MIMO-COOK Scheme based High Rate Optical Camera Communication

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Abstract — Radio frequency (RF) has already existed and continuously developed for a long time with massively ubiquitous applications over the world. However, it also raises big problems for human health because of electromagnetic waves. Basically, human health is easily affected by high frequency if the signal power exceeds the allowed threshold. Therefore, optical wireless communication (OWC) is growing rapidly as strongly consider a potential competitor with RF technology. In this paper, a multiple-input multiple-output (MIMO) scheme which develops the camera on-off keying (COOK) scheme by applying other technologies such as region of interest (RoI), matched filter. The proposed scheme promises to deliver great performance for the existing OCC system by reforming bit error rate, data rate, and communication distance as well. The proposed scheme can operate perfectly at 20 m communication distance with a low error rate.

Keywords — optical camera communication (OCC), multiple-input multiple-output camera on–off keying (MIMO-COOK), region of interest (RoI)

I. INTRODUCTION

Nowadays, wireless communication has developed rapidly over wired communication due to the remarkable advantages in implementation and data broadcasting without the wired connections. Radio frequencies (RF) commonly used in wireless communication have ubiquitous growth in mobile network applications. Nonetheless, many operators occupied the bandwidth of RF resources which this resource becoming increasingly depleted. Many practical applications require high data rate communication that means they need more communication frequencies. Besides the huge advantages of RF, it is necessary to consider carefully the negative influences of RFs on human health [1]. Thence, new technologies are investigated extensively to reduce the use of RF technologies. As a result, many studies have demonstrated that visible light can transmit data without RF techniques. A rolling OFDM system based OCC system is proposed in [2]. By using two transmitters, MIMO-COOK also studied in [3] at various distance. An application for monitoring system in smart factory is proposed in [4]. A method for enhancing performance of OCC system using OFDM scheme is shown in [5]. In [6], a novel neural network-based method for decoding and detecting of the DS8-PSK Scheme in an OCC system is implemented for improving performance of OCC system in harsh environment.

In this paper, I proposed and implemented a novel MIMO-COOK scheme by upgrading the previous COOK scheme using many techniques such as MIMO, RoI, and match filter. In [7] the COOK scheme is also introduced and added in IEEE 802.15.7-2018 standard. However, I proposed MIMO-COOK scheme with many advantages in terms of enhancing the performance OCC system compared with the conventional COOK scheme such as data rate, distance communication, BER.

II. DESIGN OF THE MIMO-COOK SCHEME FOR OPTICAL CAMERA COMMUNICATION

The OCC systems which used the OOK technique can transmit data by using two states of LED (ON/OFF).

![Proposed architecture of the multiple-input multiple-output–camera on–off keying (MIMO–COOK) scheme.](image)

Figure 1. Proposed architecture of the multiple-input multiple-output–camera on–off keying (MIMO–COOK) scheme.
In OOK technique, a binary zero is represented by the absence of a carrier for the specified period of time, and a binary one is represented by a carrier for the same period of time. Due to the simplicity of OOK scheme, it can be implemented for many applications. In this chapter, I discuss explicitly more about my proposed MIMO-COOK scheme as shown in Figure 1. The conventional COOK is implemented without ROI algorithms leads to reduce the performance of the previous system. Therefore, ROI algorithms are applied in my proposed system to quickly detect the light source. Moreover, I also used matched filter to detect and decode the preamble of the data packet instead of using a zero-crossing filter in the conventional COOK system.

III. MIMO-COOK IMPLEMENTATION AND PERFORMANCE ANALYSIS

To evaluate the higher performance of the MIMO-COOK scheme, my implementation is conducted ten times with the rolling shutter camera to perform frame rate variation impact to my proposed system. Many asynchronous processes occurred in my proposed systems such as the detection of losing parts, merging data scheme, and decoding process. For each experiment, the length of the SN is setup thoroughly for over implementation based on the quality of the optical channel. The receiver side is deployed based on the Point Gray rolling shutter camera.

The performance comparison using COOK scheme between the zero-crossing filter and the matched filter at the same exposure time of 100 us is shown clearly in Figure 2. It is clear that the performance of the system using the matched filter is much better than the zero-crossing filter instead of the same channel environment, same communication distance. Nonetheless, it is the big problem if we increase the exposure time too much lead to the communication bandwidth mitigation due to blur states of LEDs.

VI. CONCLUSION

In this paper, I already demonstrated thoroughly about my proposed MIMO-COOK scheme with many remarkable advantages over the previous COOK scheme. It is obvious to state that the proposed MIMO-COOK scheme is a perfect upgrade version of the previous scheme. My proposed MIMO-COOK scheme can enhance remarkably the entire OCC system performance. The findings provide a concrete idea for researchers and manufacturers for future development of OCC network.

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