Touch-driven Interaction via an NFC-enabled Smartphone

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***Abstract*—With the advent of smart home technologies, convenient and intuitive cyber-physical interaction methods are in great need. We demonstrate a touch-driven interaction system with home appliances via an NFC-enabled smartphone. By touching the phone to NFC tagged devices, we can establish connection and exchange information, control devices from phone, and share media between them. We also demonstrate three applications, Touch&Connect, Touch&Listen, and Touch&Watch, to demonstrate touch-driven interaction in a smart home environment.**

***Keywords*-NFC; smart environment; mobile interaction; cyber-physical interaction**

I. INTRODUCTION

Modern living environment is equipped with various kinds of home appliances, such as televisions, home theater systems, personal computers and tablets, etc. These devices, together with the underlying networking infrastructures, create a virtual, electronic space upon the physical space, which can be defined as cyberspace [1]. However, interaction between cyberspace and physical space is neither convenient nor intuitive. Most appliances provide specialized interfaces for monitoring and controlling them, such as complicated dashboards and controllers. Furthermore, configuration and operation on such appliances are usually difficult for general users, especially for senior people and people with disabilities [2], [3].

Many approaches have been proposed to address the challenge. Multimodal interaction approaches provide user with multiple modes of interfacing with appliances, such as speech, gesture, gaze, etc. [4–6]. However, the robustness, accuracy, and efficiency of such approaches are not optimized [7]. Sensing-based interaction approaches, on the other hand, use wearable or ambient sensors to detect human behaviors, and trigger interaction automatically [8], [9]. Such approaches, however, suffer from inconvenience and inaccuracy, and may raise privacy concerns [10].

This is a demonstration of our previously published paper [13]. We propose a touch-driven interaction system between cyberspace and physical space based on Near Field Communication (NFC) [11]. NFC is a wireless communication technology that uses electromagnetic wave to detect object approximation at a short distance [12]. Instead of using specialized NFC readers, we take smartphones with NFC chips to combine the potentials of mobile computing and NFC technology. By storing device information in NFC tags, smartphones can interact with devices via simple touch actions. Fig. 1 shows the smartphone (Google Nexus S) and NFC tag we use in this demonstration, as well as three NFC tagged devices (a TV, a router, and a speaker).

Figure 1. The smartphone (Google Nexus S) and NFC tag, as well as three NFC tagged devices (a TV, a WiFi router, and a speaker).

II. SYSTEM ARCHITECTURE

Fig. 2 illustrates the system architecture of the touch-driven interaction approach. The interaction is initiated by a touch action between the phone and the tag. Combining tag information and context information, the touch action is translated into information flow in cyberspace, such as media sharing and device controlling. As a result, the information flow is reflected in physical space as device activities. Please refer to [13] for details.

A. Touch Action

We utilize NFC tag and smartphone to build a touch interface for both human and devices. First, we store device information in NFC tags, and attach these tags to the corresponding devices. Such information includes device metadata, network connection information, and media types the device can handle. Second, an NFC equipped smartphone is used as the representation of human. By touching the phone to the tags, a touch action between human and device is triggered, and the device information stored in the tag is read by the phone in a short time. Finally, some context information is collected at the same time, such as applications running on the phone, ambient data from phone sensors, and device status, etc. Combining both device information from tags and context information from phone and devices, we are able to translate the touch action into corresponding information flow in the cyberspace.

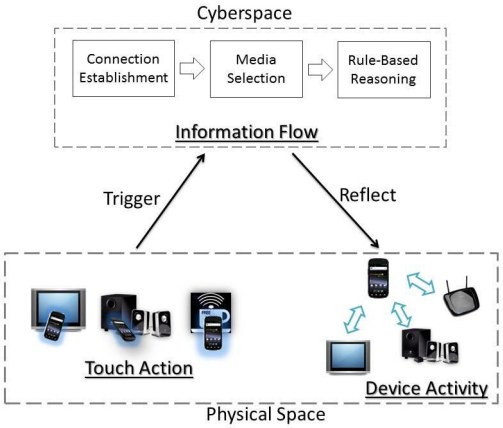

Figure 2. System architecture of the touch-driven interaction between physical space and cyberspace.

B. *Information Flow*

It takes several steps to translate the touch action into information flow in the cyberspace. First, a connection between the phone and the device is established in cyberspace. Second, we determine the information to be transmitted, exchanged, and shared. Based on information from tags and device context, we can figure out the corresponding media resources, such as video, audio, URL, etc. Finally, we conduct a rule-based reasoning to infer the user intent, and then route the information flow through the network.

C. *Device Activity*

Information flow is reflected in physical space as device activity, such as status changes and media playback, etc. These activities give user explicit feedback to help understand the interaction, and provide them with intuitive interfaces for interacting with devices.

III. APPLICATIONS

We present three applications to demonstrate the touch-driven interaction. First, we introduce Touch&Connect, an application that enables connection between phone and device via a simple touch. Upon this basis, we implement Touch&Listen and Touch&Watch to illustrate intuitive and convenient media sharing between phone and device.

A. *Touch&Connect*

Connecting a phone to a WiFi network in a public place is not an easy task. For example, when attending a conference, we usually have to ask the staff for the WiFi password, and manually input it to the phone. To solve this problem, we develop the Touch&Connect application for convenient password delivery and connection making. With Touch&Connect, the network information can be stored in NFC tags, and delivered to users along with conference badges. After arriving at the conference place, users can connect to the WiFi network by simply touching their smartphones with their badges, as illustrated in Fig. 3.

Figure 3. Touch&Connect: Connecting to WiFi network by touching the smartphone with the conference badge.

B. *Touch&Listen*

High-Definition stereo systems provide great music experience both in car and in public places. On the other hand, more and more music can now be purchased and downloaded on the phone via services such as Apple iTunes or Google Music. However, connecting the phone to the stereo systems usually requires specialized cables or configurations. Such inconvenience greatly reduces the music experience at driving, at work, and at party places.

In order to make it easier to utilize these stereo systems, we develop the Touch&Listen application, which is capable of streaming music from the phone to the stereo system automatically over the Bluetooth network. In detail, an NFC tag is affixed to the stereo, containing the connection information as well as speaker parameters. When we touch the phone with the tag, the Touch&Listen application reads information from the tag, and queries the Music application for the music being played on the phone, including the playback progress and other details. At last, the selected music is routed to the stereo system seamlessly (Fig. 4).

Figure 4. Touch&Listen: Streaming music seamlessly from the phone to the Bluetooth speaker via a simple touch.

C. Touch&Watch

State-of-the-art smartphones are capable of taking high resolution photos and record fine quality videos. However, the small phone screens are not perfect for sharing or reviewing these media with friends and family. Therefore, we develop Touch&Watch to utilize TV screens for media presentation.

By touching the phone to the NFC-tagged TV, connections can be established over WiFi or Bluetooth network. Using standard protocols such as UPnP, we can control media activities on the TV from the phone. The Touch&Watch application supports photo reviewing, video playback, and other device control commands from the phone. Here, we have hacked the Gallery3D application to add some media query interfaces.

IV. CONCLUSIONS

We presented a touch-driven interaction system between cyberspace and physical space via an NFC-enabled smartphone. We demonstrated three applications named Touch&Connect, Touch&Listen, and Touch&Watch, to show how the NFC-based interaction can be used in smart home environment to enable convenient and intuitive interaction with home appliances.

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