Haptic Aura: Augmenting Physical Objects Through Mid-Air Haptics

Figure 1a: As the user's hand moves towards a physical control, haptic aura conveys its functionality.

Figure 1b: The push button is rendered as a pulsing dot

Figure 1c: The rotating dial is rendered as a circling dot

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Abstract

This work explores how mid-air haptic rendering can augment physical control elements to provide haptic feedforward. We propose how feedforward can guide the hand towards the location of a control element, aid in identifying the type of control, and communicate its underlying functionality without visual labels.

Introduction:

Well-designed physical objects provide us with rich haptic feedback as we hold and use them. The satisfying click of a camera shutter-release button, or the smooth turn of a volume knob give us precise control over parameters and are pleasing to use. For this reason, most devices have physical controls like buttons, dials, knobs and sliders. To understand the functionality of these controls even before touching them, they are often labeled with icons, as a visual form of feedforward [3]. It is often hard or impossible to understand controls without such visual aids. Consider the example of changing the temperature in a car: When we get into it for the first time, we look around to identify the location of the control, decipher its label to understand its function, and if it is well-designed, we also perceive how we should press a button, turn a knob, or push a slider to change the temperature. In our research, we explore a different approach to feedforward: What if users could perceive

Figure 2a: As the robot end effector approaches the hand, the user perceives a tactile mid-air sensation

Figure 2b: This haptic feedforward allows the user to anticipate the robots action.

the functionality of a control through tactile mid-air sensations, that surround the object like a haptic aura? Such haptic feedforward could guide the hand towards the location of a control element [3], aid in identifying the type of control, and communicate its underlying functionality, all without the need for visual labels. A simple example of this approach can also be found inside the car: To change the direction in which an air vent blows, we usually do not need to look at it. Instead, one can find the vent location by feeling the stream of air escaping from it, which also conveys how to adjust it to change its direction. We argue that this form of mid-air haptic feedforward can be extended to a wide range of controls and devices. We refer to this generalized concept as *haptic aura* and propose several initial experiments to test its effectiveness for feedforward. The tactile mid-air sensations for these experiments are rendered with an Ultrahaptics UHDK5 Development Kit. While ultrasound arrays have been utilized for mid-air haptic feedback [1], we argue that haptic aura explores a new design space for haptic feedforward in combination with physical objects.

Guiding Towards Control Location

In this setup, the haptic aura guides users towards the placement of a physical control element, which is visually concealed. When moving their hand closer to the element, users feel an increasingly strong tactile sensation, guiding them towards the element. For finer granularity, the tactile sensation may also render a vector pointing towards the physical control.

Identifying Control Type

Figure 1 depicts a setup with three physical control elements that all share the same shape but have different affordances: one is a button to be pressed, the next a dial to be turned, and one a directional joystick to be pushed. As a user moves their hand towards an element, the different sensations on their skin renders its affordances: a pulsing haptic dot for the button, a circling dot for the dial, and a dot travelling in a cross shape for the joystick.

Predict Robot Movement

Figure 2 depicts a setup in which a robotic end effector is moving in an unpredictable way in 3 dimensions. In this experiment, the mid-air haptics provide feedforward to inform the user of the direction in which the robot is going to move next.

Next steps

So far, we have defined ways in which haptic feedforward can enhance physical objects and conducted initial tests. We see this workshop as an opportunity to discuss the role of haptics in feedforward along with real world applications.

References

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