Optical Spectrum Estimation Technique for Optical Interference Cancellation in High Speed Transmission MISO-OCVLC Environment

Doohee Han
Kyung Hee University,
Seocheon-dong, Giheung-gu, Yongin-si, Gyeonggi-do,
446-701, Republic of Korea,
hdh9038@khu.ac.kr

Kyujin Lee
Corresponding Author, Semyung University,
579, Sinwoul-dong, Jecheon-city,Chungbuk, 390-711,
Republic of Korea,
kyujin@semyung.ac.krline

Abstract— In this paper, we have studied the multiple light source image sensing technology for high speed transmission in optical camera CCD sensor based visible light communication system. To improve transmission capacity in optical camera communications via image sensors, different data must be transmitted simultaneously from each LED. However, multiple LED light source environments for high-speed transmission can cause interference between adjacent LEDs. In this case, since the visible light communication system generally uses intensity modulation, when a plurality of LEDs transmit data at the same time, it is difficult to accurately detect the respective LEDs due to the light scattering interference of the adjacent LEDs. In order to solve these problems, we propose spectral estimation technique and pixel image signal processing technique for each LED. A threshold value is generated based on the center value of the spectrum at the center of each LED, and only the LED which is sensed above the reference value is recognized independently by the ISP. If the spectral level is below the center value, that LED is recognized as off because it is affected by the light spread of adjacent LEDs. This technique accurately recognizes multiple LED pixels and improves the total average bit error rate and throughput of the MISO-OCVLC (Optical Camera Visible Light Communication) system.

Keywords— Optical wireless communication, Visible light communication, MISO-OCVLC, Inter-light Interference Cancellation, Optical camera

I. INTRODUCTION

Recently, visible light communication has attracted attention as an illumination-IT fusion technology due to the development of LED devices. With the development of smart devices, IoT technology has become a hot topic, and active research is underway with the advent of many next-generation convergence technologies. Visible light communication is a technology that simultaneously provides communication with lighting using LEDs. It is a technology with high utilization value because it can easily establish a wireless network environment by using lighting infrastructure. In the future, the 5G network is expected to deliver a wide range of new services with advanced requirements such as ultra-high-definition(UHD) video streaming, augmentation and virtual reality, cloud gaming, smart homes, connected vehicles and remote controls. In order to meet these requirements, visible light communication uses LEDs with high-speed response characteristics. Therefore, since no RF is used, no frequency permission is required, a wide LED bandwidth can be used without existing frequency interference, It is also considered as a next-generation home networking device that can replace high-speed multimedia data transmission[1][2]. Visible light communication uses visible light that transmits an image sensor (camera) or photodiode to the receiver. In this paper, we have studied the multi - source image sensing processing technology for high - speed transmission environment for the next generation wireless service as image sensor based communication using visible light. Visible light communication can be subject to various interference such as sunlight and other light sources. Thus, for efficient and robust image sensor communication, accurate channel modeling, adaptive coding and modulation schemes, perfect synchronization, channel estimation and allocation are required. Moreover, in the case of stronger interference or in the case of long-term communication, signal detection and estimation are difficult, and in this case a more efficient signal detection and estimation method is needed. In addition, since the visible light communication system generally uses intensity modulation, when a plurality of LEDs transmit data at the same time, it is difficult to accurately detect the respective LEDs due to the light spreading interference of the adjacent LEDs. In order to solve these problems, we propose spectral estimation technique and pixel image signal processing technique for each LED. A threshold value is generated based on the center value of the spectrum at the center of each LED, and only the LED which is sensed above the reference value is recognized independently by the ISP. If the spectral level is below the center value, the LED is recognized as off because it is affected by the light spread of adjacent LEDs. This technique can accurately recognize multiple LED pixels and improve the total average bit error rate and throughput of a MISO-VLC system.

II. SYSTEM MODEL

In a visible light communication system, when data is transmitted from a light source used as a transmitter to a receiver, a received signal can be divided into a transmission signal and an interference signal. The transmission signal means an information data to be transmitted by the transmitter, and the interference signal means an environment in which light is reflected by an unwanted signal or an obstacle such as a wall or a table from another light source. In the optical wireless channel environment, the intensity of the received signal is as follows. The average optical signal intensity emitted by the LED light by the direct path from the transmitter to the receiver is given by:

$$P_t = \lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T} X(t)d \tag{1}$$

In addition, the average received optical signal intensity of the radiated illumination is expressed by the channel environment multiplied by the intensity of the radiated illumination, as follows.

$$P_r = H(0)P_t \tag{2}$$

In this paper, we assume the system is Line of Sight (LOS) link. Thus, all optical paths are seldom obstructed. The most practical modulation scheme is IM/DD. A photo detector in DD receiver produces photocurrent which is proportional to the optical power of the received signal.

The optical wireless channel model is shown in Eq. (3) [2]. The transmitted waveform is the instantaneous optical power of the light wave emitter. The received waveform is the instantaneous current in the receiving photo detector (PD), which is proportional to the received instantaneous power. We can assume that the noise is additive white gaussian noise (AWGN) [3].

$$R(t) = \alpha S(t) * G(t) + N(t) \tag{3}$$

Where the * symbol denote convolution and α is the detector responsively. G(t) is the impulse response, N(t) represents the AWGN.

III. THE INTERFERENCE MODEL OF THE PROPOSED SYSTEM

Figure 1 shows the LED array matrix environment for high-speed transmission. As shown in the figure, m * m matrix pixels consist of LEDs for high-speed transmission, and each LED transmits different data at wavelengths of 700nm ~ 380nm simultaneously. The receiving end consists of an optical camera image sensor and reads and processes the pixel LEDs in the m * m matrix simultaneously.

In this environment, adjacent LEDs cause interference due to the spread of light. As shown in Figure 2, LEDs between adjacent pixels are subject to light interference from both LEDs, which prevents the image sensor from reading the correct data. In addition, such overlap area interference causes distortions such as misalignment, perspective distortion, blurring, and vignetting.

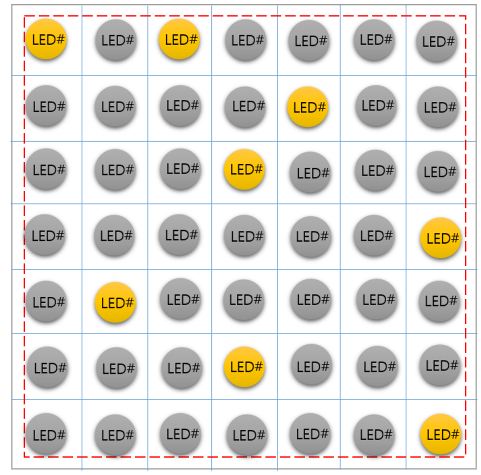

Figure. 1 LED array environment model of m*m matrix

Visible light communication based on image sensors is vulnerable to such interference. To solve this problem, accurate channel modeling,

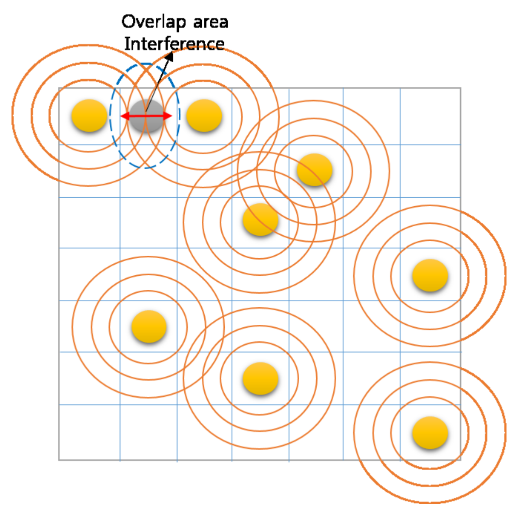

Figure. 2 Interference area of adjacent LED

adaptive coding and modulation schemes, perfect synchronization, channel estimation and allocation are required for efficient and robust image sensor communication. Moreover, in the case of stronger interference or in the case of long-term communication, signal detection and estimation are difficult, and in this case a more efficient signal detection and estimation method is need.

IV. OPTICAL INTERFERENCE CANCELLATION IN HIGH SPEED TRANSMISSION MISO-OCVLC

Conventional optical image sensor based visible light communication is focused on single link modeling only. However, in order to construct a system for high-speed transmission, simultaneous parallel link processing of multiple

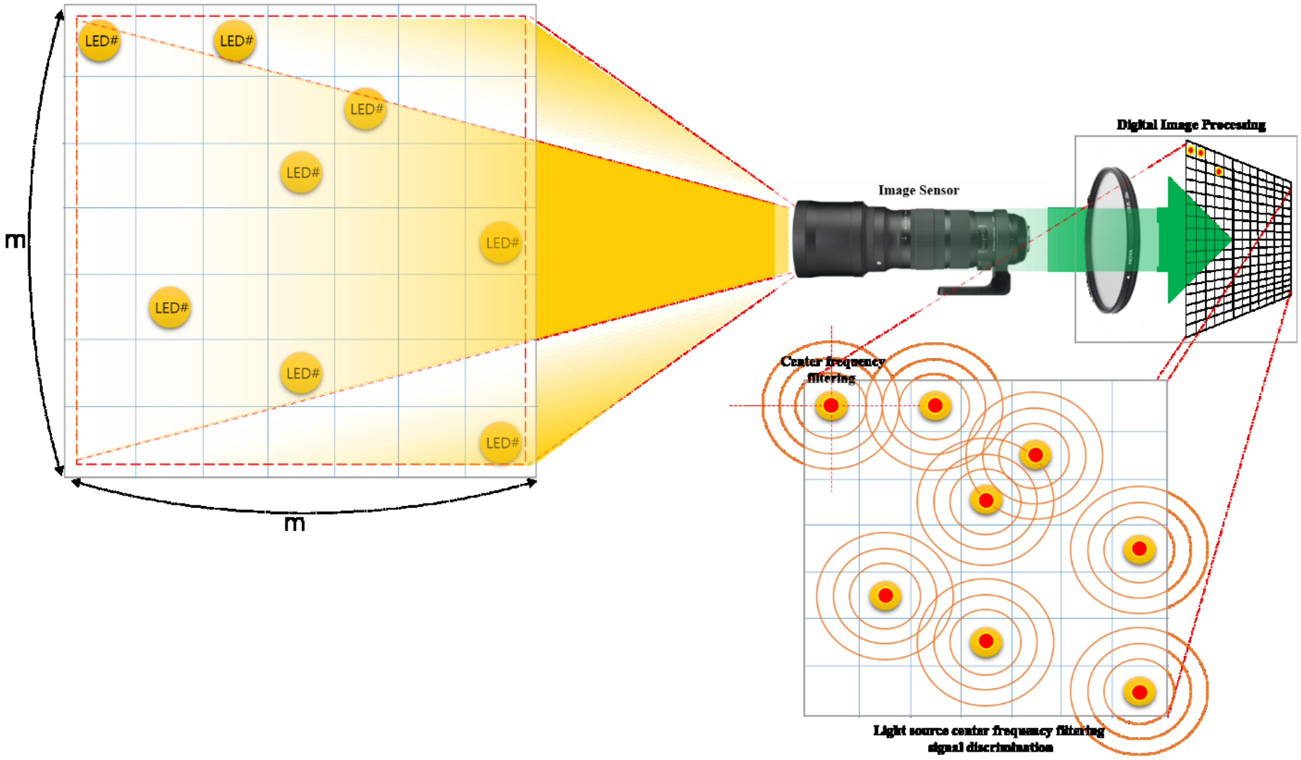

Figure. 3 Proposed System Model Structure

LEDs for capacity expansion is required. In this MISO-OCVLC, as described in Section 3, when multiple LEDs transmit data at the same time, it is difficult to accurately detect the respective LEDs due to the light scattering interference of the adjacent LEDs. In this paper, we propose spectral estimation technique and pixel image signal processing technique for each LED to solve this problem. The spectrum of the unique wavelength band of each LED is analyzed to find the center frequency. Also, when each LED is ON, the center value of the spectrum of the center point is measured at the physical position of the LED. The threshold value R is generated on the basis of the center frequency and the center value of the center point, and the light source received by the optical image sensor is compared with the threshold value R or higher through the ISP to recognize only the LED having the R value or more as ON . In the receiving end, since the center point of the LED is correctly recognized as ON only when the center point of the LED is higher than the reference point R, among the plurality of light sources, the bit error of adjacent pixels due to inter-light interference can be completely prevented. This intelligent machine learning based spectrum estimation technique enables accurate estimation of data from inter-source interference. Authors and Affiliations

V. Conclusion

In this paper, we propose an intelligent optical spectrum estimation technique for analyzing the light scattering interference of adjacent LEDs occurring when LEDs simultaneously transmit data in an optical camera based visible light communication system for high speed transmission. For parallel processing of multiple LEDs for high-speed transmission, research on these interference and channel conditions is needed. In addition, since it is very difficult to communicate LEDs in an environment such as a rough atmospheric environment and a bad weather (mist, rain), a study on a transmission technique for overcoming this problem should be conducted. Through these studies, we expect to be able to provide a service that satisfies the QoS of the whole system by improving the transmission efficiency.

Acknowledgment *(Heading 5)*

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