Demo: Real-Time Screen-Camera Communication Behind Any Scene

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1. EXTENDED ABSTRACT

Enabling screens and cameras to communicate has been attracting growing interests. The idea is simple: information is encoded into a visual frame shown on a screen, and any camera-equipped device can turn to the screen and immediately fetch the information. Operating on the visible light spectrum band, screen-camera communication is free of electromagnetic interference, offering a promising out-of-band communication alternative for short-range information acquiring. The most popular example is QR code [1], where information (typically a URL) is encoded into a 2D barcode. Recent research endeavors have led to innovative barcode designs to boost data rate or to enhance reliability.

These efforts are exciting, however they commonly require displaying visible coded images, which interfere with the content the screen is playing and create unpleasant viewing experiences. In this work, we seek approaches to enabling unobtrusive screen-camera communication, which allows the screen to concurrently fulfill a dual role: displaying content and communication. Ultimately, we envision a screen-camera communication system that transmits and receives dynamic data in real time, while ensuring communication occurs unobtrusively regardless of the content the screen is displaying — let it be an image, a movie, a video clip, a web page, a game interface, or any other app window. As the user interacts with the screen and switches the content, the communication sustains. Hence, communication is truly realized as an additional functionality for the screen, without placing any constraints on the screen's original functionality (displaying content). Existing designs on unobtrusive screen-camera communication, however, are limited to screen content in a standalone file (e.g., image, video) and fail to support arbitrary content on the screen, which can be generated on the fly with user interactions.

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In this demo, we demonstrate HiLight [3], the first system that supports real-time, unobtrusive screen-camera communication atop arbitrary screen content using off-the-shelf smart devices. HiLight is built upon a new design paradigm that *decouples* communication and screen content image layers. Our key idea is to create a separate image layer (a black matte, fully transparent by default) dedicated to communication atop all existing content image layers. We encode data into the pixel translucency change at the separate image layer, so that the receiver (camera) can perceive the color intensity change in the composite image and decode data. To control pixel translucency, we leverage the alpha channel [4], a well-known concept in computer graphics. We control the level of pixel translucency change so that it is perceivable only to cameras but not human eyes. Furthermore, by controlling the translucency of each pixel independently, we enable multiple simultaneous transmitter elements on the screen. This creates a MIMO communication channel between screens and cameras, which can further boost data rate or improve transmission reliability.

Our methodology has two key benefits. *First*, since alpha values are blended by GPU, the encoding can be done with 1 ms, critical to support real-time communication atop arbitrary dynamic content. *Second*, by realizing communication at a separate image layer, the system makes unobtrusive communication universally available and truly parallel to the content playing on the screen — no matter it is a static, dynamic, or multi-layer content, and regardless of the frame rate it is playing and the frame resolution. Users can use the screen as it is, while the communication between screen and camera occurs behind the scene in real time, unobtrusively.

We have made a collection of HiLight demo video clips available at [2]. By offering an unobtrusive, flexible, and lightweight communication channel between screens and cameras, HiLight presents opportunities for new HCI and context-aware applications for smart devices. For example, a user wearing smart glasses can acquire additional personalized information from the screen (*e.g.*, TV screen, smartphone, or tablet screen) without affecting the content users are currently viewing. HiLight also provides far-reaching implications for facilitating new security and graphics applications.

2. REFERENCES

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