Technical Disclosure Commons

Defensive Publications Series

November 2020

Utilizing A Light Source to Encode and Transmit Information

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Utilizing A Light Source to Encode and Transmit Information

ABSTRACT

Electronic devices that include screens can provide different QR codes corresponding to different actions or applications. However, devices that lack a screen are limited to a single QR code that is printed on the device (or device package). This disclosure describes the use of LED transmission to optically encode and send information that can be received and decoded by a camera, to enable a device without a screen information similar to a QR code. The information is encoded, e.g., using a Bernoulli fingerprint method to make the signal robust and to address noise in optical transmissions that can result from motion artifacts and ambient lighting changes. The techniques allow for easy out of the box set up or pairing for devices that do not have screens, and for transmission of other information from such devices.

KEYWORDS

- Quick Response (QR) code
- Vector fingerprint
- Bernoulli matrix
- Bernoulli pattern
- Temporal encoding
- Optical transmission
- Smart speaker
- Device pairing

BACKGROUND

Mobile and wearable devices include cameras that a user can utilize to capture a quick response (QR) code and display information or invoke actions encoded by the QR code. Electronic devices that include a screen can display QR codes that when captured automatically provides more information (e.g., link to a web page) or initiates actions (e.g., device pairing). Electronic devices that include screens can provide different QR codes corresponding to different actions or applications. However, devices such as smart speakers lack a screen. Such devices are limited to a single QR code that is printed on the device (or device package), e.g., that encodes a device setup (e.g., pairing) action or identifies the device.

DESCRIPTION

This disclosure describes techniques to utilize a light emitting diode (LED) or other light source available on a device (that lacks a screen) to encode and transmit information that can be captured and decoded by another device with a camera. The LED is utilized to transmit a light pattern that encodes information temporally (whereas a QR code encodes information spatially) and can mimic the functionality of a QR code. The techniques enable devices that lack a screen to transmit different codes that correspond to different actions, similar to devices that can display different QR codes.

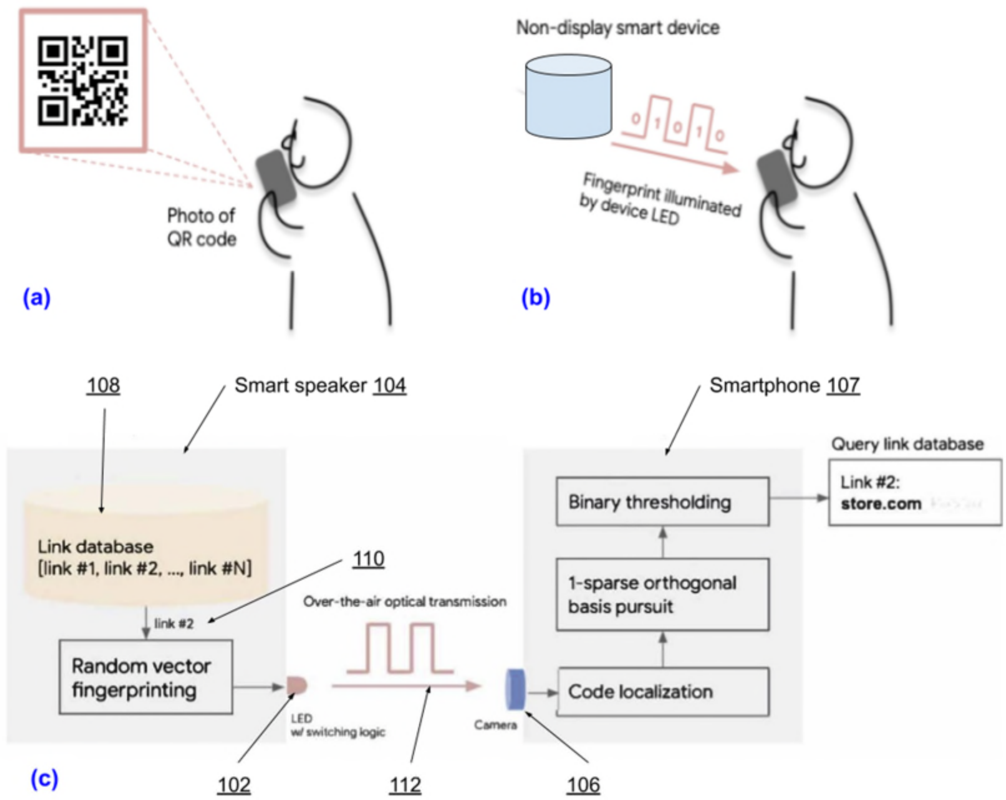

Fig. 1: (a) scanning a QR code; (b) scanning an optical code; (c) Optical transmission and reception of information

Fig. 1(a) illustrates the conventional process in which a user takes a photo of QR code using a smartphone which can then decode the information in the QR code. Fig. 1(b) illustrates a user utilizing a camera of their smartphone to receive a fingerprint illuminated by a device LED of a smart device that does not include a screen.

Fig. 1(c) illustrates an operational example of utilizing a light emitting diode (LED) (102) on a smart speaker (104) to encode and transmit information. As shown in Fig. 1, the light emissions can be captured and decoded by a camera (106) on a smartphone (107). As illustrated in Fig. 1, the smart speaker (104) has access to a link database (108) of multiple links. Link 2 (110) is encoded using random vector fingerprinting and is transmitted via the LED. The receiving device performs code localization and decodes the information.

The link can be encoded using random vector fingerprinting based on a Bernoulli fingerprint method. This method is used to make the transmitted signal robust and to address noise resulting from motion artifacts (e.g., motion of the capturing device) and ambient lighting changes resulting in potential inaccurate localization of the LED illumination.

The camera (104), e.g., a smartphone camera, detects the encoded over-the-air optical transmission (112) from the LED (102). The decoding process first localizes the code in space. This can be guided by a user interface and an image-pyramidal search within a particular region of interest (ROI). The pyramidal search approach makes the localization robust to scale such that it can detect both illuminations happening in small and large regions with equal accuracy. An example illustration of the image patches defined during nested pyramid search is shown below in Fig. 2.

Fig. 2: Nested pyramid search

Referring again to Fig. 1, after optimal region selection, decoding continues as follows. The decoder buffers up the right number of bits that the original message defines. For example, if in the transmission side, if *m* codes have *n* bits each, then in this decoder step, *n* samples are buffered. Then, the original message is inferred from the received signal by solving the sparse linear system by 1-sparse orthogonal basis pursuit. The 1-sparse property exists because the transmitter only sends one message at a time by design.

In this manner, the sent code is identified as Link 2. Link 2 represents a link to the web page "store.com." The user can then use the smartphone (or other device) to connect to store.com. From the user's perspective, they are simply able to aim their smartphone camera towards the LED on the smart speaker and automatically receive a user interface prompt to connect to store.com. The encoded message can include any of the links from the link database on the smart speaker.

The encoding and optical transmission can be implemented in any suitable device that has a LED (or other light source), such as a smart speaker, soundbar, appliance, or other device.

While the foregoing discussion refers to use of a smartphone with a camera as the decoding device, the described decoding techniques can be implemented on any suitable electronic device that includes a visual sensor. For example, a tablet, laptop, personal computer, wearable device, smart glasses, or other device can decode the transmitted optical signal.

The user is provided with options to configure their device to enable or disable transmitting or receiving information via LED, or to turn off the feature entirely. When disabled or turned off, no LED transmission or detection is performed.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., LED transmissions from a device, optical signals detected by a camera, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes the use of LED transmission to optically encode and send information that can be received and decoded by a camera, to enable a device without a screen information similar to a QR code. The information is encoded, e.g., using a Bernoulli fingerprint method to make the signal robust and to address noise in optical transmissions that can result from motion artifacts and ambient lighting changes. The techniques allow for easy out of the box set up or pairing for devices that do not have screens, and for transmission of other information from such devices.

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