Interacting with Multiple Mobile Devices using the Kinect

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Abstract
The Microsoft Kinect sensor can be used to rapidly prototype bodily interactions with mobile devices. Current mobile technologies restrict user interaction to a single device and require a user to switch between each device that they are engaged with. Movement may be investigated to orchestrate many devices at once. We propose a framework for the design and evaluation of bodily interactions that uses the Kinect to detect the movement of users and that couples mobile sensors with user movement to detect subtle interaction. We conclude with directions for future research.

Keywords
Kinect, mobile, multi-device interaction, rapid prototyping, ubiquitous computing.

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Introduction
Mobile technologies such as smartphones, tablets and e-readers are personal devices that each have a unique benefit to the user. However, the benefit of additional devices is devalued when a user must interact with each device individually. For example, the simple task of turning a mobile phone to silent mode is increased in effort when there are additional devices to manage. Web services have helped with the management of multiple devices by storing content in a central server such that it is made available to any device connected to the network. Methods of interacting with multiple devices are less unified. A common interaction channel would allow a user to interact with their devices as one. We propose investigating body movement for this purpose for the reason that bodily interaction can be decoupled from a single receiver, providing a natural method of communication with multiple devices. Additionally, by adopting visual rather than strictly inertial techniques, a user is free from holding a controller and this enables situations where touching a device is not possible. We discuss body movement as a method of interaction with multiple mobile devices with the aim to increase the possibilities of interaction between a user and their devices.

Interest in the field
Bodily interaction can be sensed without direct control of a device and may be investigated to interact with

multiple devices. Whole body interaction has been explored with the Microsoft Kinect sensor, which provides a cheap and robust 3D sensor suitable for tracking the pose of humans in indoor settings. The Kinect for Windows SDK provides support for skeletal tracking and gesture recognition and allows a developer to rapidly prototype designs for spacial interaction. Developing with the Kinect is beneficial as it requires minimal equipment for sensing, is low cost and causes little disruption to the working environment. Since the hardware and development environments are widely available, any system developed to work with the Kinect can be shared with many other users.

A framework was created to rapidly associate content and services from multiple devices with surfaces and regions in a room. The Kinect was used in this application to track the user and trigger a response from devices connected to the server when the user entered a target area. By using the Kinect to simulate a proximity sensor, a user can place many hotspots in a room and access the shortcuts associated with each hotspot while keeping their hands free. A virtual bookshelf application was prototyped to illustrate how this interaction may be used in the home. With the application, a user can place a hotspot for the virtual bookshelf application next to a bookcase, using the physical object as a mnemonic for its virtual position in 3D space [1]. To access the application, the user chooses a device that supports this service and stands in the correct region of the room. The Kinect server broadcasts the command stored at the hotspot to all connected devices and the application is launched. The prototype is illustrated in Figure 1. Though the example is application specific, the method of interaction can be applied to other services that benefit a user, such as notification alerts that are filtered by the context of the room. A key advantage of this interaction technique is that a user can use their virtual shortcuts to interact with any device connected to the Kinect server. Furthermore, information to identify a user can be stored on a personal device and this can be used to enable personalisation of hotspots, such that other users may personalise the same interaction space with their own virtual services.

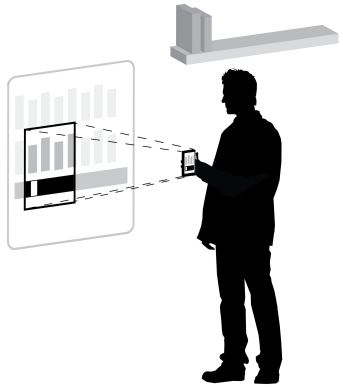
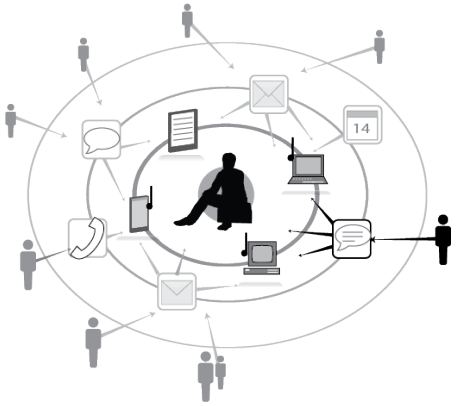


Figure 1: Virtual bookshelf prototype. The user stands in the position of a virtual proximity sensor which launches a virtual bookshelf application on a mobile phone.

In our current application, mobile devices are not detected by the Kinect camera and, with this method alone, it would be difficult to direct commands to a single device. This would be a problem if multiple users and their devices were to share the same interaction space. The sensors available in mobile devices can help to reason about the device in current use and, by



Scenario 1: A user with concurrent applications and services finds it difficult to manage all devices at once.

Scenario 2: A user walking into a room enters a social environment with virtual parties.

synchronising device acceleration with the movement of users, we could become more certain about the relationship between a user and a set of devices.

Related work

Interaction between mobile devices has been demonstated with gesture file sharing [2] by using inertial sensors to communicate interactions and user defined gestures have been explored for connecting mobile devices [3]. Body movement has been used to control a mobile device [4] by inferring pose from inertial sensors and in proxemic interaction [5] by using reflective markers for user and device tracking. Difficulties of user detection with vision techniques [6] are relevant for interaction with the Kinect and the cognitive effects of interrupts [7] is an important consideration when designing for multiple devices as the attention of a user can be split across many displays. The social acceptability of gestures [8] should also be considered, particularly in social contexts when users are less comfortable performing bodily interactions.

Scenarios

We motivate future research with the following scenarios that highlight current issues with interacting with multiple mobile devices.

Scenario 1: Concurrent applications and services

Applications and services are supported by many different devices. However, as current mobile technology does not intercommunicate, they each compete for the attention of the user. With concurrent applications, sometimes this means repeating the alerts received on another device. As it is the job of a user to configure personal devices, a common interaction channel could help to reduce this effort.

Scenario 2: Social interaction with devices

In a social environment, there are opportunities to interact with the devices of others. An example may be to add tactile feedback to a video call when another user enters a remote room. Additionally, as personal displays form a disconnection between a user and the environment, movement can be used to remove this barrier and make it possible for both virtual and physical users to engage through their devices.

Future research

Future research will involve investigating novel ways for users to interact with many devices. We propose the following research questions:

- What are the relevant issues with regard to managing multiple devices and how should interaction be designed around these?
- How can body movement improve communication with multiple devices and when would it be appropriate to use bodily interaction?
- How should body movement be used in a social environment with regard to multiple device interaction?
- How should bodily interaction be evaluated for its effect on the ways in which users manage their devices?

- What tools are required to design interaction with multiple devices and what are the implications on future technology?

Conclusion

Optimal methods of interaction should be designed for users with multiple devices. Currently, the effort of managing additional devices interferes with the benefits that a user can gain from mobile technology, such as personalisation and alerts. The lack of common interaction channel also limits the potential for novel interaction. Tools to design interaction with multiple devices and ways of evaluating these will be required in order to discover the relevant issues. Technical limitations, such as restrictions in power, sensing and communications, will be important for interaction design and will have implications on future technology.

We have shown that bodily interaction with the Kinect can be used to rapidly prototype novel interaction with multiple devices. This may contribute more generally to research in the design of mobile interaction, including studies on the usability of interactions which may benefit from the detailed logging of user and device movement. These ideas will be discussed in the mobile gestures workshop to gain insight from researchers in the community with have similar interests and to inspire new ideas and open opportunities for collaboration.

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