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# Haptic Feedback for Mid-Air Gestures: What, When, How?

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**Abstract**

Mid-air haptic displays allow gesture interface designers to give haptic feedback directly to the hands as they gesture. These displays have typically been used to create the feeling of touching controls in mid-air, but haptic feedback could also be used to give richer information about the interaction. Three questions need answered when designing feedback: what information is useful, when is it most relevant, and how should it be presented using haptics? In this abstract, we give examples of novel mid-air haptic feedback for gesture systems and encourage others to think about how haptic feedback can be used in mid-air gesture interfaces.

**Author Keywords**

Gestures; Haptic Feedback; Mid-Air Haptics.

**ACM Classification Keywords**

H.5.2 [User Interfaces]: Interaction Styles

**Gesture Feedback: What, When, How?**

Mid-air haptic feedback is typically used to inform users when they are touching a control or 'screen' in mid-air. This is a simple use of haptic feedback but can improve usability: it reassures users that they are gesturing in the right place [1] and it can improve their sense of agency, making them feel more in control [4].

Our first question asks what other types of information would be relevant during gesture input. Users might want to know about the quality of input sensing, to help them find a better hand position [2]; they may want to know about the value or state represented by the control [3]; or they may want cues about how to perform gestures. In recent work, we used ultrasound haptic feedback that encodes a metric of sensing quality, to help users find where to perform gestures. Our initial results are promising: the feedback guided users with 16mm error in 2D and 40mm error in 3D. In past work [1] we encoded gesture progress (0–100%) using haptics, but this was limited to vibration from a wearable; this is another example of information that may be helpful when gesturing.

Our next question is when would feedback be most relevant and useful. Haptic feedback is mostly given *during* input, in response to a user's actions. There are opportunities to give useful feedback in the time *before* and *after* interaction, and these should also be explored. For example, our feedback to guide users is most relevant before they start interacting, as it helps them position their hand as they first approach the sensor; however, it may be less appropriate once the user begins gesturing. There may be novel types of feedback that are more useful after input ends; for example, telling users how well they performed a gesture, showing the final value/state of a control widget, or explicitly confirming that interaction has ended.

Our third question asks how information should be rendered using haptic feedback. There are many parameters that can be used to encode information (e.g., frequency, amplitude, waveform) but it is important to choose the best representation for each type of information. More work is needed to understand the perception of mid-air haptics, as this may influence which parameters are used to encode information: e.g., if amplitude can only be discriminated at three levels, it

should not be used if five states need presented.

As mid-air haptic technologies improve and become more widely used in gesture systems, we encourage designers to ask what?, when? and how?, so that haptic feedback can be used in the best possible way.

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