iPvlc: Pixel-level Visible Light Communication for Smart Mobile Devices

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1. Introduction

The collaboration between a public large display and personal Smart Mobile Devices (SMDs) is a promising technical field for the visual communication and interaction. This paper focuses on the combination of an image projector as the large display, and smartphones and tablet PCs as the SMDs. The pioneering work in this field used Personal Data Assistants (PDAs) and electromagnetic sensors for detecting their positions roughly [Rekimoto et al. 2000]. It is clear that the latest SMDs are much more powerful than the PDAs at that time. However, technical challenges still remain in the precise detection of the relative positions and inclinations of SMDs placed on a large display. For this purpose, this paper introduces the Pixel-level Visible Light Communication (PVLC) projector [Kimura et al. 2007] as the large display and proposes a simple method for extending the communication function of iPod touch and iPad as the SMDs. We call the system iPvlc.

2. iPvlc system

First of all, Figure 1 shows the implemented system. Colorful aerial photographs appear in SMDs placed on a blank map image. We can see that the photographs and the map image are precisely aligned. The SMD can interactively superimpose the detailed information on the projected large image.

This is achieved by the PVLC projector which can project a visible image and invisible pixel-by-pixel signals. It consists of a Digital Micromirror Device (DMD) and can generate high-speed flickers. People perceive just the integrated brightness as a visual image (a blank map). Each pixel of the projected image contains the latitude and longitude data embedded as high-speed flickers.

Figure 2 illustrates the system configuration. The embedded data from the PVLC projector is received by photo detectors and passed to a microphone terminal of an SMD through a microcontroller. While the PVLC projector works at 12,500 [bps], the baud rate of the microphone terminal is limited to 1,200 [bps] based on the standard of software modem. So, the microcontroller is designed to extract the embedded digital data at 12,500[bps] and convert a part of it to an analog microphone signal by the frequency-shift keying (FSK) modulation. In order to stabilize the transmission, preamble is also added.

Figure 3 shows the actual set up of the system. Two photo detectors are placed apart on the backside. Each photo detector simply receives the latitude and longitude data. As for the distance between the two photo detectors, larger is better, since this distance affects the calculation of the inclination of the SMD.

This approach has the following three major merits:

- The pixel-level accuracy can be achieved for the detection of relative positions and inclinations of SMDs placed on the projected image.
- Just a small plug-in device is attached to an SMD to receive the embedded latitude and longitude data from the projected image. The system doesn’t need any other calibration devices.
- It is suitable for multiple user interaction. Even if many people put their own SMDs on the projected image at once, it works well.

From the experimental results shown in Figure 1, we can see that the potential applicability of the system to realize the above mentioned merits.

References
