Gesture Connect:
Facilitating Tangible Interaction With a Flick Of The Wrist

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ABSTRACT

The Gesture Connect system streamlines the process of connecting to and/or controlling objects from a user's personal mobile device. Typically, in order to connect two devices together they users must follow a two-step process that consists of first selecting which devices should be connected, and then specifying what the devices should do once they are connected. By combining contact-based connections with gesture-based selection, the Gesture Connect system combines these two steps into a single physical action for simple actions, greatly simplifying the common case. In order to demonstrate and test the underlying concept, a hardware extension comprising Near Field Communication (NFC) and accelerometer capability has been developed for standard commercial mobile phone devices, along with the associated tagging and gesture recognition software. This system greatly reduces overall interaction time for common-case interaction, enhancing the overall user experience.

Author Keywords

NFC, physical gestures, mobile phones, tangible interaction

ACM Classification Keywords

H.5.2 User Interfaces: Input devices and strategies and Interaction styles.

INTRODUCTION

Near Field Communication (NFC) and accelerometers (for gesture recognition) are two emerging technologies that can be used to create a tangible interface for a user's personal mobile device (PMD) in order to interact with nearby computing infrastructure. The Gesture Connect system combines these capabilities with Bluetooth communication to enable users to quickly invoke common actions on target systems using their own device. The Phone System Interface (PSI) is a small extension board designed to add capabilities, such as NFC and accelerometers, that are not currently standard features on most mobile devices.

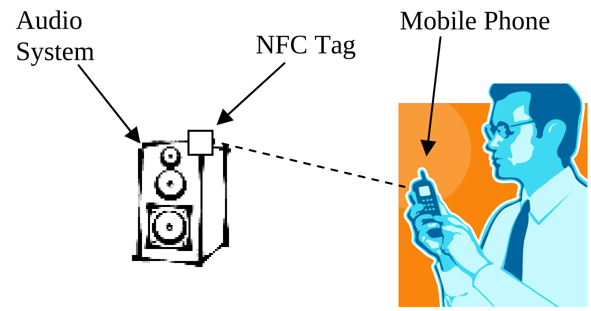

Fig 1: The Gesture Connect system enables users to easily control objects with a combination of NFC tag proximity scan and then physical gesture.

An example use of the Gesture Connect system is to support the interaction between a user's PMD and a standard audio stereo system. Given these two devices, there are many actions the user may wish to perform, such as: capturing the information about the currently playing audio track on their mobile device, transferring playback of the song currently playing on their mobile device to the stereo system, browsing through the music library available on the stereo system, etc… Some of these operations are very simple (find out about the current song), while others require much more detailed interaction (browsing the music library). Ideally, the interaction would be streamlined and simple for the basic interaction while still enabling the more in-depth situations. This same basic interaction can easily be extended to many other situations, such as transferring an active phone call from the mobile device to another phone, or controlling lights in a conference room.

To facilitate this interaction, the Gesture Connect control-flow, detailed in Figure 2, would allow the user to capture the currently playing information by scanning an NFC tag situated on the stereo system and flicking their wrist to the

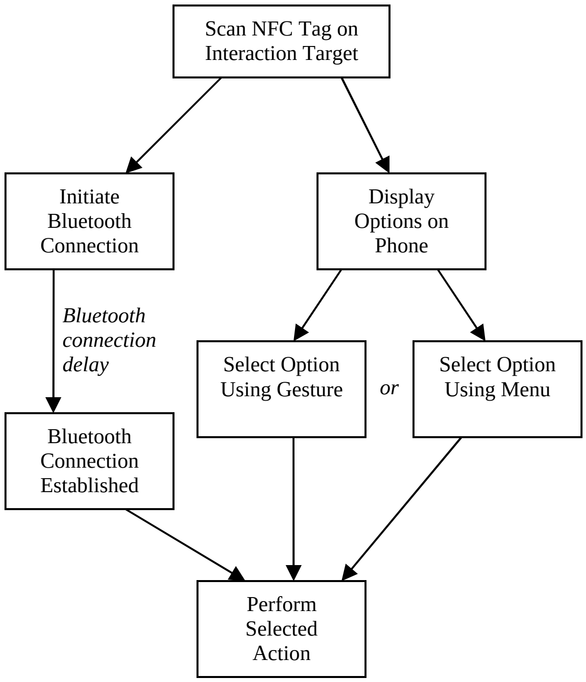

Fig 2: Gesture-Connect Control Flow. The Bluetooth connect process can proceed in parallel with the user selection process.

left. Alternatively, to transfer a song currently playing on their mobile device to the stereo, they could flick their wrist to the right. For more complex interactions, they would simply scan the NFC tag and then use the mobile device's on-screen interface to complete the interaction. Using physical gestures combined with the NFC tag effectively allows optimization of commons case instead of always requiring an involved interaction – allowing users to accomplish their goals without unnecessarily involving technology. As discussed below in more detail, the system also incorporates the use of Bluetooth to enable the mobile device to communicate with the target system after the initial interaction: a necessary communication channel because, for example, the device may move out of NFC range as a result of the selection gesture.

The primary contribution of this work is the realization of combining NFC and gesture recognition to enable streamlined interaction using a tangible interface. A proof-of-concept implementation highlights the technical feasibility of the idea, and also demonstrates technologies that can be used to extend the capabilities of commercial mobile devices, enabling research into new kinds of physical and tangible interaction systems.

RELATED WORK

There are many techniques possible for connecting two devices together. [8] presents an empirical comparison of

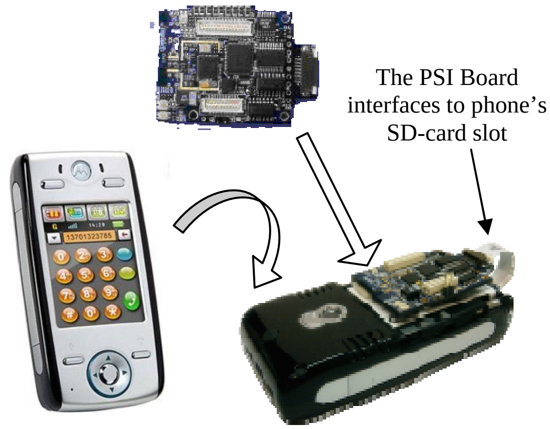

Fig 3: The PSI board attaches to the back of a Motorola e680i mobile phone, interfacing with the phone's SD-card slot to provide a compact configuration.

user preferences between touching, pointing, and scanning connection techniques. [4] describes a technique for pairing two devices together through a sequence of manual button presses on the different devices – enabling an intuitive way for users to connect two devices together. Similarly, basic tagging techniques can be used to connect two devices together simply by being within a couple of centimeters of each other – enabling very intuitive connections without the use of wires, described in [10,7]. None of these techniques, however, address what happens after the two devices are connected together – an aspect that is addressed by the gesture portion of the Gesture Connect system.

Using physical gestures to control systems is a concept that has been around for a long time, but has not gained widespread adoption. In some senses, the traditional desktop mouse is a physical gesture input device. [5] provides a comprehensive look at how gestures can be used for remote control. However, this work assumes the pre-existing connection between the devices – and does not address how the two systems are initially connected together.

Camera phones are a popular solution for facilitating interactions between mobile phones and other objects [9,2], and can be used in a fashion similar to that of Gesture Connect – combining the connection mechanism between two devices with remote control capability. Optical control, however, has many different affordances than using NFC and physical gestures. Using optical tags requires that the user carefully position the device such that the optical tag can be effectively recognized, and poor lighting can confound the image processing algorithm: although this interaction may be better than using the device's on-screen interface, it may not be natural to the user because it requires careful positioning of the device.

The Elope system [6] explores an approach which allows a user to control components in the infrastructure through tangible objects found in and near that space. Similar to Gesture Connect, the user scans an RFID tag on an object in the environment with their phone, effectively transferring control of the system to the scanned object. This object, then, can be used to control access to content stored on their phone. For example, to implement the scenario outlined above the user would scan a “music player cube” with their phone, and then use the cube to control music playback. Although incorporating some of the same technologies, the underlying system is different because Elope does not provide a way for users to specify a simple interaction as part of the initial connection action, increasing the interaction overhead for simple operations. In this situation, the gesture made with the phone after scanning the cube could be used to define exactly what operation the cube would be able to perform.

iStuff Mobile [1] is a prototyping environment that allows designers to easily add sensors and other capabilities to mobile phones. Unlike the PSI board, however, this system communicates all data from the added components to the nearby infrastructure where it is processed. So, although it works very well for prototyping applications and exploring new areas of interaction, it is not intended as a long-term solution that takes into account mobile phone platforms.

ARCHITECUTRE & IMPLEMENTATION

The Phone System Interface (PSI) module, detailed in Figure 4, is a small board designed to interface to commercially-available cell-phone platforms through the phone’s SD-card socket, as shown in Figure 2. The module is designed to provide a general-purpose expansion capability for mobile devices. Designed around a small single board, it supports an SD-interface for the phone connection, a MSP430 embedded microcontroller, a 3-axis accelerometer, and a CC2420 802.15.4 radio built-in. Additionally, there are expansion connectors that can be used for a variety of purposes, such as adding NFC capability. The prototype system combines the PSI board with a Motorola e680i mobile phone, which supports the Linux operating system, and touch-screen interface. Programmatic access to the PSI board is provided through custom kernel drivers. The phone, rather than the PSI module, has a Bluetooth capability for communication with nearby computer systems.

Figure 2 highlights the control flow for the Gesture Connect implementation. The NFC tag contains the Bluetooth MAC address necessary to form a connection between the mobile device and the interaction target. Additionally, the NFC tag provides the information necessary to display the options menu to the user. The user may then either use a physical gesture to trigger the selected action, or they can select the action from the mobile device’s on-screen menu capability. While the user it performing their selection, the Bluetooth connection process will proceed, and once complete the Bluetooth channel can be used to communicate the resulting action.

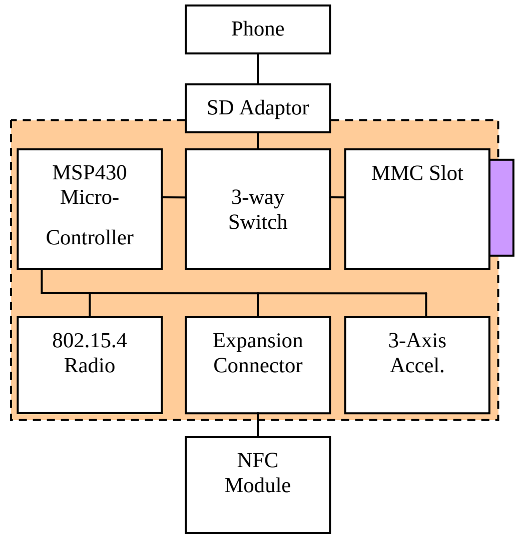

Fig 4: PSI Block Diagram. This basic module connects to a phone through it’s SD-card slot.

By overlapping the Bluetooth connection process with the selection process, the overall time of interaction is reduced. Additionally, using the NFC tag proximity scan to read the set of actions that are possible once connected, reduces the overall interaction time by providing the user with the options before the Bluetooth connection can be established. Without the combinations of the two technologies (i.e., NFC only or Bluetooth only), the user would either have to keep the phone near the tag, or wait until the bluetooth connection is activated before performing any actions. Although it is a bi-directional communication technology, it’s not feasible to use NFC to communicate the results of the selection option because the devices must remain close to each other in order to communicate. Therefore, if the device is moved away from the tag during the selection process (either as a result of the gesture, or moving the screen closer to the user in order to interact with the on-screen menu), the device will not be able to communicate the result back to the interaction target.

GESTURES AND ACTIONS

The Gesture Connect prototype system uses a basic gesture recognizer that can distinguish three simple gestures based on the orientation of the mobile device: rotate left, rotate right, and turn-down. These gestures are simple enough to provide a basic proof-of-concept system, and can likely be extended in a manner similar to [5]. In the prototype implementation, these gestures are hard-coded to specific actions, which are also shown to the user as a list on the mobile device.

The gesture recognition code is written in J2ME as part of the selection-UI application on the mobile device. To determine the orientation of the device, it calculates a geometric mean of the raw accelerometer readings and signals when a significant change in device orientation occurs. As soon as the NFC tag is successfully scanned, the phone beeps and then initiates a Bluetooth connection to the MAC address read from the tag. After the beep the phone displays the list of available actions to the user and starts reading the accelerometer state at approximately 10 samples per second, which is sufficient to recognize these simple gestures. Once an action is selected (either through a gesture or list selection), the result it communicated to the host system over the Bluetooth link and displayed on the screen.

The general question of which gesture should map to which action is beyond the scope of the prototype system, but raises some interesting questions about this system. There are many different potential sets of gesture to action mappings, since any given mobile device can be used to interact with many different kinds of objects. One simple solution would be to standardize on a set of simple operations, similar to the "copy and paste" metaphor pervasive in desktop computing. Relating back to the example, the "copy" operation would be used to transfer current song information from the stereo to the mobile device, while "paste" would push the current song from the phone to the stereo. Only after the Gesture Connect system became commonplace would it be possible to fully understand the mapping that would be most appropriate for these interactions.

CONCLUSION

The Gesture Connect system explores how NFC and physical gesture-recognition technologies can be added to commercially-available mobile devices in order to enable users to more easily control the surrounding computer systems from their mobile device. This system combines the intuitive nature of physical interaction with the flexibility of the mobile phone platform. Overall, this technique reduces the time to perform basic operations to approximately 2 seconds, while still allowing access to the full functionally afforded by the underlying systems.

Prototyping novel interfaces on mobile phones is often a very difficult process because, unlike common desktop systems, the hardware and software environments for mobile devices is closed to independent developers & researchers. The PSI Board extension module enables additional capabilities to be added to Linux based mobile phones. For the Gesture Connect system, NFC and accelerometers were combined with a commercial mobile phone for a proof-of-concept demonstration. Outside of this basic use, the PSI module could also be used for other applications such as enabling the device for health monitoring & wellness applications by incorporating other sensors or connecting it to a body sensor network.

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