HaptiGlow-Helping Users Position their Hands for Better Mid-Air Gestures and Ultrasound Haptic Feedback

【Main Content】:

We present HaptiGlow, a technique that combines ultrasound haptics with peripheral visual feedback to help users find where to place their hand for improved mid-air interaction.

【HaptiGlow】:

Our goal is to use this feedback to guide users to better hand positions before interaction, which improves input sensing and tactile quality. Once in a better position, the input should seamlessly transition to its intended use (for example, grabbing a virtual object or manipulating a virtual control).

Feedback Design:

(1) Visual feedback

(2) Haptic feedback:

We did this by creating an ultrasound haptic cone, whose base was centred in the sweet spot (Fig. 3). The orientation of the cone was changed so that it was always perpendicular to the palm of the hand. This preserved the spatial relationship between hand position and the feedback, whilst ensuring it could be perceived regardless of hand orientation (Fig. 4). The conical shape of the feedback meant that users perceived its circular cross-section on their hand, increasing in diameter as they approached the sweet spot, as in Fig. 3.

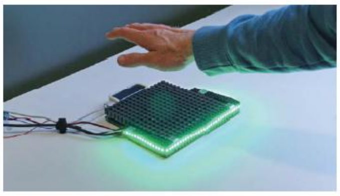

Fig. 1. HaptiGlow combines ultrasound haptics with peripheral visual cues from lights, to give feedback and help users find where to gesture.

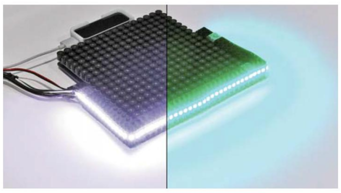

Fig. 2. *HaptiGlow* consists of LEDs wrapped around the user-facing half of an Ultrahaptics mid-air haptic display. This image shows the two colours our visual feedback interpolates between: white and green.

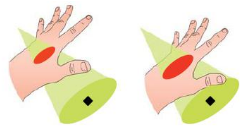

Fig. 3. Users feel the circular cross-section of the haptic cone as their hand intersects it. As the hand approaches the base at the sweet spot (♦), the wider cross-section creates the feeling of stronger feedback.

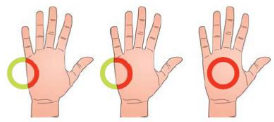

Fig. 4. Users can feel where the feedback is in relation to their hand position, giving spatial hints about where to move. The red shaded area shows the region of the circle outline that would be felt at each position.

【Experiments】:

We use a design with three types of feedback:

(1) LIGHTS

(2) HAPTICS

(3) HAPTICS + LIGHTS

Results:

Our results show that HAPTICS and LIGHTS had unique strengths that, when combined, led to an effective multimodal feedback design. Haptic feedback was good at conveying the position of the target point in the horizontal plane (Fig. 6). This was not surprising, because the haptic feedback gives spatial information directly to the hand; users knew they were in the right area when the feedback was centred on their palm and many of our participants said this in the post-study survey.

In contrast to the HAPTICS condition, visual feedback under the LIGHTS condition results in good accuracy in the z-axis, but not in the xy plane (Figure 6). We wanted HAPTICS to provide better performance because it provided spatial information, but we were surprised that visual feedback successfully helped users place their hands at the correct height above the device.

The HAPTICS + LIGHTS condition results in the best accuracy and fastest time.

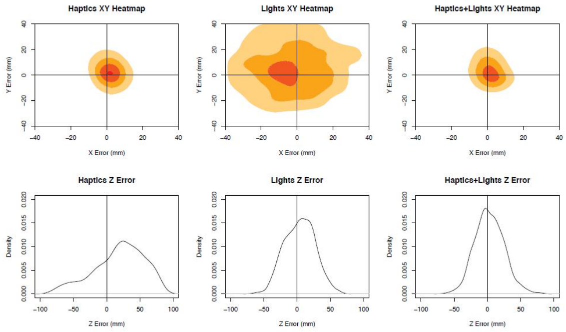

Fig. 6. Top: heatmaps showing the distance between the final hand positions and the target points in the horizontal plane (x and y axes), for each feedback type. Bottom: density plots showing the height difference between final hand positions and the target points (z axis), for each feedback type.

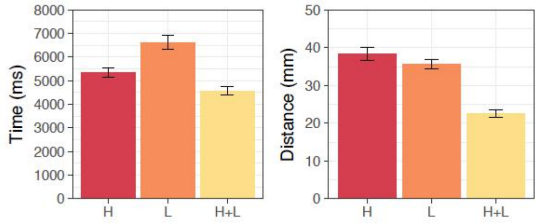

Fig. 5. Mean *Time* (left) and *Distance* (right). Error bars show 95% CIs.

【Conclusion】:

We studied its ability to guide users to aim to targets to better understand how to use feedback to help them find the right hand posture before starting an interaction. The combination of light and air haptics is more effective than the individual methods. Users use them in different ways, taking advantage of each method to minimize time and improve hand positioning accuracy. This also shows the benefits of adding low-cost peripheral vision to ultrasound haptic devices, as our simple visual feedback is sufficient to improve interactivity.