Palm-based Interaction with Head-mounted Displays

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Abstract
Head-mounted displays (HMDs) are an emerging class of wearable devices that allow users to access and alter information right in front of their eyes. However, due to their size and shape, traditional input modalities (e.g., multi-touch sensing on the device) are not practical. In this position paper, we argue that palm-based interactions have a great potential to ease the interaction with HMDs. We outline two interaction concepts and present directions for future research that can lead to more enjoyable and usable interfaces for HMDs.

Author Keywords
Human Factors; Design; Head-mounted Displays

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction and Background
Head-mounted displays (HMDs) are an emerging class of wearable devices, made commercially viable by recent advances in creating miniaturized transparent high-resolution displays. Such devices allow users to see, access and alter digital information in front of their eyes anywhere and anytime.

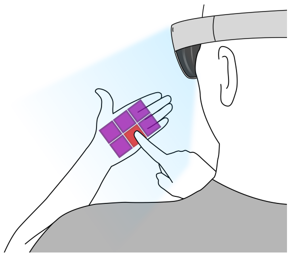

Figure 1: For AR interfaces, the user's palm acts as a 2D interactive surface with registered visual output. The user can interact directly with the content through touch gestures.

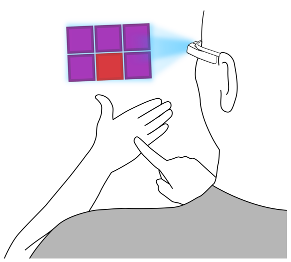

Figure 2: For HUD interfaces, the visual output is mapped to the palm's surface. The user can then select options by touching the corresponding location on the palm.

There exist two distinct classes of devices that can be categorized as either (a) monocular head-up display (HUD) interfaces, that present information floating in the user's peripheral vision (e.g., Google Glass), or (b) binocular augmented reality (AR) interfaces, that are able to blend digital content with physical objects (e.g., Microsoft HoloLense). Due to their unique shapes and small sizes, traditional input modalities such as physical buttons or multi-touch input are not practical. Furthermore, both classes of systems currently suffer from a lack of direct manipulation of content.

Body-based input modalities received considerable attention for interaction with imaginary [2, 3], projected [4] and augmented [6, 1] interfaces. This is based on the natural properties of interactions with the human body: it is omnipresent and does not rely on a mediator device and, thus, provides more direct interaction. In particular, the hand and forearm received attention within the HCI community because of their nature of being unclothed in most situations as well as being socially acceptable to touch [7].

We believe that the large number of degrees of freedom offered by our hands and forearms can be used to extend the input space of HMDs and to provide more enjoyable and usable interfaces to interact with information presented in front of the user. In particular, we envision the user's palm as a promising interactive surface that can be leveraged to ease the interaction with HMDs. As a first step towards this approach, this position paper focuses on concepts for palm-based interactions that support one and two-handed interactions for both, AR and HUD interfaces.

Concepts for Palm-Based interaction with HMDs

In this section, we present two interaction concepts that leverage the user's palm as an input modality for both, HUD and AR interfaces.

Using the Palm as a 2D Interactive Surface

We propose the user's palm as a 2D interactive surface to interact with HMDs. For AR devices, the visual output can be registered to the user's palm (cf., Figure 1), resembling the interaction with a touch device carried in the user's hand: when the user moves her hand, the interface moves together with the palm. This style of interaction supports a vast majority of traditional input techniques based on multi-touch including tactile feedback, allowing direct manipulation of digital content right in the hand of the user.

Similar to [2], this approach can also be transferred to HUD interfaces: The spatial layout of the UI (presented as a floating rectangular box) can be mapped to the palm's surface. The user then selects options by touching the corresponding location on the palm (cf., Figure 2). Through the sense of proprioception [5] and the tactile feedback provided by the hand, users interact with the interface without giving visual attention to the hand.

Using the Spatial Location of the Palm as an Input Modality

We propose to use the degree of freedom offered by the elbow joint, i.e., (a) flexion by moving the hand toward and (b) extension by moving the hand away from the body as a one-handed input modality. For this, we divide the interaction space in front of the user into multiple parallel planes, where each plane corresponds to a layer with visual content. The content of the layer can be displayed either bound to the user's palm as an AR interface (cf., Figure 3) or as a hovering box for HUD interfaces (cf., Figure 4).

In this interaction space, the user can move her hands towards or away from the body to browse through successive layers. Similar to [8], the thumb position (upright or parallel to the palm) can additionally act as a means to select and interact with a layer. This interaction style resembles the physical way of navigating through filing cabinets and

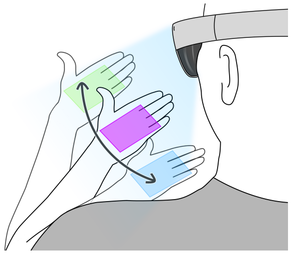

Figure 3: The input space in front of the user is divided into multiple parallel layers. The user can access different layers by moving her hand through the space. The visual output is registered to the hand.

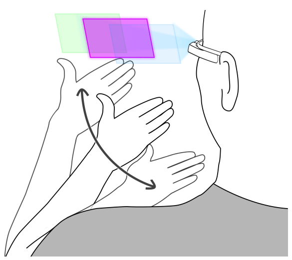

Figure 4: Similar to Figure 3, the input space in front of the user is devided into multiple parallel layers. For HUD interfaces, the output is displayed as a hovering box.

therefore is immediately understandable to users. As a one-handed interaction concept this approach can support immediate and short-term interactions, such as serendipitous discovery of contents, fast peeking into information or executing a shortcut.

Conclusion and Future Work

In this paper, we present concepts for palm-based interaction with HMDs for both, head-up display and augmented reality interfaces. We envision such palm-based interfaces to ease the interaction with HMDs in comparison with currently deployed interaction concepts and to provide a more joyful user experience.

To gain further insight into the area, the following challenges need to be addressed in future research:

1. How can the large number of degrees of freedom provided by our hands and forearms support interaction with HMDs?
2. How well can users interact with their palm in terms of efficiency and accuracy?
3. How does this approach relate to other approaches such as voice or mid-air gestures in terms of usability and user experience?

In summary, we strongly believe that further research on palm-based interactions can guide the field towards more usable interfaces for HMDs.

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