An Eyes-Free Input Concept for Smartglasses

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Abstract: With the advancement of augmented reality (AR) technology in the recent years, several AR head-mounted displays and smartglasses are set to enter the consumer market in the near future. Smartglasses are usually employed as output devices to display information and require a paired input device, an integrated touch panel or buttons for input. They can communicate and collaborate with other wearables like smartphones or smartwatches. This makes it possible to distribute the user interaction elements over multiple connected wearables. A concept for the eyes-free input for smartglasses using wearables such as smartphone, smartwatch or using an additional accessory is presented here.

Keywords: Wearables, eyes-free input, augmented reality user interfaces

1. Introduction

Augmented reality (AR) technology has been advancing fast along with virtual reality the past few years. Sooner or later people will be moving around in public spaces or factories wearing smartglasses and probably a host of other wearables like smartphone, smartwatch etc. which assists them in their daily activities. They will be interacting with a distributed user interface spread across a collection of networked devices. The dynamic context in which smartglasses are used, e.g. while moving in a complex outdoor environment, makes the interaction design complicated. The limited physical and attentional resources that the user has at his disposal have to be considered.

The input devices available for AR head-mounted displays or smartglasses currently in the market or in development can be divided roughly into two categories. The first category comprises of smartglasses with an additional input device, a paired wearable like a smartphone or a dedicated controller like in the case of Sony SmartEyeglass (Sony Mobile Communications Inc. 2015). The second category includes head-mounted displays like Microsoft Hololens (Microsoft 2015) and Meta Glasses (Meta Company 2015) with Natural User interfaces that use gestures and speech recognition for interaction. Gesture or speech interfaces are not practical in every situation especially in outdoor environments. In the case of a paired input device, if its interface should be visible during input interactions there will be an overlap with the AR interface. This superposition can exhaust the user and further occlude his field of view. This can be avoided using an eyes-free input interface.

2. Background

The user interface design of mobile devices has to consider important characteristics of mobile use like dynamic user configuration, limited attention capacity, high speed interaction and context dependency (Pascoe et al. 2000). A mobile user has constantly changing user configurations like walking, standing etc. It is important to minimize the amount of time devoted to interacting with the interface, so that the user can focus on his environment or the task at hand. In some cases the interactions are also time critical. According to Pascoe et al. (2000) the success of a mobile interface depends on a user interface that is context aware and needs minimal attention. Context awareness can be achieved through various embedded sensors which would adapt the user interface to the current context. An eyes-free input method can among other things help meet the requirement for minimal attention binding.

Eyes-free input involves simple gestures or movements which are kinesthetically identifiable and can be reinforced by audio or haptic cues (Oakley and Park 2007). E.g. the users are aware of the translations of the thumb through kinesthetic sense. Oakley and Brewster (2007) note that the gestures considered for input should consider human anatomical constraints and the interaction model should provide a simple mapping from the gesture to the system state.

Some design principles derived from research in the field of touch interface accessibility for blind users can be applied to eyes-free interaction design. Kane et al. (2008) extracted design guidelines for touchscreen interactions through interviews with blind users. The suggestions include reducing demand for selection accuracy, using intuitive gestural mappings, allowing quick browsing and navigation and an option to return home from the current screen at any point in time. McGookin et al. (2008) studied different characteristics of eyes-free touchscreen interaction using blindfolded users. They noticed that users found it hard to start interacting with specific spatial locations on the screen since they are not aware of the relative location of their finger on the screen. They emphasize the need for a distinct home key and also avoiding short impact related gestures which could be triggered unintentionally like a tap.

Smartphones or an integrated touch panel on smartglasses can offer single handed interaction and thus free a hand for other physical demands common to mobile activities. During single-handed interaction with a smartphone, the thumb is usually used to perform touch gestures. A study on thumb mobility by Karlson et al. (2006) reveals that moving the thumb diagonally along devices of any size is difficult and should be avoided. They found that thumb movements are the fastest in regions within easy reach of the thumb and suggest using horizontal and vertical movements for repetitive tasks.

3. Concept

An eyes-free input mechanism for smartglasses can avert the visual distraction during input interactions and adopting a smartphone or wearables like a smartwatch as input device eliminates the need to carry around an additional device. An eyes-free input concept has been developed for the head mounted display Lite-Eye LE-750 A (see Figure 1) in a laboratory environment which can use a connected LG D821 android smartphone, a Samsung Gear Live smartwatch or a Moto 360 converted into a custom integrated touch panel as an input device. The augmented reality user interface highlights objects of interest in the virtual environment. The interface also provides an associated menu for each object.

The user can interact with the user interface using touch gestures. The types of user interactions required in this scenario include object selection and menu interaction (Mine 1995). For object selection, the user needs a mechanism to indicate a selection, change the selection and to deselect. For menu interaction, the user needs a mechanism to open the menu, open a submenu, navigate menu levels and select menu items. The selected touch gestures and their mapping to the respective user interactions are detailed in Table 1.

Figure 1. *Lite-Eye LE-750 A (Liteye Systems Inc. (2015)) with a custom touch panel. The Lite Eye can also be paired with a smartphone or a smartwatch.*

The selected touch gestures conform to familiar metaphors and take into account the limitations of the movement of the thumb. Multi-touch gestures were avoided because of the smaller touch sensitive area of the smartwatch and the head mounted touch. The gestures can be used anywhere on the screen and thus eliminates the need to identify specific locations on the touch surface.

Objects in 3D space are highlighted using visualizations which are 2D projections on 3D objects. To interact with these objects, the user has to start selection mode using a single tap or a horizontal swipe. The object closest to the center of the display is selected so that the selected object is in focus. If an object is already selected, the user can change the selection to other highlighted objects in a horizontal order using horizontal swipe gestures. Since the AR user interface is display-referenced, prolonged selection methods such as drag & drop are problematic because changes in head position change the reference for the selection. Therefore, atomic interactions like swipes are preferable. The user can exit the selection mode at any point in time during the interaction using a long press.

The interaction with elements in 3D space and those in 2D space is distinguished by an explicit interaction. A vertical swipe upwards brings a 2D menu into view and the interaction is now with reference to the menu. A vertical swipe downwards at the top menu level fades the menu out of view and the interaction refers again to elements in 3D space.

In 2D space, the display-referenced menu is located at the bottom of the user interface in the user's field of view. As opposed to world-referenced or object-referenced menus, the user can invoke the display-referenced menu without changing his angle of view. The menu can be invoked at the time of interaction using a vertical swipe up gesture and thus will not occlude the user's field of view for prolonged durations. The menu is always presented at a fixed offset making it easier to read compared to an object-referenced menu in 3D space. The user can use horizontal swipe gestures to switch between the various menu items and vertical swipes to switch between menu levels. A swipe up or a single tap opens a submenu for the currently selected menu item; a swipe downward closes the submenu again. The user can select a menu item or open a submenu with a single tap. With a long press, the menu is reset to its initial state.

Table 1. *Mapping of gestures to user interaction (Images: Mobile Tuxedo (2015))*

Gesture	Interaction	User Action
 **Single tap**	Object Selection, Menu Interaction	Select menu item. Select the object closest to the center of the display.
 **Long press**	Object Selection, Menu Interaction	Reset menu. Deselect object.
 **Swipe up**	Menu Interaction	Open menu. Open submenu.
 **Swipe down**	Menu Interaction	Close submenu. Close menu.
 **Swipe left**	Object Selection, Menu Interaction	Change selection to the object on the left. Select object closest to the center of the display if no object is selected. Change selection to menu item on the left.
 **Swipe right**	Object Selection, Menu Interaction	Change selection to the object on the right. Select object closest to the center of the display if no object is selected. Change selection to menu item on the right.

4. Conclusion

A concept for using touch gestures on wearables with varying touchscreen sizes as input to an AR user interface was developed. An experiment will be conducted to establish the usability of wearables attached to or held by the user as an input device. The different wearables can be compared to see how they affect the performance of the user and how satisfied the user is.

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