Challenges in Watch-Centric Cross-Device Applications

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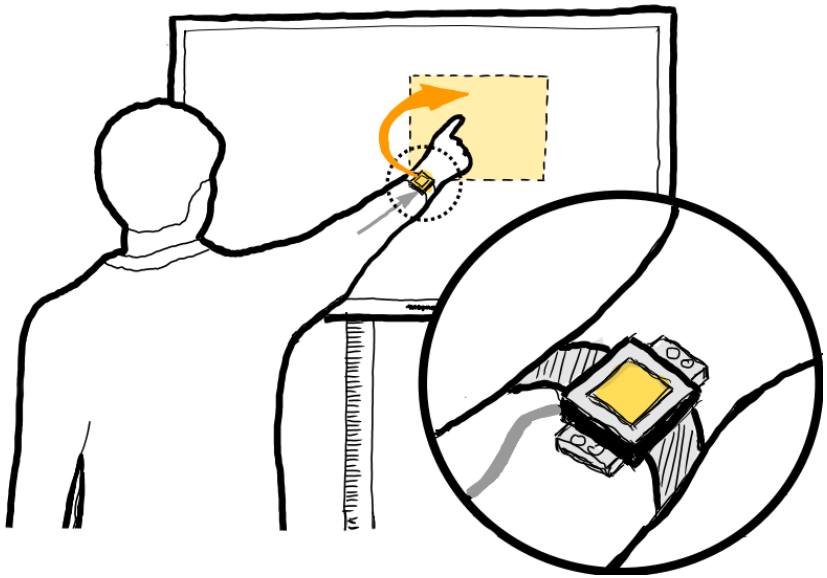

Submitted for review to CHI2015 workshop on Mobile Collocated Interactions: From Smartphones to Wearables

Abstract
People are increasingly interacting with an ecology of devices that include smartwatches, smartphones, tablets and other traditional desktop-based devices. As a small wearable device, the smartwatch has the ability to become a central mediating device that instruments the human hand into a reconfigurable tool that provides other devices with personal access to users personal information, thus, mediating interaction between other devices. In this paper, we discuss a number of interaction techniques and applications that demonstrate how a smartwatch can allow for interaction within an ecology of devices. We summarize open challenges and describe directions for future work.

Author Keywords
Smartwatch; Cross-Device Interaction; Gestural Interaction; Interface Design; Instrumental Interaction

ACM Classification Keywords
H.5.2. Information Interfaces. User Interfaces – input devices and strategies, prototyping.

Introduction
Smartwatches provide people with lightweight and easy access to their personal information, such as messages, notification or even entire applications. Despite the

increasing use of smartwatches as a standalone device, they can be leveraged to be become mediators in complex cross-device applications. People are increasingly using smartwatches in tandem with other devices, such as smartphone, tablets and other computing devices. Smartwatches, as a wearable portal or key, can be used to configure and move information within device ecologies, using physical interaction with the watch hand. By leveraging the sensors of the smartwatch, the watch hand can be elevated to a reconfigurable instrument that can modify digital information and devices through direct mediated interaction.

With the exception of a few research papers (such as Duet [2], WatchConnect [3], UI Beaming [4] and SleeD [5]) there has been remarkable little approaches that explore watch-centric cross-device applications and interaction techniques. In this paper, we provide an overview of a number of watch-centric cross-device applications, and describe a number of open challenges for future work.

Interaction Space

In previous work [3], we described the interaction space that emerges when the input/output space of a watch is connected with the input/output space of an interactive surface, such as found on a smartphone, tablet or large interactive surface.

Input on the watch

Input on a smartwatch can be organize according to three input areas: (i) on the watch, using touch input on the screen, bevel and strap, (ii) above the watch, using distance sensors to support mid-air gestures, and (iii) in the watch, using available IMU and motion sensors to allow users to perform gestures and postures with the watch hand.

Figure 1 Watch input space on, above and in the watch

Input on the interactive surface

When using a smartwatch, interaction with an interactive surface can be categorized into three main interaction: (i) identify the watch hand input, (ii) differentiate in standard 2D touch input between the watch and non-watch hand, and (iii) using the existing motion sensors to perform volumetric interactions in the 3D space in front or above the interactive surface.

Figure 2 Input space of an interactive surface

Joint output space

Blending the interaction space of a watch and an interactive surface creates a joint output space that can be leveraged to distribute the interaction across displays. The output space can be (i) limited to only the main output on the interactive surface, (ii) the small display of the watch, or (iii) distributed across both displays.

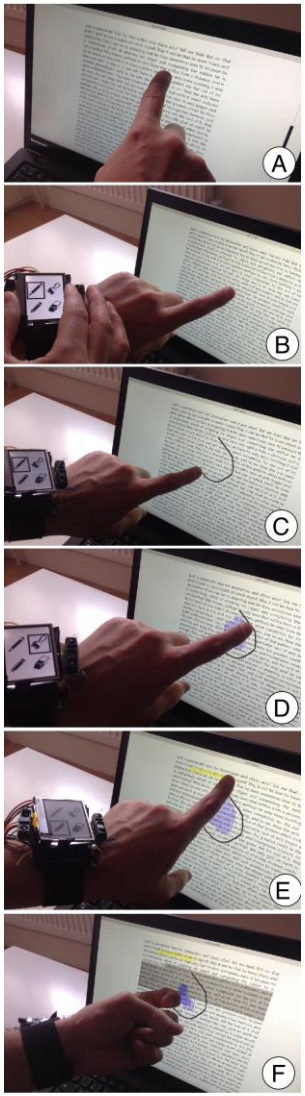

Figure 3 Reconfigurable watch hand input.

Cross-Device Applications

To demonstrate how applications can use the input and output space of the blended interaction space, we presented a number of example watch-centric cross-device applications [3].

Instrumental e-reader

To allow for instrumental and menu less interaction with a touch-enabled e-reader applications, we designed the *gesture and touch* interaction technique (**Figure 3**). This technique differentiates touch input on the surface between the watch and non-watch hand. Using the non-watch hand, users can simply scroll and browse the text (A). The watch-hand of the user can be reconfigured into different instruments [1] that allow users to edit the text. Users can configure their touch input by selecting an instrument on the watch display by touching the bevel of the watch (B). These instruments allow users to draw with a black pen (C), paint with a blue stencil (D) or mark text using a yellow marker (E). The user can select text using the knuckle of the watch hand (F), as propose in Duet [2].

Synchronized map navigation

To support seamless and rich interaction with a digital map, we designed the *touch and push* technique (**Figure 4**). When users touch the interactive map with the watch hand, the second map on the smaller watch display is synchronized and shows a zoomed scope view with more details (A). Users can touch the bevel on the left and right side to zoom the map (B), grab the top and bottom bevel to change the map view between normal map, satellite or hybrid view (C). Finally, users can touch the watch screen, while touching the map, to add a push pin or select a target (D).

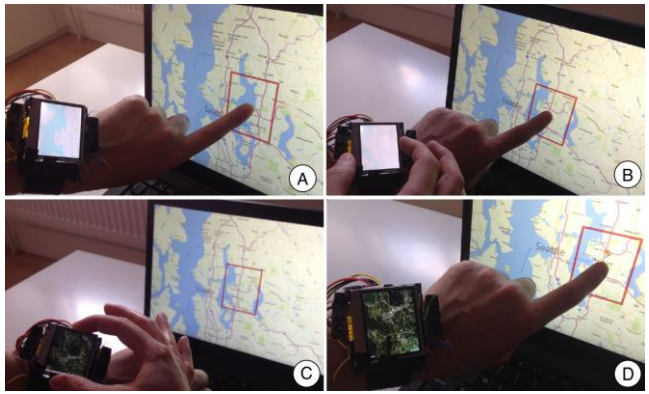

Figure 4 Synchronized map navigation using direct manipulation.

Game Controller

The watch can also be uses as a game controller that is used as input for a game on a large interactive display (**Figure 5**). The *connect and gesture* interaction technique allows users to control the game character using spatial gestures similar to that of a Kinect or Wiimote controller (B). Moreover, the watch display can be used to visualize the *heads-up display* (HUD) that shows information on the amount of lives left, how many enemies were captured and how many points were scored during the game (A).

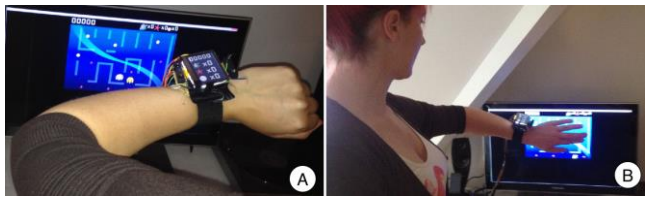

Figure 5 Using the watch as game controller.

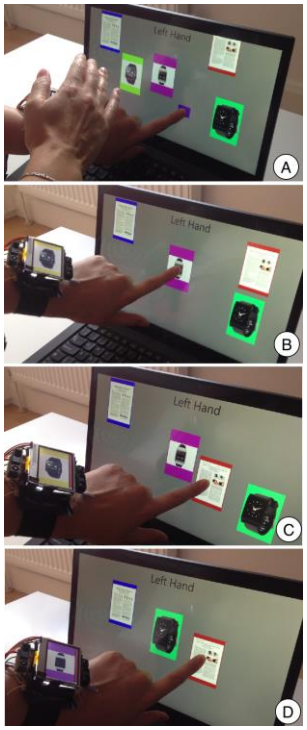

Figure 6 Cross-device data transfer using direct manipulation.

Data transfer

To support seamless transfer of data between a watch and interactive surface, we designed the *touch and swipe* techniques, in which users can perform midair gesture to naturally express the direction of the resource transfer (**Figure 6**). Users can browse data on the watch by touching the bevel. Once a resource is selected, users touch an empty spot on the screen and touch the screen with the watch hand. This causes the application to show a rectangular progress bar at the touch location to visualize a time window in which the user can perform a left-to-right gesture to send the selected resource to the display (A-B). Touching an existing resource on the interactive surface, updates the UI on the watch to visualize if the touched resource can be send back to the watch (C-D).

Challenges

Interaction techniques: How can we design interaction spaces for ad hoc multi-device collaborative setups? Within these multi-device setups, how can we design techniques following temporal sequences for more expressive user interactions?

Technologies and infrastructure: What are the infrastructure requirements for supporting cross-device interaction spaces? What are adequate toolkit building blocks supporting designing for entire device ecologies, rather than individual devices? What kind of sensors and hardware enables new expressive interactions with smartwatches?

Social and collaboration: How can we better understand user requirements and social implications of watch-centric cross-device setups?

About the authors

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