Abstract— In this paper, we have designed and implemented an optical camera communication system for monitoring the temperature data in the indoor environment. The temperature data is collected from a single LED using the on-off-keying modulation technique. Besides, an indoor localization scheme is proposed to eliminate the additional positioning errors created by changing the position of the LED. The collected data automatically sent to the cloud server for further analysis. The entire system is demonstrated in Python 3.7.

Keywords—optical camera communication, on-off-keying, monitoring, localization, cloud server.

I. INTRODUCTION

Light-emitting diodes (LEDs) have become a popular and widespread use in industries, offices, homes, factories, etc. Those LEDs provides fast modulation of the light source, besides it can be used as a transmitter by controlling the light’s illumination in different frequencies. In indoor sites, the camera is available and commercially used, due to its low frame rate; those cameras are operated in low communication bandwidth. By using those cameras, the transmitting data and localization information can be extracted based on optical camera communication. In short distance communication cases, the rolling shutter effect was successfully utilized; the image of the blinking light source contains fringes, which can be used to decode the transmitted code. The data can be decoded from a single image that is the main advantage of this method.

However, LEDs are used as a light source also propagate through small distances; as a result, data transmission is a big challenge in the field of visible light communication in long distances. However, the previous statistics shown some different approaches of implementation of OCC in 60m distance using RGB LED with DSLR camera though the data rate is very low around 150 bps [1]. The communication distance in the field of OCC depends on the LED size or LED array. Again using smartphone camera-based OCC implementation with maximum communication distance 7.5m using deep learning technique to improve the system capacity and stability [2]. In mathematical simulation was derived in some respect to enhancing data rate, SNIR, and communication distance from the viewpoint of the quality of the user satisfaction [3]. In data transfer process is performed with different modulation in both low frame rate or high frame rate camera but found the majority of low frame rate in every application. In IEEE 802.15.7-2018 standardization from PHY layer IV to VI has evidenced various modulation techniques that are mainly used in low frame rate OCC. Some modulations are performed under-sampled [4] and multilevel [5] [6] with conventional modulation techniques have shown some achievable and significant results using a rolling shutter effect.

In this paper, our focus is to operate in continuous data reception processing including localization of LED and data storage to the cloud server. For this, we have used a single LED that transmits continuous temperature data. At first, the LED is detected, and then the data is extracted based on the on-off keying modulation and send to the cloud server. Besides, an algorithm is developed to measure the distance between the transmitter and receiver.

II. OCC ARCHITECTURE

The temperature data is collected from a sensor named AM2302. Then, the data is processed by converting it into binary bit-stream. The binary bits combine with the channel coding and prepare with the OOK modulation technique for transmitting through the LED. The operating frequency of the LED is 2 kHz. After that, the light is travels via the wireless medium and incident to the image sensor. In the image sensor, the data is capture based on the rolling shutter effect of the camera.

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Then the LED detection is occurred by using the neural network technique. We used a darknet platform for training the data. After detection and identification of data transmitting LED, the normalized intensity is measured from the corresponding image. The normalized intensity contains noise, that can be filtered out with its DC component. For generating binary bits from those values, a threshold is needed to define. In that case, we have taken the average value of normalized intensity as a threshold. Afterward, the data is decoded based on the OOK demodulation technique.

Besides, the position of the LED is determined by using an algorithm. This algorithm measures the distance based on the number of pixels in the bounding box and previously assigned some factors that depend on increasing the distance. By increasing distance, the number of pixels in the detected box decreases. The rate is not linear it create a polynomial equation. The variable from the equation is taken from the width of the detected box. In that case, we can achieve more than 90% of accuracy.

![LED detection, data decoding, and distance measurement](image1)

**Fig. 2.** Demonstration of LED detection, data decoding, and distance measurement.

### III. RESULTS AND DISCUSSION

At first, the light incurs on the image sensor, and based on the rolling shutter effect stripe pattern is generated. The pattern mainly visualizes clearly by controlling the exposure time. In figure 2, the LED detection, temperature values, and distance measurement is shown. For LED detection, the grayscale image is capture first. After that, the image is binarized with a certain threshold value. Then, a contour-based region on interest detection is performed. Besides, the data collection and distance measurement procedure is described in section II. After collecting the data in a python environment, the data is stored in a separate CSV file. The data also send to the cloud server for further analysis and continuous monitoring. In our experiment, we used an IoT cloud server where an authorized person can access the data using a login ID and password.

### IV. CONCLUSION

In this paper, we have designed a system that continuously monitors the temperature data and measure the position of the LED concerning the transmitter. The data is transmitted using a single LED and capture with a low frame rate camera (30 fps). The data is decoded using the OOK modulation technique in a Python environment. Finally, the data is sent to the cloud server for further analysis.

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### REFERENCES


