# In Tandem: Exploring Interactive Opportunities for Dual Input and Output on Two Smartwatches

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**Figure 1. Examples of applications designed for two smartwatches operated in tandem: (a) browsing a list of contacts on one smartwatch, while sending and receiving phone calls on the second watch; (b) visualizing a full-screen detailed view of selected content from one smartwatch on the other; and (c) text entry using a tiny soft keyboard by positioning a cursor on each key with the finger sliding on the touchscreen of the second smartwatch.**

## ABSTRACT

We introduce, explore, and prototype in this work new interactive opportunities for dual input and output on two smartwatches that users wear on both hands and operate simultaneously. To this end, we present practical implementations of wearable applications designed for two smartwatches working "in tandem" that demonstrate new ways to perform generic input and output tasks, such as item selection from a list, text entry on a tiny soft keyboard, and generic content manipulation on small screens. We hope that this work will draw the community's attention towards the richness of interactions that become possible by utilizing not one, but two smartwatches in tandem and, consequently, will inspire new and rich interface designs for the computers that we wear on our wrists.

### ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g., HCI): User Interfaces – *Input devices and strategies (e.g., mouse, touchscreen).*; B.4.2. Input/Output Devices

### Author Keywords

Smartwatches; Wearables; Bimanual input; Gesture input; Touch input; Interactive prototypes; Synchronous input; Input/output devices; Item selection; Text entry.



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## INTRODUCTION

In the realm of mobile and wearable computing, smartwatches are unique wearable devices that can deliver rich notifications, accept always-available input, and collect and process a wealth of user performance data and body signals [2,3,6]. Moreover, being attached to the body, smartwatches do not need to be picked up, held, and then put away, which makes them suited for sensing input for specific user categories, such as people with motor impairments [4]. Nevertheless, effective input on the small screens of smartwatches is challenging and designers need to compromise between content legibility and the amount of information that can be effectively presented to users at once [1,6]. In this work, we address this problem by *designing for two smartwatches* that are worn by users on both hands and operated in tandem.

The contributions of this work are: (1) we introduce the idea of dual, simultaneous input and output on two smartwatches that users wear on both hands. Unlike previous research that focused on single smartwatch designs, we point to the benefits of seeing smartwatches as generic input/output devices (actually, they represent powerful computers[1]), always-available on our wrists; (2) we present several prototypes that demonstrate practical interactions involving two smartwatches, such as browsing the contents of a list of items (phone contacts and a list of songs), performing item selection, and text entry.

[1] Today's smartwatches embed powerful computing technology and resources. For instance, the Apple Watch Series 3 embeds a Dual-Core CPU, 16 GB of internal storage, and 768 MB RAM. Samsung's Gear S3 smartwatch features a powerful Dual-Core 1.0 GHz CPU, 4 GB of internal storage, and 768 MB RAM. Even the lighter version, Samsung's Gear Fit 2, which we use in this work, runs on a Dual-Core 1.0 GHz CPU, 512 MB RAM, and embeds a variety of sensors, such as GPS, HR, accelerometer, gyro, and barometer.

## IN TANDEM: APPLICATIONS FOR TWO SMARTWATCHES

We implemented several interactive prototypes for two Samsung Gear Fit2 smartwatches.[2] We chose Gear Fit2 for their light (31 g) and small (51.2 mm $\times$ 24.5 mm with an 1.5-inch screen) form factors, which makes them easy to wear. Our prototypes are Web Applications developed with the JavaScript-based Tizen Web API. [3] The two smartwatches communicate and share data through a custom server developed in Python with the Django framework and the Django Channels library for WebSockets. Our software architecture is based on a bidirectional, full-duplex data exchange between the server and each connected watch. The packages sent to the server contain information about the touch events on each smartwatch.

### Collection Browser

Browsing collections of items (e.g., the list of phone contacts, a collection of photographs, or a selection of songs) is a frequent task performed on mobile devices and wearables. Our "Collection Browser" is a two-smartwatch application that enables users to browse a list of items with touch input performed on one smartwatch, while the second watch delivers a detailed, full-screen and occlusion-free visualization of the selected item; see Figure 1a. Browsing the list is performed with directional up/down flicks, while taps are used to select and visualize a specific item on the second smartwatch.

### Music Player

Our "Music Player" prototype explores further the separation of content and control between the two devices. The list of songs is displayed on one smartwatch and a detailed view (e.g., the full song name, artist, and album name) is shown on the second smartwatch together with specific controls, in our case, play, pause, and stop; see Figure 1b. The two views of the same application available on two displays enable better presentation of content compared to the single-display approach where users need to repeatedly switch back and forth between two application views on the same screen.

### Text entry on a tiny keyboard

We implemented "Text Entry for Two," a two-smartwatch soft keyboard featuring 36 touch keys of just 1 $mm^2$ each; see Figure 1c. The application detects the finger sliding on the touchscreen of one smartwatch, which controls the position of a cursor shown on top of the keyboard displayed by the second watch. Key selection is performed on finger lift off. This design solves the finger occlusion problem for tiny screens, which we expect to improve the selection accuracy of tiny targets due to the use of indirect touch implemented with a pixel-accurate cursor, validation that we leave for future work.

### Handling situationally-induced impairments

Situationally-induced impairments, with either visual or motor causes, occur often in mobile settings when the user is temporarily unable to attend to the mobile device because of encumbrance [5], dedicating attention exclusively to navigation and walking [2], or when the hand supposed to perform input is simply not free to use [3]. With two smartwatches, notifications can be transferred from one smartwatch to the other, either implicitly by detecting context or explicitly, such as with a shake gesture or a tap on one device that transfers the notification to the second, easier to access screen.

[2] http://www.samsung.com/global/galaxy/gear-fit2/

[3] https://developer.tizen.org/development/api-references/web-application

## CONCLUSION

We will continue our explorations of applications for two smartwatches operated in tandem with controlled experiments to evaluate user performance on tiny keyboards or the benefits of assistive input techniques enabled by two smartwatches for users with motor impairments [4]. Other interactive opportunities, such as collaborative interactions between multiple users or exploring mixed input between smartwatches and other mobile and wearable devices, such as smartphones, smart rings, or digital jewelery are also left for future work.

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