FlashTouch: Data Communication through Touchscreens

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ABSTRACT
FlashTouch is a new technology that enables data communication between touchscreen-based mobile devices and digital peripheral devices. Touchscreen can be used as communication media using visible light and capacitive touch. In this paper, we designed a stylus prototype to describe the concept of FlashTouch. With this prototype, users can easily transfer data from one mobile device to another. It eliminates the complexity associated with data sharing among mobile users, which is currently achieved by online data sharing services or wireless connections for data sharing that need a pairing operation to establish connections between devices. Therefore, it can prove to be of particular significance to people who are not adept at current software services and hardware functions. Finally, we demonstrate the valuable applications in online settlements via mobile device, and data communication for mobile robots.

Author Keywords
Touchscreen based communication; mobile; stylus; data sharing; tangible.

ACM Classification Keywords
H.5.2. User Interfaces (D.2.2, H.1.2, I.3.6): Input devices and strategies (e.g., mouse, touchscreen).

INTRODUCTION
With the evolution of technology and the market place, mobile devices have become more feature-intensive and sophisticated. Even so, a section of users cannot use all the features of a mobile device effectively. For example, it is easy for users with intermediate-level skills to use smartphones to share their data, including photos and personal information. However, novice users find this difficult. Although mobile devices offer numerous options for sharing data wirelessly, their data-sharing mechanisms are not well known to users. This adds an element of surprise to these devices and adversely affects data-sharing operations via online data-sharing services. Wireless communication using mobile devices often causes blackboxing of data.

FlashTouch technology enhances user experience with regard to mobile data sharing with a hardware strategy involving touchscreen-based communication, based on visible light and capacitive touch, to facilitate data transfer. This technology is more efficient than other similar solutions. For example, there is a solution that enables communication through the audio plugs of mobile devices [1]. However, this solution can be used only if audio is disabled.

The stylus prototype designed with FlashTouch technology allows user interaction via touchscreens. In addition to being a data transmitter, the stylus acts as an external storage medium for data displayed on touchscreens. In terms of storage, it is akin to a USB flash drive. To share data that is displayed on a touchscreen by using the stylus, a user first has to place the stylus on the touchscreen. This transfers a copy of the data to the stylus. Next, the user can place the stylus on the touchscreen of another device and transfer the data to that device. The user can understand how the data he or she wants to share is transmitted via a visible and tangible object.

FlashTouch can enhance visible light communication because it digitalizes capacitive touch by alternation using a relay switch that is embedded in the prototype device. Although it offers a lower transmission speed than wireless and wired signal connectors, FlashTouch provides intuitive interaction with mobile devices via touchscreens. Moreover, it is inexpensive to implement. FlashTouch only requires a phototransistor, a relay switch, and a microcontroller.

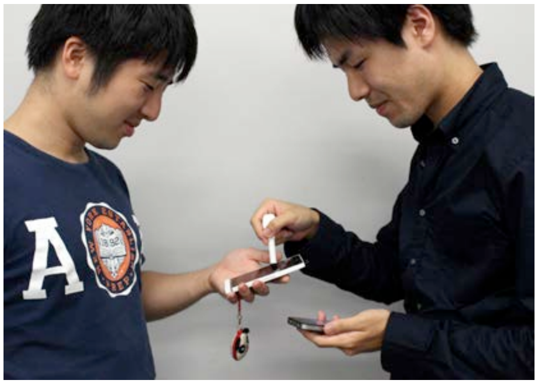

Figure 1. Using the stylus prototype to capture data displayed on a touchscreen.

The applications of FlashTouch are summarized below:

- Wireless data sharing is time consuming and requires a paring operation to prevent transmission to unauthorized devices. Although wireless networking ensures fast data transfer, it is difficult to connect to devices in the real world.
- There are many techniques for transmitting data. However, most of them are inconvenient.
- The user interfaces (UIs) of most data communication applications are complex. There are relatively fewer techniques for mobile devices to communicate with other devices instantly and interactively.

RELATED WORK

Many researchers have proposed concepts similar to ours. For example, the Pick-and-drop [2] concept has been proposed as a means to move data across computers using a pen-type interface. FlashTouch aims to realize real-time data sharing interactions whereby users only have ordinary mobile devices. SPARSH [3] is based on a similar idea, providing users with natural methods to transmit information among digital devices. A user has to authenticate himself by drawing a unique pattern to identify each device. These technologies have overlooked a common drawback, i.e., users have to set preferences in advance, and the interaction region is limited for devices. By contrast, FlashTouch does not need to set up a system for demonstration and has been implemented and tested for touchscreen-based mobile devices.

Some alternative ideas that realize ID input using touchscreens have also been implemented. For example, TUIC [4] leverages capacitive-touch signals to recognize digital IDs through time division multiplexing. CapStones and ZebraWidgets [5] constitute another idea to provide a tangible channel of touch interaction using real objects. Even though touchscreens can be hacked for ID tagging and tangible interfaces, FlashTouch has a different goal than touchscreen hacking. It achieves interactive data communication through visible light.

Visible light communication and display-based computing (DBC) [6] are two ideas that we have implemented through FlashTouch. Here, we would like to mention that DBC is used for signal communication by a monitor for a robot controlling application. This application uses visible light on display or under a projector to create signals, using the DBC technique. Phone as a pixel [7] is a modern application based on optical communication. However, in this case, the visible light communication and DBC can be used only one-way. By contrast, with capacitive touch, FlashTouch provides two-way interactive data transmission.

FLASH TOUCH

FlashTouch is implemented by digitalizing visible light and capacitive touch as communication media for data transmission. Using FlashTouch, touchscreen-based devices can communicate with different media through digital signals as described in figure 2. In this context, a touchscreen has two functions: LED display and capacitive touch sensing. The touchscreen emits digitalized visible light and a phototransistor senses the level of this light, which changes at a constant speed. Capacitive touch is another technology used by FlashTouch. Following the launch of Apple's iPhone, mobile devices started to adopt capacitive touch displays to sense the location of a user's touch according to desired data. We used a relay switch to create a circuit between the touchscreen and the ground to digitize touch input.

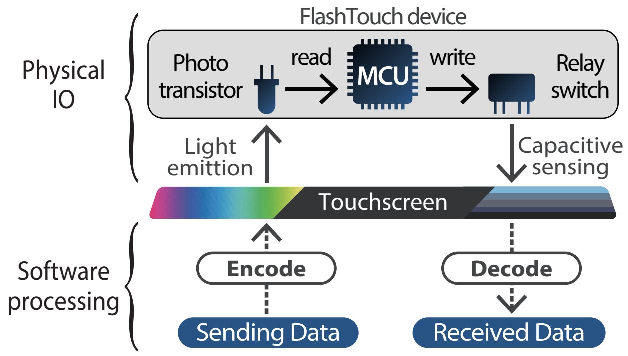

Figure 2. Overview of data transmission via touchscreen as communication media.

Technical Details

FlashTouch was developed and tested using Apple iPhone 4 and iPad 3. During our tests, we discovered that the minimum reaction time of the devices to visible light was 0.02 s. As a relay switch controls capacitive touch, its minimum reaction time to detecting touched and untouched states is 0.03 s. All byte code data is converted to ASCII expression. For instance, if the character "A" is encoded to "0x41," represented as "01000001" in bits, the application emits visible white light as "1" or displays black as "0." On the other hand, capacitive touch should be enabled even if transmission is off. Receiving data "0" is expressed as an untouched state. Faster transmission can be implemented with channel multiplexing by adding an optional FlashTouch connection. Because Apple's iPad 3 can recognize touch intensities of up to 11, the highest speed that can be achieved is 366bps (≒1/0.03*11), depending on capacitive touch. This speed is lower than that of visible light.

Communication Protocol

The data transfer format between FlashTouch and mobile devices is shown in Figure 4. The initial code represents a command that a mobile application requests to FlashTouch to read data by light or to write data by touching. A command means RECV represented as "1010" or a SEND as "1011." An RECV request is usually sent by the UI component along with the data to be transmitted. This data format is illustrated in Figure 3. The initial code is required to avoid sensing noise input even though there is no user operation. Then, the first 3 bits of the RECV/SEND command guarantee the start point of valid transmission.

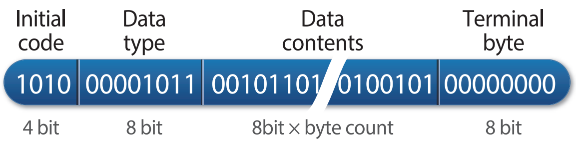

Figure 3. Data format to be sent from touchscreen side.

The communication protocol can be expressed by automata shown in Figure 4. The data to be sent constitute text that not only include "\0". A 4-bit header is used for adjusting the signal timing, distinguishing SEND/RECV, and finding the start timing. In both SEND/RECV, the header must be emitted from the display. A 5th bit will be continuously emitted when sending from the display. The stylus starts to switch touching to send the data stored in the stylus. If the sensor or the screen receives 8 bits of zero, the system determines that the stylus has left the display or accepts a terminal byte "\0"; then, the operation is complete. The problem with the stylus remaining can be solved by inserting length data into the packet. As touch sensing on the mobile device adjusts the sending points along with the stylus, there is no slip of the stylus.

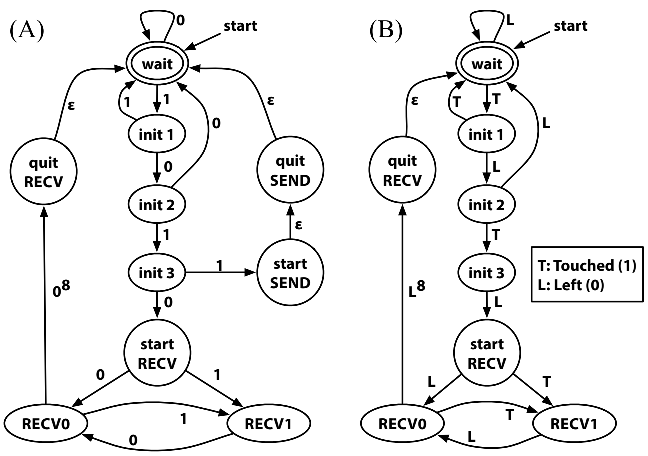

Figure 4. Protocol written in NFA (Nondeterministic Finite Automaton). Diagram represents reception design of (A) reading light on FlashTouch device and (B) sensing touch on mobile application.

PROTOTYPE DESIGN

Implementation

FlashTouch is prototyped as the stylus shown in Figure 5. To reduce the inner capacitance generated around the conductor wire, the stylus has a relay switch at the top, near the conductive sponge, to be touched through the screen. The conductor sponge surrounds the phototransistor so that visible light input and capacitive touch output can be transmitted at one point on the screen. We selected NJL7502L (New Japan Radio Co., Ltd.) as the phototransistor; it is known as an ambient light sensor. The relay switch is Y14H-1C-3DS (HSIN DA PRECISION Co., Ltd.). It can be smaller when an SMD (surface mount device) part is selected. The microcontroller is a custom-designed AVR circuit with Arduino software. A mono-color transistor is selected is reduce the transmission speed because touch sensing is not as fast as light transmission.

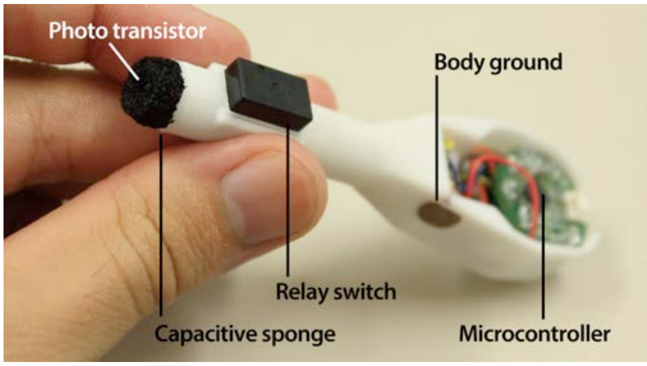

Figure 5. Hardware design of stylus.

Software Interface for FlashTouch

Mobile applications for FlashTouch should have a user-friendly interface to provide user proactive interaction. This UI prescribes a view area with information symbols, such as text and images, to work as the transmitters and receivers. The procedure is described in Figure 6. Data areas where data such as photos, and personal information are stored emit data from the screen to the stylus when the user places the device on the screen area. On the other hand, a blank area receives data from the stylus via the touchscreen, by emitting a request command to FlashTouch, which is required to write out its data. This UI helps users pick and drop information that they want to share across devices, applications, and time spans. This UI is an implementation of the view component of mobile applications that interact with FlashTouch devices. Because the device is placed on the screen, any visible light signal area under the finger or device is hidden from user's sight.

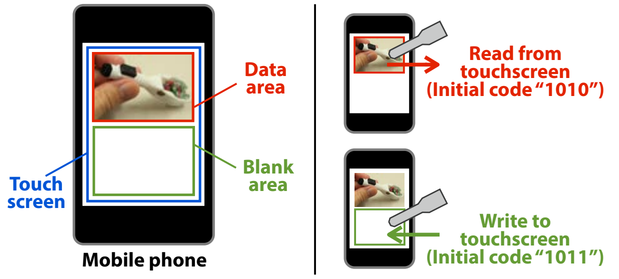

Figure 6. UI works as selective view area depends on content when stylus is put.

Designing Group Interactions

The stylus provides three advantages. (1) Maintaining personal space is an important factor in the case of computer-supported cooperative work. The stylus helps to solve this issue. (2) Focused attention is crucial for collaborative tasks. The stylus has a data flow operation that is understandable by all users. (3) The concept of tangible [8] interface is realized by making prototype with real world substance and interaction with touchscreens. It allows users the freedom to share any type of data easily and quickly with its stylus shape.

APPLICATIONS

A. Electronic Funds Transfer in Real Stores

With regard to the cost of introducing new payment systems with expensive technology such as near-field communication (NFC), FlashTouch is practical in terms of the cost and data rate and the space occupied by the reader, which is critical at checkout counters. Therefore, we developed prototype hardware consisting of a read/write terminal for credit card, membership card, gift card, and online payment service that is connected to a traditional credit card system using a USB connected to a POS terminal. Figure 7 (A) shows the reader hardware and mobile phone to communicate with it.

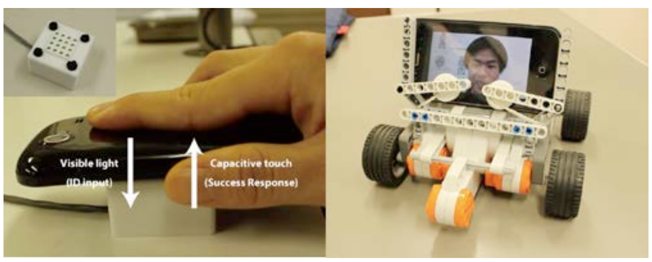

Figure 7. Application images of (Left as A) reader for electronic Funds and (Right as B) robot controller.

Serial Communication and Robot

The use of wireless communication for interaction between a toy robot and a mobile device is infeasible owing to its high cost and complexity. A wired method, such as the use of an audio jack, may be adopted; however, multiple connections would be required in the case of multiple users and robots. FlashTouch can be implemented as a universal asynchronous receiver/transmitter (UART), the standard mode of communication between digital devices. Then, by implementing the FlashTouch-based pseudo-UART on a touchscreen, wired or wireless motion control of a toy robot can be achieved. This approach can be adopted to realize tele-presence because FlashTouch does not disable the audio input/output of a mobile device, and its operation can be accelerated via multiplexing. Figure 7 (B) shows the reader hardware and mobile phone to communicate with it.

DISCUSSIONS AND LIMITATIONS

We understand the different ways of high-speed and durable transmission of large amounts of data. However, we focus on solving difficult device pairing and difficulty in sending data in an online network without a social connection. Although an external device is required to do so, stylus prototype reduces the difficulty experienced in wireless, socially non-connected relationships by using tangible method. Moreover, FlashTouch can be implemented in browsers using JavaScript to detect touch and send visible light signal. Simple implementation and user-friendliness can increase its economic value in the mobile market. Finally, we showed the possibility that FlashTouch can be a platform of input/output interfaces for touchscreen devices. This implies that existing traditional hardware will not be replaced with new technology very soon, and there is still an opportunity to introduce inexpensive technologies that work with existing systems.

CONCLUSIONS

We proposed a new perspective of stylus interaction by FlashTouch and stylus prototype. Contribution of this research is that finding touchscreen-based communication and implementing in daily, economical applications including from online settlement verification to tele-presence robot.

ACKNOWLEDGMENTS

This work was supported by the JST PRESTO program.

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