Influence of Walsh-Hadamard Code Sequency in Visible Light Communication Using an Event Camera

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1. Introduction

The event camera is expected to be used as a new receiver in visible light communication (VLC) for its fast response speed [1]. In VLC, the event camera detects and outputs the brightness change in the blinking LED as an event. However, it is difficult to detect the transmitter LED from the background when the receiver is moving. This is because the changes in background brightness caused by the camera movement is detected as events as well. To solve this problem, this study focuses on the sequency of Walsh-Hadamard codes (WH codes). The sequency is the number of positive and negative exchanges per second [2]. The sequency of a WH-coded fast blinking LED is high compared with the brightness change in the background. In this study, we successfully separated the LED transmitter from the background when the event camera is moving and demodulated the data.

2. System Model

The system model is shown in Fig.1. We transmit 3-bits information at once. As shown in Fig.1, WH codes of w_0~w_7 are assigned to the 3-bits information (i.e. a_0~a_7). We use WH codes because each WH code has a different sequency. On the receiver side, the Walsh-Hadmard transformation (WHT) is performed for received events. The WHT evaluates the correlation between each WH code and the transmitted data. We show the WHT equation as follows:

$$I_k = \sum_i p(t_i) w_k(t_i) \quad (k = 0, 1, \cdots, 7), \qquad (1)$$

where I_k is the sum of the WHTs of each code, $p(t_i)$ and $w_k(t_i)$ are the polarity and the WH codes at time t_i, respectively. According to equation (1), the higher the correlation of the WH codes with the transmitted data, the larger the I_k. Therefore, The system searches for the $w_k(t_i)$ that has the largest I_k and demodulates the data assigned to this $w_k(t_i)$ as the received signal.

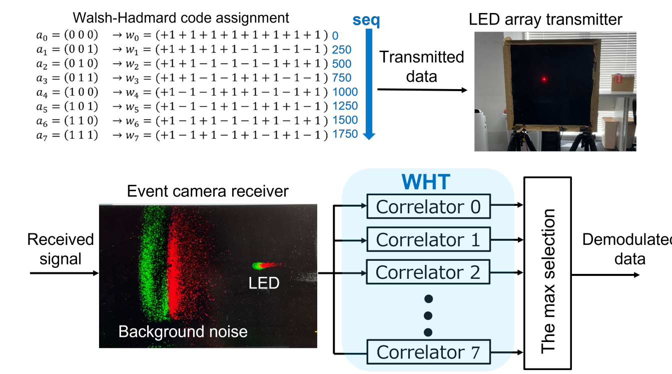

Fig. 1 System model of LED array transmitter and event camera receiver. Here, we show a captured image of the event camera while moving by a hand, where green means change in luminance from dark to light and red means change in luminance from light to dark.

3. Experimental Results and Summary

In this study, 1,200 bits of information modulated by WH codes were transmitted. we calculated the sequency of transmitted data and background noise, and measured the bit error rate (BER). In the experiment, we manually moved the event camera (DVXplorer Lite) horizontally while capturing the blinking LED (see Fig.1). The communication distance was 2.5 m and the LED blinking frequency was 2,000 Hz. The transmitted data sequency was 875 per second. That is an average of w_0~w_7, while the background noise sequency was 45 per second. The measured BER was 2.8×10^{-2}, meaning the transmitted data was decoded with high accuracy. This result is attributed to the large difference in sequency and the effect of background noise could be neglected in the WHT.

The experimental result indicates that the WH codes are effective for the VLC using the event camera.

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