Mobile Interaction Using Steganographic Image on Mobile Display

Genta Suzuki\textsuperscript{1} Nobuyasu Yamaguchi\textsuperscript{1} Shigeyoshi Nakamura\textsuperscript{2} Hirotaka Chiba\textsuperscript{1}
\textsuperscript{1}FUJITSU LABORATORIES LTD.
10-1 Morinosato-Wakamiya, Atsugi,
Kanagawa 245-0197, Japan
+81-46-250-8223
\{suzuki.genta, nobuyasu, nakamura.shige3, chiba.hirotaka\}@jp.fujitsu.com

\textsuperscript{2}FUJITSU LIMITED
1-17-25 Shinkamata, Ota,
Tokyo 144-8588, Japan
+81-3-6424-6294

ABSTRACT
This demonstration shows novel interaction between mobile devices and their nearby devices using digital images on a mobile display. The interaction needs neither special hardware for communication, nor additional software for existing mobile devices. In the interaction, users of mobile devices can easily interact with nearby devices by three procedures: 1) selecting an image, 2) displaying an image in full-screen mode, or 3) holding the display over a camera connected to the device. The key technology of the interaction is FPcode (Fine Picture code) which is a kind of steganography and can be invisibly embedded in printed images. To enable FPcode to be applied to images on mobile displays, we have developed a camera control method for reducing the influence of moire stripes on the display and variations in display brightness. In the demonstration, we show an application using FPcode on a mobile display.

Categories and Subject Descriptors
H.5.4. Information interfaces and presentation (e.g., HCI): Hypertext/Hypermedia; H4.3. Information systems applications: Communications applications

General Terms
Design, Performance, Experimentation, Human Factors

Keywords
Mobile phones, steganography, image processing, mobile display, mobile ticket, user interface, mobile gaming

1. INTRODUCTION
A key issue of mobile interaction with devices in the environment is simplicity of operation. Mobile devices such as mobile phones and PDAs are helpful for using these devices. For example, a user can use his/her mobile phone as a browser of other devices, as a user interface, and as a means of transmitting data to other devices.

Interactions between mobile devices and other devices can be made by short-range wireless communication such as IrDA, BlueTooth, and NFC (Near Field Communication)[1]. But although these can realize multiple interaction functions, they require appropriate hardware and software in the mobile devices, such as found in some models of mobile phones in Japan. In addition, these interactions may require additional applications to be installed in a mobile device, which users must then learn how to use.

In the demonstration, we show simple interaction using image data and a pre-installed image viewer in mobile devices. Users of mobile devices merely choose an image of the desired interaction, display it in full-screen mode, and hold the mobile display over a device with which to interact. To realize this simple interaction, we have developed a technique of embedding data in a displayed image invisibly and decoding it. The next section presents an overview of our research and section 3 shows an application example of the proposed interaction method. The last section describes a demonstration at MobileHCI 2008.

2. RESEARCH OVERVIEW
We have developed a method for embedding data invisibly in printed images of natural images that enables such printed images to be used for interfacing with a user. An image in which data is embedded invisibly is called FPcode. The demonstration uses an improvement of the research that applies FPcode not only to printed materials but also to images displayed on mobile displays.

2.1 FPcode (Fine Picture code)
FPcode is a printed image in which code data is embedded invisibly. Users can decode the code data by taking a photograph of the FPcode using a mobile phone camera and accessing the website related to the FPcode. The amount of code data is equivalent to a 12-digit decimal number as used in the Japan Article Number code (JAN code), which is a one-dimensional barcode widely used in Japan. ASP services using FPcode have already started[2] and decoder applications can be downloaded to many of the mobile phones now sold in Japan.

Figure 1 shows (a) an original image, and (b) an encoded image of FPcode. The difference between these images is hardly visible

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to the human eye, so the images can be used in printed materials such as advertising leaflets and catalogs as is conventionally done. An advantage is that no unsightly additional image such as a barcode is needed.

Figure 1. (a) Original image, (b) FPcode image.

FPcode encoding uses the characteristic that yellow-color shading can hardly be distinguished by the human eye. Figure 2 shows a typical encoding diagram. The input image is divided into small blocks whose blue levels are varied (blue is the complementary color of yellow). The gradation levels of two adjacent blocks are compared with each other; if the gradation level on the right side is larger than that on the left side, 0 is assumed. If the gradation level on the left side is larger than that on the right side, 1 is assumed. Details of the encoding and decoding of FPcode are presented in reference [3].

Figure 2. Typical Embedding Diagram.

One of the important issues of FPcode ASP services is to guarantee readability of the printed FPcode. Printers and papers may change the blue levels from those existing in the input image. Furthermore, mobile phone cameras do not perfectly duplicate the colors of scenes. We have therefore developed an emulation and evaluation method to reject input images whose encoded images cannot be decoded by mobile phones. From the colors and complexity of patterns of the input image, the FPcode encoder assesses the image and if the score is low, the encoder recommends changing the image or its colors.

2.2 FPcode on Mobile Displays

As an enhancement of FPcode for communicating between mobile devices and other devices, we have developed a framework for applying FPcode on mobile displays.

2.2.1 Interaction Model

The proposed interaction uses a mobile device that has a display and a device which has a camera and can decode FPcode on a mobile display from an image captured by the camera. An example of displaying FPcode on mobile phones is shown in Figure 3 a), and an FPcode reader device which incorporates a USB camera is shown in Figure 3 b). Images of FPcode delivered to the user’s mobile device are JPEG format data and the FPcodes also have the same 12-digit codes as FPcodes for printed materials. If the mobile device has a common JPEG image viewer and display, then no additional software or special hardware functions are needed.

Figure 3. Hardware Examples of FPcode on Mobile Displays

The basic procedure of using the mobile device is divided into three steps: 1) Select an FPcode image from images in the mobile device (see Figure 4 (1)). If the image viewer of the mobile device supports thumbnail viewing, this operation is more intuitive. 2) Display the selected FPcode image in full-screen mode (see Figure 4 (2)). 3) Hold the mobile device over the FPcode reader device (see Figure 4 (3)).

2.2.2 Performance Improvement for Mobile Displays

Compared to FPcode for printed materials, FPcode on mobile displays has readability issues such as moire stripes on the display and variations in display brightness. Moire stripes adversely affect the blue component of FPcode’s embedded blocks (see Figure 5). Depending on the particular mobile display, it may be too bright or too dark for decoding the embedded blocks of FPcode using the same USB camera settings. These effects vary depending on the image display size, resolution, display structure, image processing, and so on. We have developed methods of camera
control to minimize such influences. The focus of the camera embedded in the FPCode reader device is configured to be slightly out of focus to avoid moire. Gain and exposure are consequently varied throughout the process of decoding FPCode to deal with differences in brightness of the mobile device. These methods enable encoding, decoding, and emulating of FPCode to be conducted on mobile displays the same as FPCode for printed materials. As a result, the proposed interaction can support various types of mobile display, as shown in Table 1. Additionally, since the hardware and software requirements are limited, many mobile devices can be supported: we have evaluated more than 180 models of mobile phones sold in Japan since 2006, and most of them can display readable FPCode images.

Table 1. Specifications of Mobile Displays

<table>
<thead>
<tr>
<th>Display Size (inches)</th>
<th>Resolution (pixels)</th>
<th>Colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.9</td>
<td>240 x 320</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.5</td>
<td>480 x 864</td>
</tr>
</tbody>
</table>

3. APPLICATIONS

Although there are many possible applications for using FPCode on mobile displays, we propose the following three applications as examples.

3.1 Mobile Tickets and Mobile Coupons

Mobile tickets for admission to event sites and mobile coupons for discounts or obtaining something are effective applications of FPCode on mobile displays.

An example of the mobile ticket application is shown in Figure 6. Two users receive the same designed mobile tickets including different FPCode IDs for a singer’s concert. They can refer to their history of attending the singer’s concerts by holding their tickets on the mobile display over an FPCode reader device placed at the concert venue.

3.2 Device Control

The FPCode on the mobile display can be used as a user interface for other devices such as an information system with a large screen. In this case, FPCode images are designed to indicate the operation. For example, the image of a right arrow indicates a “select right” command. FPCode’s 12-digit ID embedded in an image denotes both commands for devices and users. When a user holds the mobile display to an FPCode reader device of the target system, the system can recognize the FPCode, identify the user, and execute the corresponding command.

3.3 Virtual Trading Card Game

The trading of cards has long been a popular game; people enjoy collecting cards and using the cards to play games. The third example application expands these trading card games to virtual card images delivered to mobile devices. Before delivering images, the trading card’s vendor embeds ID data which identifies a character or item of the card and a user who receives the card in an original card image. To play a virtual trading card game, users display the card image on a mobile display and touch the device with the FPCode reader device connected to a game machine. Since the game system traces the users of the image from the FPCode IDs, playing with unauthorized image copies can be avoided.

4. Related Work

There are several approaches using codes or markers on mobile display for mobile interaction, but they are not natural images. Therefore, FPCode on mobile displays has an advantage in respect of design and visibility for users.

Mobile QR code [4][5] realizes mobile tickets on mobile displays using a two-dimensional barcode, and there are now many services using mobile QR code. For example, Japanese
airline companies have started offering mobile QR code services to check in. However, if a user has many of these tickets, he/she may not be sure which is which, since QR codes appear as a meaningless pattern to the person. On the other hand, an image of a mobile ticket using FPcode can show the contents, so the user can understand what the mobile ticket is for (e.g., an image of a singer in the case of a mobile ticket for a concert). In addition, mobile tickets of FPcode have a sales promotion effect because users want to collect attractively designed images.

C-Blink [6] adopts a color blinking pattern on mobile displays to enable mobile phones to be used as an interface for ubiquitous large screens with cameras. In [8], a visual marker of AR Toolkit [7] displayed on a mobile phone is used to detect the phone from the image captured by a camera attached to an eyeglass display. Their blinking patterns and markers serve as tracking coordinates of the display on captured images, but the freedom of marker design is limited. In the case of C-blink, only 3 solid colors (red, green, and blue) are used to make up blinking patterns, while in the case of the visual markers of AR Toolkit, it is hard to distinguish similar patterns of different visual markers.

5. DESCRIPTION OF DEMONSTRATION
At the demonstration, we show an application of FPcode on mobile displays. The demonstration uses mobile phones, a USB camera, and a laptop PC. Participants can operate the mobile phones and use FPcode on the mobile display.

6. REFERENCES