SurfaceReach: Assistive Guidance by Electrovibration on a Large Table

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Fig. 1: Evolution of the SurfaceReach concept from sketches (left, middle) to initial prototype (right).

***Abstract*— We present SurfaceReach, an application of surface haptics by electrovibration designed to safely guide a person with visual impairments to a target object by displaying a tactile path on a table. We describe the creative process that led to the elaboration of this concept, which included brainstorms and interviews with 9 persons with visual impairments. We also describe the implementation of a prototype of the concept using a large custom-made electrovibrating surface and our initial experimentation with variations of tactile path renderings.**

I. INTRODUCTION

Electrovibration allows the friction experienced by a finger sliding on a surface to be modulated, thereby creating programmable sensations of localized textures when coupled with touch sensors. This effect is produced by driving a conductive surface with an oscillating voltage and feeling the surface through an electrically-insulating layer. Although discovered decades ago, this principle has been used extensively in recent years to produce tactile effects on the surface of touchscreens (e.g., [1]), and has also been adapted for use on the surface of everyday objects [2]. The simplicity of the required hardware makes it theoretically possible to apply electrovibration to objects of arbitrary size and shape.

In this work, we aimed to explore applications of electrovibration for persons with visual impairments. Prior work has considered the use of electrovibration for the display of tactile graphics [3] or for sensory substitution with a camera-equipped tablet as an intermediary [4]. Guiding persons with visual impairments with electovibrating tracks produced on augmented walls has also been proposed conceptually in [2].

We continued this exploration through brainstorms and interviews with persons visual impairments. This led to the development of SurfaceReach, an application of electrovibration designed to guide a visually impaired person's hand to an object on a table through textured paths. We first describe our exploration of electrovibration for persons with visual impairments, and then describe the initial development of a prototype of the concept on a large custom-made table.

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II. EXPLORATION OF ASSISTIVE APPLICATIONS

The design of SurfaceReach was inspired and informed by brainstorms with our research team and interviews with persons with visual impairments. Our objective was to find a use for electrovibration that addresses a problem encountered by persons with visual impairments in their daily life.

We first conducted brainstorms with members of our research group to identify possible applications of electrovibration for persons with visual impairment. The brainstorms were conducted in a dedicated space that allowed drawing on walls and tables, facilitating the exploration of concepts related to everyday objects (Fig. 1). The brainstorms identified promising concepts that were validated and expanded upon through interviews with persons with visual impairments.

We conducted these interviews with 9 persons with visual impairments ranging from light perception to complete blindness, aged 25 to 65. The interviews were approved by the Research Ethics Committee of ETS. The participants were recruited through a local association for persons with visual impairments and the participants took part in the interviews after giving their informed consent. The 1-hour interviews began with a broad discussion of problems encountered in daily life and possible solutions, with prompts centered on themes such as travel, education, work, mobility, and sports. The interviews then continued with further explorations of these themes and problems, with a focus on solutions relying on the sense of touch and haptic technologies. The interviews concluded with a discussion of the most promising ideas identified during the brainstorm. The interviews were designed to explore problems and solutions without bias, while also gathering feedback on previously identified concepts.

This process resulted in the elaboration of more than seven concepts designed to solve a problem encountered by persons with visual impairments with haptic feedback. Some concepts that were thought to be promising during the brainstorm were found to be impractical when discussed with the interviewees, such as scanning an electrovibrating surface with a thumb while walking. The remaining concepts, generated either through the brainstorm or interviews, were ranked based on how often the problem or solution was mentioned by the interviewees and the feasibility of implementation with electrovibration within the project's time constraints.

The selected concept was SurfaceReach, an application of electrovibration intended to safely guide a person with visual impairements to an object resting on a table (see Fig. 1). With SurfaceReach, we imagine a table capable of producing tactile patterns on its surface that can be followed with a finger to a target object, avoiding obstacles along the way. A person may for example ask a virtual assistant to be guided to their smartphone, and be able to follow a path to it on the table that avoids a hot coffee mug. The next section describes our initial implementation and exploration of this concept.

III. Initial Prototype

For our initial prototype, we chose to implement a custom large-area electrovibrating surface. While prior work has shown that a large capacitive touch surface can be used for this purpose [5], our goal was to develop a more flexible solution that could be used to produce electrovibration on surfaces of arbitrary shapes and sizes in the future. We therefore experimented with the use of various insulating tapes and paints, which were reported in prior work (e.g., [2]) but not described in sufficient details for replication. We obtained the best results with the deposition of an electrically insulating paint (Red Insulating Varnish, MG Chemicals) with a pressure-regulated air spray gun (CA Technologies). Applying a smooth, uniform coat of insulating paint nevertheless remains a challenge, and we found our prototype to have a perceptible texture that can interfere with electrovibration at certain excitation frequencies.

Our initial prototype of SurfaceReach consists of a 610 mm x 610 mm aluminum plate covered with insulating paint. The plate is driven with a maximum voltage of 100 V generated through the analog output of an I/O card (Sensoray Model 826) and a high-voltage amplifier (Trek Model 2205). A large resistance was used to limit the current and insure safety in the case of a short circuit. A wristband was used for electrical grounding. Tracking was accomplished using optical markers and an infrared camera system (Optitrack V120:Trio). Markers were placed on the plate, the tracked object, and the fingertip of the user.

As an initial step, we investigated the rendering of tactile guides as straight paths to a target object, without any obstacle. We considered three variations of tactile guides, as illustrated in Fig. 2. The first approach consists of a path filled with a uniform texture, which we expect to be explored in a zigzag motion centered on the path. The second approach marks the limits of the path with two textured lines, theoretically preventing the user from sliding outside of the intended path. The third approach produces a conic shape that narrows towards the target, possibly indicating both the direction and distance to the target. The textures were produced using a 100-V square signal at 25 Hz, a frequency that was found to produce a sensation distinct from the natural texture of the painted surface. Our preliminary results suggest that a 4-cm textured path (first approach) is most intuitive and easiest to follow.

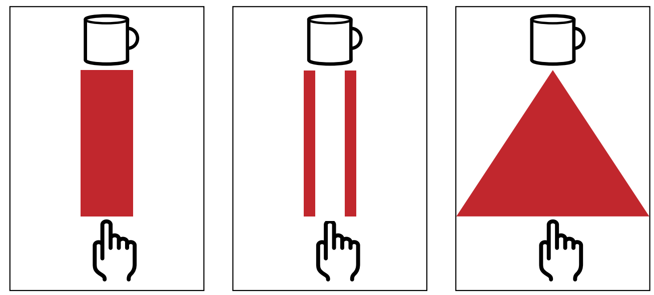

Fig. 2: Variations of tactile guides: (left) texture path, (middle) delimited path, and (right) conic shape. Areas where electrovibration is applied are shown in red.

IV. Conclusion

We have presented our initial exploration of SurfaceReach, an application of electrovibration to guide persons with visual impairments to a target object on a table. We have described both the creative process that led to the elaboration of this concept, and the development of an initial prototype. Future work will focus on further development of the concept with more complex paths and tactile guides, as well as its validation with persons with visual impairments. Our preliminary results suggest that SurfaceReach can be used to easily find an object and meets a need expressed by the persons with visual impairments that we interviewed.

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References

[1] O. Bau, I. Poupyrev, A. Israr, and C. Harrison, "Teslatouch: Electrovibration for touch surfaces," in *Proc. UIST'10*, 2010, p. 283–292.

[2] O. Bau, I. Poupyrev, M. Le Goc, L. Galliot, and M. Glisson, "Revel: Programming the sense of touch," in *CHI'13 Extended Abstracts*, 2013, p. 2785–2786.

[3] C. Xu, A. Israr, I. Poupyrev, O. Bau, and C. Harrison, "Tactile display for the visually impaired using teslatouch," in *CHI'11 Extended Abstracts*, 2011, p. 317–322.

[4] A. Israr, O. Bau, S.-C. Kim, and I. Poupyrev, "Tactile feedback on flat surfaces for the visually impaired," in *CHI'12 Extended Abstracts*, 2012, p. 1571–1576.

[5] S. E. Emgin, A. Aghakhani, T. M. Sezgin, and C. Basdogan, "Haptable: An interactive tabletop providing online haptic feedback for touch gestures," *IEEE Transactions on Visualization and Computer Graphics*, vol. 25, no. 9, pp. 2749–2762, Sep. 2019.