Actuation Plate for Multi-Layered in-Vehicle Control Panel

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ABSTRACT

High-fidelity localized feedback has the potential of providing new and unique levels of interaction with a given device. Achieving this in a cost-effective reproducible manner has been a challenge in modern technology. Past experiments have shown that by using the principles of constructive wave interference introduced by time offsets it is possible to achieve a position of increased vibration displacement at any given location. As new interface form factors increasingly incorporate curved surfaces, we now show that these same techniques can successfully be applied and mechanically coupled with a universal actuation plate.

Author Keywords

High Definition Haptics, Virtual Tactile Exciter, Interference Maximum, Actuation Plate

CCS Concepts

•**Hardware** → **Haptic devices; Sensors and actuators;**
•**Human-centered computing** → **Haptic devices;**

INTRODUCTION

Buttons, knobs, and switches have become increasingly less common as we see devices and interfaces forego these naturally tactile inputs for the now ubiquitous capacitive interface. Like many, the automotive industry has seen similar trends with the commonly found in-dash infotainment system [5]. The lack of tactile response in these systems increases driver distraction in contrast to the introduction of haptic feedback [4]. High fidelity haptics aims to both enhance the user experience while re-introducing the increased safety that accompanies tactile feedback.

In our work we aim to reproduce a simple method of vibration localization that has been shown to work over a flat surface [2]. The placement of actuators beneath the surface can be used to produce standing wave vibration interference at precise points over a display by triggering them at a predetermined offset. We have taken this same concept and placed the actuators over a universal actuation plate that is placed below a curved multi-layered surface where we intend to produce localized points of increased vibration displacement.

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MEASUREMENTS AND RESULTS

Before it was possible to produce a point of localized feedback we needed to find the best offsets to trigger the actuators with, to find the offsets, we measured the vibration from a range of offset signals using the MicroSense sensor. The offset that produced the highest peak vibration at a given point was stored for later use. This was repeated for each 10mm step starting near the left of the interface slider to near the right of the slider (Figure 1).

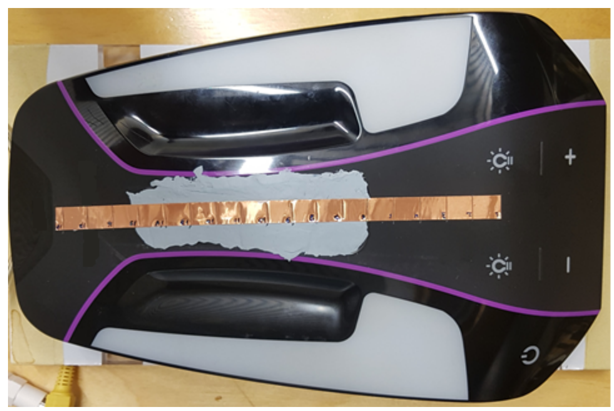

Figure 1. Control panel top view.

The top graph in Figure 2 illustrates the individual maximum vibration displacement measured for the required offsets for maximum vibration found at each position. The results match what we would expect from data in our previous research (compared to figure 3 in [1]). The 8cm measurement location is equidistant from actuators. Therefore, this central location surpasses attenuation to create a larger vibration maximum. The maximum displacement found afterwards drops due to the effects of attenuation over the surface material. We see a final peak as we approach the maximum vibration possible near the actuators located on that side. In an ideal material we would hope to reveal a flat line indicating equal maximum interference at any given point. This is something that should be targeted by experimenting with compatible elastic materials. At the moment we are using a hybrid modeled material that is not designed with localized haptics in mind, therefore the shown attenuation is to be expected.

If we Look at the bottom graph in 2, for all measurements, we are using the offset required to reach a point of maximum

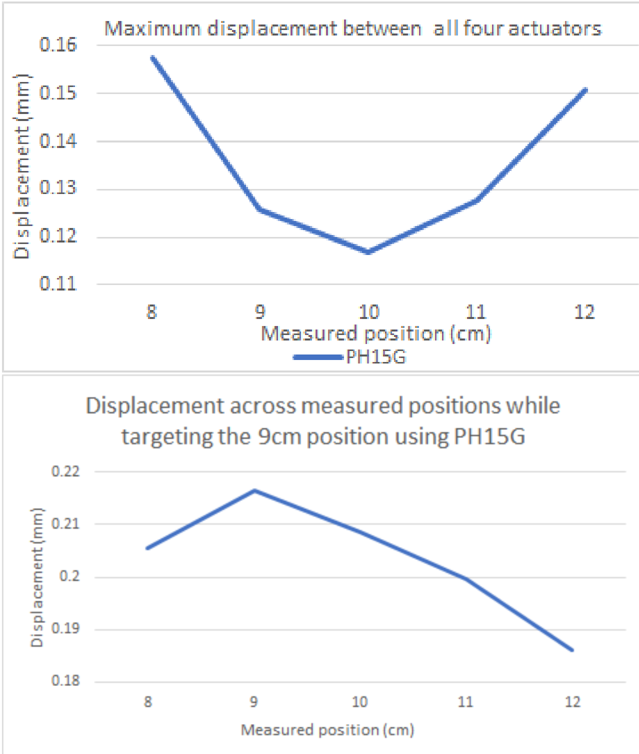

Figure 2. Top: Required offsets to achieve maximum displacement at given points across the control panel slider. Bottom: Displacement measured accross the slider when targeting the 9cm mark.

vibration at the 9cm mark. It is clear that there is a maximum vibration point at the 9cm mark. This also allows us to see a dip in the surrounding region, providing a 13.3dB difference for the range measured; nearing the ratio necessary for perceivable localized stimulus [6]. In addition to the results of constructive wave interference we would also expect destructive wave interference to occur before the targeted point, further enhancing the effect.

DISCUSSION

We have successfully demonstrated that the methods from existing research [1, 2] over flat surfaces can be applied to curved and even multilayered surfaces when they are mechanically coupled with a universal actuation plate. This has the potential to provide high-fidelity haptics over a variety of form factors and surface shapes. Although required offsets need to be calculated for each design, once the offsets are found, they can be used for the consistent output of localized maximum points of vibration.

With continuing miniaturization [3] of printed circuit board assembly (PCBA) size considerations have become a key design choice. Due to the small footprint and simple design of the TDK PowerHap 15G, we can expect streamlined integration into existing boards. An additional advantage to these actuators is their reliability and long operation life. This makes the implementation ideal for devices with few serviceability options. It is necessary to aim towards an implementation that is simple to incorporate into existing designs while making use of standard components if we expect high-fidelity haptics to be implemented in current device designs.

There is still plenty of room for improvement in our current implementation. Decreasing vibration attenuation as well as improving localization detection through the use of intermediate materials are long term goals. Existing research makes us aware that materials can be incorporated to enhance the sense of touch. For example, employees at body shops have been found to use cellophane to improve the detection of imperfections on the surface of polished vehicles [7]. In addition, we have already studied a variety of materials in similar localization research [1], concluding that different materials can reduce attenuation experienced. Changing a surface material cannot always be done, in which case we would like to introduce a material layer to an interface that would provide reduced vibration attenuation along with improved tactile perception of localization.

Our previous research [1, 2] has shown that offsets in use to achieve focal points occur milliseconds apart. The implication would be that a rapid series of offset actuations would allow simultaneously perceivable points of localization. If this can be achieved, the possibility to draw feelable, detailed, imagery may become a reality. This opens up a form of increased bandwidth to a touch interface. It can be imagined that the surface of large kiosk displays could include maps for the visually impaired, or that a mobile phone could communicate detailed information directly through touch.

CONCLUSION

Using the universal actuation plate, along with appropriate time offsets, peak vibrations have successfully been shown to occur at localized points across the surface of a multilayered curved interface. In the given application, interacting with a touch interface while driving, we believe that the localization provided by high-fidelity haptics will create a safer environment to a driver. The piezoelectric actuator in use, the TDK PowerHap 15G, performed well when targeting vibration localization. The small, flat dimensions of the actuator, and the relatively low cost, are convenient for use in manufacturing. Our research builds on existing work, successfully achieving localized points of vibration, and moves onto a versatile actuation plate with the intention to provide high-fidelity haptics to a multitude of interfaces.

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