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Visible Light Communication using MATLAB

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Abstract - *This paper presents the review of visible light communication. It is secure communication when compared with other wireless communication using radio frequency. This technology is envisioned to be used in a wide range of application both indoor as well as outdoor. In this paper, mobile camera phone used as a visible light communication receiver. It receives light in the form of dark and light strips. Received light is then decoded by the MATLAB in the computer. To mitigate the interference of the LED facula and elongate the VLC communication distance, different image processing methods are used such as removal of low grayscale, grayscale conversion, histogram equalization and high pass filter. By applying all these processes image is made easier to be decoded. A second order polynomial filtering is used to define the threshold and the binary result is obtained. Thus, significant improvement of visible light communication can be achieved.*

Key Words: ***Visible Light Communication; Mobile Phone Camera; Digital Image Processing; Roller Shutter.***

1. INTRODUCTION

Visible light communication is very good attractive to radio frequency communication as it finds a wide range of applications in indoor communication compared with radio frequency communications. VLC has many advantages such as large amount of bandwidth, more secure and it has visible light spectrum available for use which is not regulated. Also, visible light communication is not harmful to human body. Over the last decade, mobile with embedded cameras have become common technology. The majority of new generation smartphone have built-in CMOS cameras which provides an ability to capture image and videos. Therefore, it is highly desirable to use these already existing mobile phone image sensor as the VLC receiver. The image is captured from a reflected surface to mitigate blooming effect of LED facula. Array image is then processed and the interference is reduced with the help of digital image processing to a certain extent.

The main contribution of this paper is the processes a feasible digital image processing scheme for the application of VLC using mobile phone camera has the receiver. The information is captured in the form of light and dark strips through the direct line of site without reflected surface. Then extracts the grayscale information transmitted to the computer. Afterward information is generated by the MATLAB and then it is decoded through digital image processing. This method continuously receives the information and decode into steam data is referred as VLC (visible light communication).

2. LITRATURE REVIEW

Visible light communication is becoming an attractive choice for next-generation wireless technology. Nowadays researchers are working on development of visible light communication systems.

In [1], author represents hardware prototype which uses commercial LEDs and describes the physical layer implementation of a VLC system based on a modified version of the classical orthogonal frequency division multiplexing. Modulation techniques also present a hardware prototype for short range broadcasting using a white LED lamp. While LED bulbs clear advantages over conventional incandescent and fluorescent bulbs, which makes them a strong candidate for future illumination equipment. European Commission has decided recently to prohibit the sale of particularly energy-intensive lamps foe household use in series stages up to 2016 and as soon as high efficient white LED bulbs are manufactured cheap enough to overtake currently favored compact fluorescent bulbs. a communication network infrastructure will be available. The fast response of the LEDs enables them to realize high-speed wireless links.

In [2], researchers introduced the sustainable LED light. LEDs are used to implement VLC lighting systems because they can modulate at much higher rates than other sources. LEDs are more efficient, reliable and durable. LEDs are used by replacing incandescent bulbs and fluorescent lamps, VLC has high data rate kilobits per second to mega bite per second. The LED provide 20 MHZ of bandwidth, but the phosphors glow limits the 3db bandwidth to 20 MHZ this is the major limitation for searching high data rate.

In [3], researchers introduced the mobile phone camera which is built by CMOS sensors and offer rolling shutter mode image capture in the form of light dark stripes. The mobile phone with embedded cameras has become common. New mobile consists of CMOS cameras, CMOS cameras capture images and videos. Various effects can be observed due to the rolling shutter operation such as skew seen in the image of a moving object. This is undesirable, this property of the CMOS camera, actually used as optical communication in order to transmit data from an LED to a mobile phone.

In [4], the camera image sensor is explained. As VLC receiver is challenging since data rate limited by the frame rate as well

as uneven light exposure, rolling shutter effects of the image sensor can use to increase the data rates. It is expected the future mobile data volume per area and number of the connected device will be 1000 times and 100 times respectively higher than the present wireless network. To provide such a high density and high capacity wireless communication is challenging, since the conventional RF spectrum has been congested, and the interference between nearby RF access points will be served.

In [5], researchers present the way to extend the VLC transmission distance and mitigate the influence of the background noise. Also, using histogram equalization and Sobel filter, enhancement in the VLC signal performance is demonstrated. In this work, demonstrated a VLC link using CMOS mobile phone camera as Rx. By rolling shutter effect of the CMOS sensor, the VLC data rate can be significantly enhanced.

In [6], researchers present the rolling shutter distortion correction. Here, rolling shutter distortion is corrected using only captured images by means of image processing. A global motion vector (GMV) between two successive image frames is firstly estimated, then the line motion vector for each line (LMV) is determined by smoothly interpolating GMVs estimated from several successive frames. The image is divided into non-overlapped blocks and the motion vector of each block is searched for using the sum of absolute difference as error criterion. Then, the GMV for the frame is determined as the majority of the obtained MVs.

3. BASIC CONCEPTS

3.1 Visible Light Communication: The Radio Frequency communication suffers from interference and high latency issues. In addition to this, it requires a separate setup for transmission and reception of RF waves. These limitations can be overcome by using Visible Light Communication (VLC) technique because of its high bandwidth and immunity to interference from electromagnetic sources. The application of visible light communication systems is to transmit data while maintaining efficient and good quality illumination service. It uses visible light spectrum i.e., between 400 and 800 MHz. It is considered as the subset of optical wireless communication technology. Light Emitting Diodes (LEDs) are semiconductor devices similar to silicon chips. LEDs can be switch at very high speeds that were not possible with earlier light bulb technologies such as fluorescent and incandescent lamps. The rapid adoption of LED light bulbs has created a massive opportunity for VLC.

3.2 Digital Image Processing: It uses computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems, the build-up of noise and signal distortion during processing. Since images are defined digital image processing may be modelled in the form of multidimensional systems.

3.3 Mobile phone CMOS camera: CMOS is a type of integrated circuit chip manufacturing process that can be used for many things, including digital camera image sensors. Each sensor array of pixels is triggered row-sequentially process known as rolling shutter. This effect allows us to transmit with data rates that far exceed the frame rate of the camera.

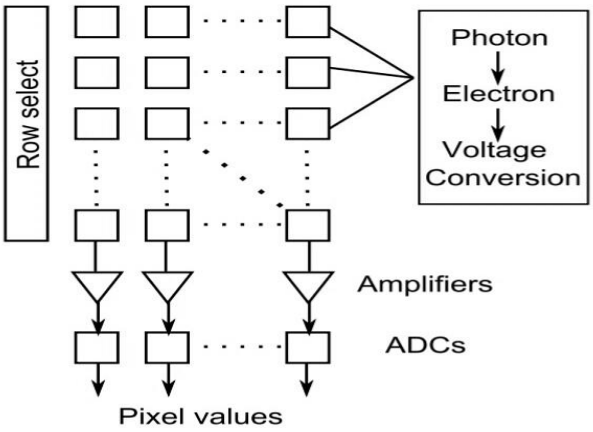

Fig.1 CMOS Camera Schematic

3.4 FPGA: A field programmable gate array (FPGA) is a general-purpose integrated circuit that is programmed by the designer rather than the device manufacturer. It is programmed using hardware descriptive language (HDL). It contains programmable logic blocks and it is used here in order to generate binary waveform.

3.5 Rolling Shutter: The rolling shutter mechanism is a method of image acquisition used by CMOS sensor cameras.

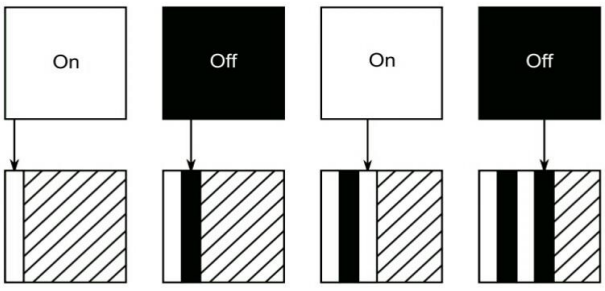

Fig.2 Rolling Shutter operation

The most CMOS sensors contain pixel that are arranged in sequentially activated rows and therefore do not capture the entire image at once. Each scan line of sensor array is exposed, sampled and stored sequentially. When this procedure is completed the scan lines are merged together in order to form a single image.

4. PROPOSE SYSTEM

Fig. 3 shows the basic block diagram of VLC experiment system. The light source is used as a transmitter, in visible light communication. White LED serves as a very good optimum transmitter. The transmitter consists of Field programmable gate array (FPGA), LED driver and LED lamp array with 15 LEDs. Firstly, an arbitrary binary waveform is generated by FPGA. The signal is transmitted to LED lamp which provides lighting LED lamp array is lightened up by the LED driven and transmits an ON-OFF keying signal.

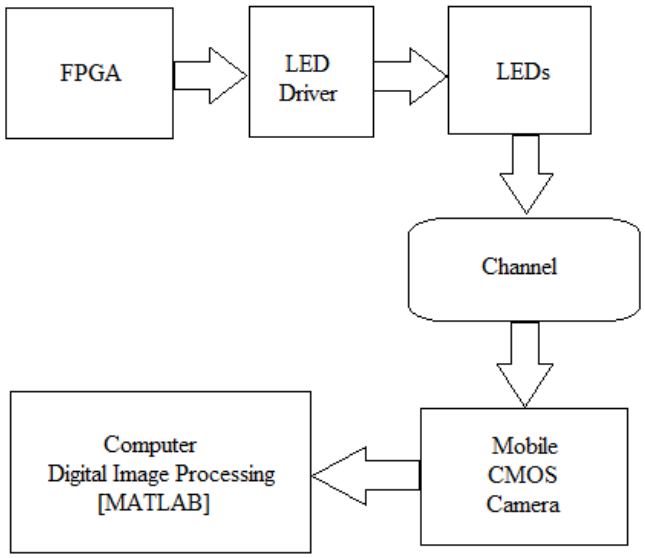

Fig.3 VLC system block diagram

The receiver side consists of mobile phone CMOS sensor and computer. The modulated light is received by a mobile phone camera through direct line-of-site without reflected surfaces. The CMOS sensor of mobile phone has a resolution and frame rate of 640×480 and 30 frames per second respectively. The camera captures the image of light and dark stripes and then digital image processing based on MATLAB is applied. The preview images are stored in a buffer of the mobile phone using the YUV format.

5. CONCLUSIONS

The potential of using visible light communications for data transmission to a mobile phone is investigated in this paper. Digital image processing scheme for VLC using mobile phone CMOS camera as receiver is proposed. In order to achieve this, different methods can be used for processing image such as grayscale conversion, removal of low grayscale and LED facula, histogram equalization and high pass filter which is used for mitigating the background noise and interface of LED facula. Through image processing clear light and dark stripes and valid information obtained binary result is displayed.

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BIOGRAPHIES

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