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Visible Light Fence System for Indoor Kids Vehicles

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Abstract: Kid vehicle is available in the market with various shape and popular product for children. Equip this product with a playground area in a shopping mall is an important entity in business. Typical operation of kid vehicles in a shopping mall is based on manual handling and monitoring by human. In order to improve this operation, the virtual fence is proposed by providing an additional safety feature for the indoor playground. In this project, the virtual fence prototype was developed based on Visible Light Communication (VLC) technology by transmitting data between light from LED to photodetector or LDR module. Arduino modules were utilized in this prototype by integrating with several white LED and LDR module. On Off Keying (OOK) modulation technique was employed to transfer a code to kid vehicle. With this virtual fence, the boundary of the playground area can be set without a physical barrier. The developed prototype was successful to trigger the buzzer if the vehicle goes beyond the boundary.

Keywords: Visible Light Fence System, Kid Vehicle, Visible Light Communication

1. Introduction

Kids vehicles are intended for carrying or transporting something from one place to another and specially created for kids. There are many of shape and types of kid vehicles such as cars, trucks, bicycles, trains and so on. Driving can be a very fun and exciting experience not only for adults but also for kids. It gives the feeling of freedom and adventure to anyone behind the wheel. For kids, it can be a perfect way to help them learn and develop their motor skills. Kids vehicles are important for parents because it can provide indirect learning to kids [1]. Shopping malls are first designed as a one-stop shop for people who need to buy things. Malls with an indoor playground are particularly attractive to shoppers [2]. Little kids do not like standing still at the spot for long term. So to keep them involved, there are kid vehicles at indoor playground that give them a new experience about other vehicles.

Concept VLC was used in this project [3]. The light signal that can be detected by human eye is the signal at the 380-780 nm wavelength interval of electromagnetic spectrum. Lighting and data transfer can be done simultaneously with the use of LEDs. The modulation techniques used vary from OOK for

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indoor visible light communication, where the amplitude of the optical source is directly modulated by the information series. The simplest modulation scheme for visible light communication is OOK modulation [4]. Depending on whether the data bits are '1' or '0', the LEDs are switched on or off. In its simplest form, digital 1 represents ON conditions of light and 0 represents the OFF conditions of light. The Arduino Uno R3 is an open source microcontroller board based on a detachable ATmega 328 dual-inline-package (DIP) chip. It may be programmed using the Arduino computer programme, which is quite easy to use and also simple method to begin working with embedded electronics. The Arduino IDE is open source software that used to write and compile the code in Arduino modules. To create high-speed wireless communication, VLC uses light emitting diodes (LEDs) capable of controlling on/off at high speeds. The photodiode or LDR, which is a type of photo detector capable of converting light into photocurrent. The LDR are used for VLC where they work in wavelength range of 190-1100 nm.

2. Methodology

This section presents the methodology to develop the proposed visible light fence system. The first subsection presents the overall block diagram of the system, followed by the flow chart operation.

2.1 Block Diagram

The visible light fence system design consists of a hardware and software implementation part. As for the hardware part, it consists of several components such as Arduino UNO R3, LDR sensor module, LED and buzzer as depicted in Figure 1. The driver circuit is connected to the Arduino board and the Arduino generates a code to identify the visible light fence area. LED is connected with a series resistor directly to the pin and with the Arduino software to turn the LED on and off. The photodiode or LDR sensor module converts light intensity into current or voltage based on the operating mode of the device. When the LED is turned on and the current flows through the LDR, the current is amplified by an amplifier circuit to send to Arduino board. At the time, when the LDR is unable or able to detect visible light with a code from the LED, the Arduino will give a command for the buzzer to on or off. Table 1 describes the hardware information.

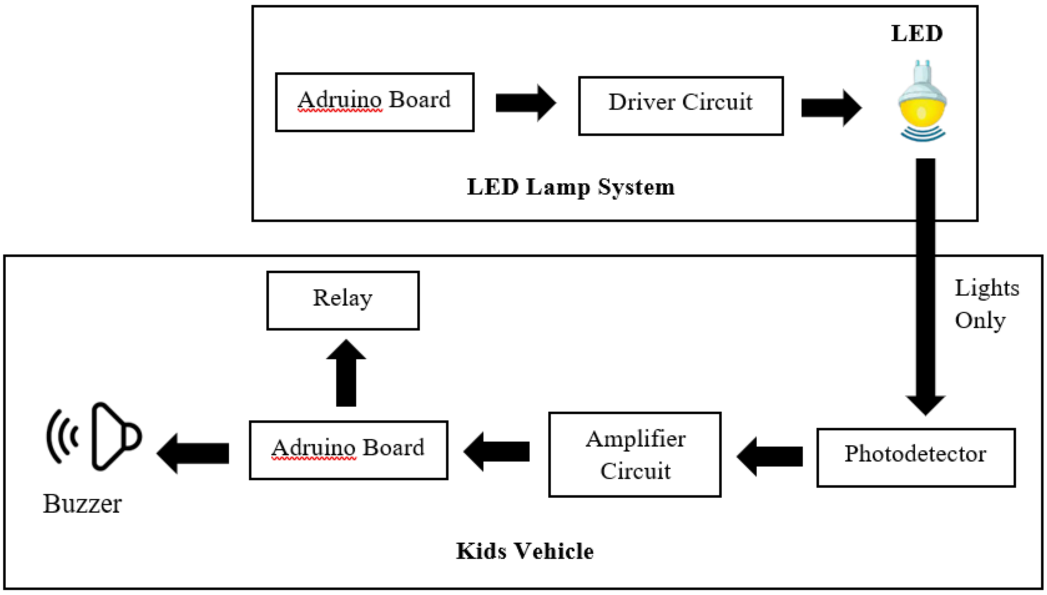

Figure 1: Block diagram of visible light fence system

Table 1: Explanation of hardware

No	Hardware	Description
1	Laptop	Dell, Intel Core i5 @2.60Ghz 8 Gb Ram
2	Arduino UNO R3	The Arduino Uno is a microcontroller board that uses the ATmega328. It has a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It also has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analogue inputs).
3	LDR Sensor Module	The LDR sensor module is used to detect light intensity. It's wired to the board's analogue and digital output pins, which are labelled AO and DO, respectively. When there is light, according to the brightness of light, the resistance of the LDR will become low. The LDR resistance decreases as the light intensity increases. The LDR's sensitivity to light can be adjusted using a potentiometer knob on the sensor.
4	Jumper wire	An electrical wire with a connector or pin on each end, or a group of them in a cable.
5	Breadboard	A breadboard is a solderless device used to prototype electronics and test circuit designs on a temporary basis.
6	White LED	In almost all lighting applications, including indoor lighting, street lighting and flood lighting, white light emitting LEDs are now used. White LEDs have become omnipresent.
7	Buzzer	The buzzer can be used by simply connecting it to a DC power supply between 4 and 9 volts. Normally used in conjunction with a switching circuit to turn ON or OFF the buzzer at a predetermined time and interval.

2.2 Flow chart Operation

Firstly, an 8 bits length code is generated by Arduino 1. The example of generated code is '0-1-0-0-0-0-0-1-0-1' in binary format. This code sequence is used to modulate a LED based on OOK modulation. In OOK modulation, binary '0' represents by LED off state and binary '1' represents by LED on state. Since the LED can switch on and off more than a thousand times per second depending on the speed of the code sequence. If the speed is low, LED blinking can be observed and this is not suitable for the normal illumination concept. Selection of speed is very important so that LED blinking cannot be detected by the human eye. Therefore, speed of code sequence must be set properly in this development so that LED blinking not happen.

At the receiver, a photodetector or LDR are used to detect light that contain the code sequence. If the LDR detects that light from the LED, the LDR circuit produces a signal and Arduino 2 process the signal based on digital signal processing concept through analog input. In this system, when the code that was sent is recovered less than 2 times in 3 seconds, the buzzer will be turned on. It means, the kid vehicles is outside the prescribed region. If the recovered code is 2 times or more, the buzzer will be turned off. The process of detecting the code is a continuous process as long as the manual switch of the kid vehicle is on. The flow chart operation is shown in Figure 2.

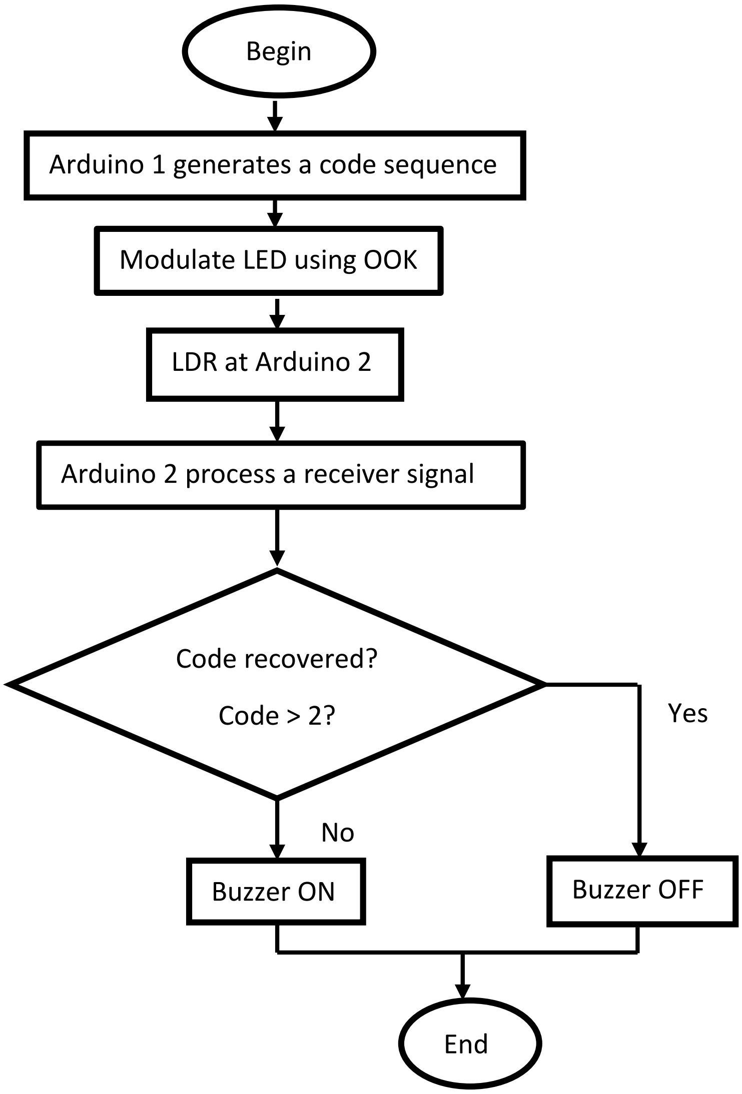

Figure 2: Flow chart operation

2.3 Circuit Design and connection

The software that has been used for designing Figure 3 is Fritzing. In this project, two circuits are used which is transmitter circuit and receiver circuit. For the transmitter circuit, the connection between the Arduino UNO R3 and LED via jumper wire. The pins that have been used are pin D13 and GND. While for the receiver circuit, the connection between another Arduino UNO R3 and LDR sensor module is connected by using a jumper wire. The pins that have been used is A0, 5V and GND.

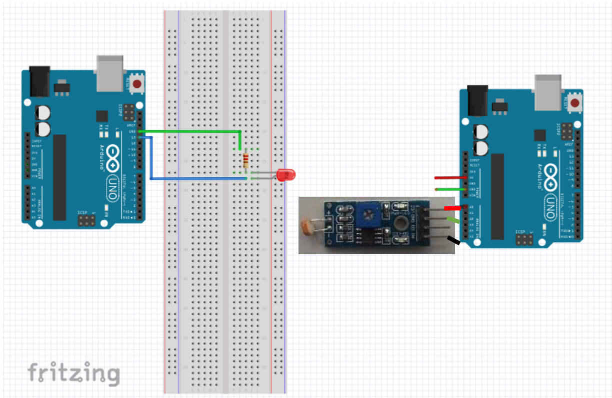

Figure 3: The circuit diagram of the visible light system

3. Results and Discussion

First of all, two Arduino boards are connected with a different electronic components which is one with LEDs and another one with an LDR sensor module. Each board is connected to an external laptop through a USB port, and a specific coding was written and uploaded to the board using the Arduino IDE.

Finally, the laptop was used to convey information back and forth between the Arduino boards or to diagnose their status when the software runs on the Arduino boards. Figure 4 shows an image of the various hardware components assembled.

Figure 4: Hardware components scheme

In order to try out whether the communication system worked or not, a binary string was chosen: 0-1-0-0-0-0-0-1-0-1. If the output of the serial monitor is the same string, the experiment was considered to be successful.

3.1 Prototype design for the system

After the circuits have been successfully tested, the software and hardware are combined to build a small scale prototype visible light fence system for kid vehicles. The prototype was tested to detect and read the 8 bits code word in the LED light. The size for this prototype is 68 x 17 x 57 cm and for the kid vehicle is 19 x 4 x 8 cm.

After the transmitter code is uploaded in Arduino 1, the LEDs is not blinking and have that code. The Arduino 1 generates a code to modulate the LEDs and the embedded code with light represents a VLC light fence. Figure 5 shows the prototype setup between the transmitter and receiver circuit when the LDR sensor board is exposed to visible light. The LEDs on top of the roof was connected with Arduino 1. In order to test the developed prototype, Arduino 2 together with the LDR sensor has been attached to the kid vehicle. The distance between the LDR sensor on the kid vehicle and LEDs are 5 cm and 7 cm to detect the light.

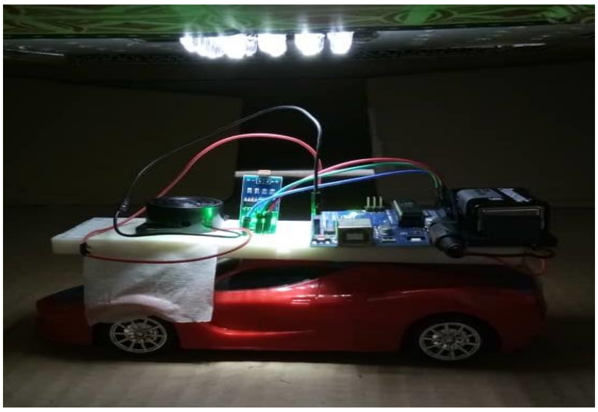

Figure 5: Prototype when LDR sensor was exposed to visible light

In order to recover the code from the LEDs, the received signal is compared with the threshold value in Arduino 2. For the distance of 5 cm, the threshold value is 180 and at the distance of 7 cm, the threshold value is 190. The threshold that has to be taken into account is related to ambient light. The brighter that one is, the harder it will be for the LDR to differentiate it from an LED signal. Also, if the received code is less than 2, the buzzer will be on. So, for this experiment, when the vehicle moves within the light beam that has the code and detect more than 2 code, the buzzer will be off. Figure 6 and Figure 7 show the received signal at a distance 5 cm and 7 cm when exposed to visible light. The x-axis represents the samples that have been collected which are 200 samples. The y-axis represents the amplitude (decimal value) of the received signal. The Arduino 2 evaluates the received signal with the threshold value and produce the binary code sequence. The binary code sequence at 5 cm and 7 cm are shown in Figure 8 and Figure 9. In 200 samples that have been captured, incorrect code or error will be obtained due to system imperfection. Therefore, the recovered code is calculated in Arduino 2. Figure 10 and Figure 11 show the number of recovered codes in 200 samples.

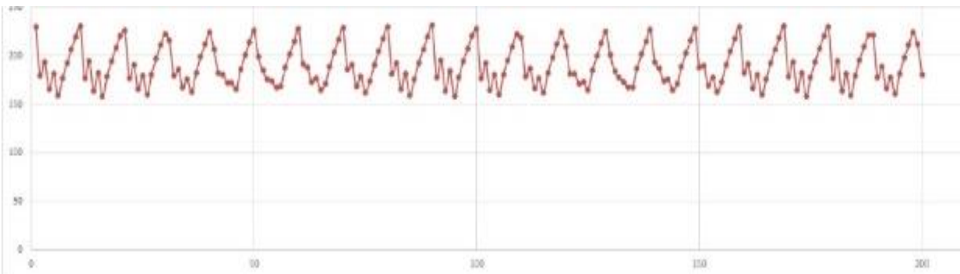

Figure 6: The received signal at 5 cm

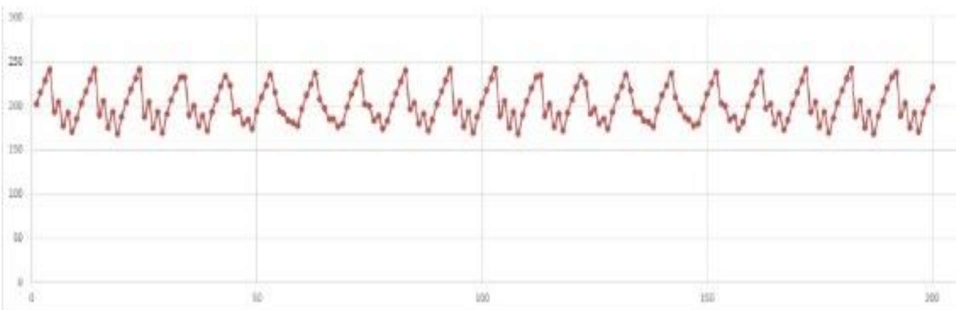

Figure 7: The received signal at 7cm

Figure 8: Binary code sequence at 5 cm

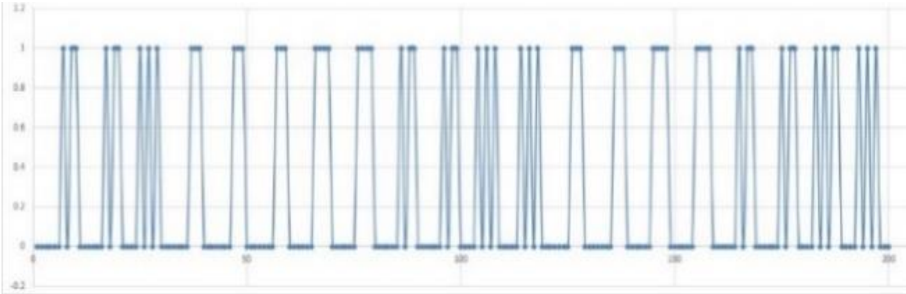

Figure 9: Binary code sequence at 7 cm

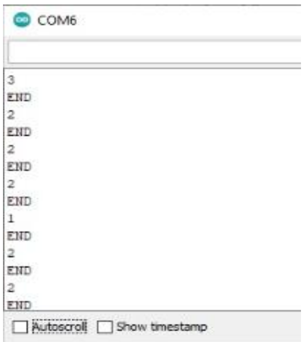

Figure 10: Data count at 5 cm

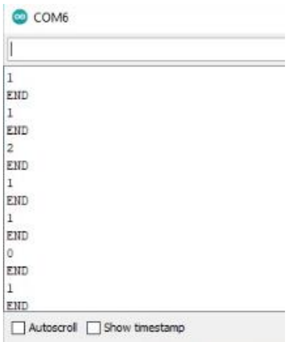

Figure 11: Data count at 7 cm

Testing setup when kid vehicle is not exposed to visible light as shown in Figure 12. If the vehicle moves to areas where there is no light with code, the buzzer will sound. Figure 13 and Figure 14 show the received signal and the recovered code count when kid vehicle is not exposed to visible light.

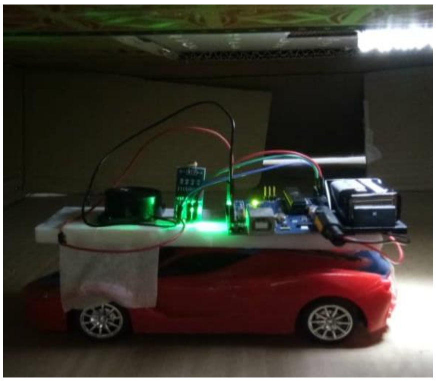

Figure 12: Testing setup when kid vehicle is not exposed to visible light

When the vehicle move to areas where is no light with code, the buzzer will sound. Figure 13 and Figure 14 show the analog data and data count when LDR not exposed to visible light.

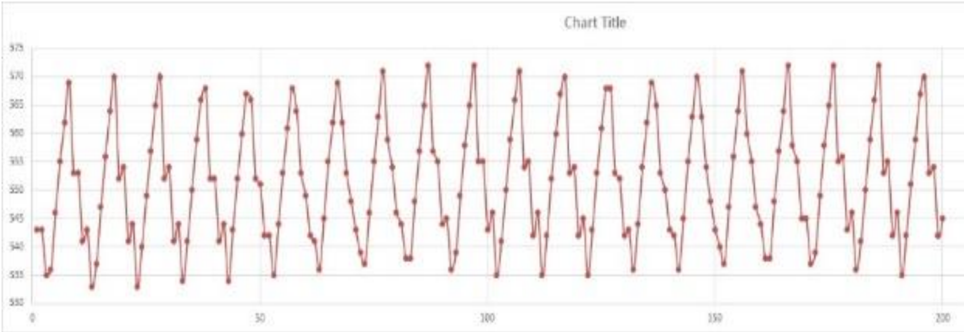

Figure 13: Received signal

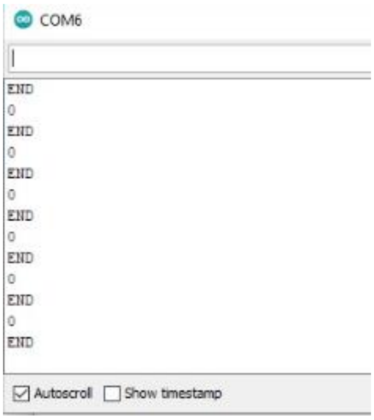

Figure 14: Recovered code count

The experiment's programming code was rather easy because it only had to receive a binary input signal, give it an OOK modulation. Detect these signals using an LDR module on the other Arduino, then demodulate the message to retrieve back the original string.

Based on the result of this project, a buzzer will be off when the LDR sensor can detect the light that has the code and had more than 2 code. Hence, the objective for this project is also achieved where this visible light fence system can functioning and can ease the user or parents to monitor their kids in shopping malls, resident or nursery.

4. Conclusion and future works

As stated in the title, this project utilizes VLC technology with Arduino capability. Thus, with the implementation of Arduino, the developed prototype can detect visible light code as virtual fence. This system has been developed to help out the parents and playground guard to monitoring their kids without worrying.

There are some of this project can be upgraded. Firstly, the system itself can be upgraded to a larger scale. Since this project develops a small scale prototype, several recommendations to upgrade the idea are identified for future work. Firstly, the system itself can be upgraded to a larger scale for making the system into commercialize product. Next, since this prototype used normal LEDs. Thus, upgrading the system to be more capable should be considered. For example, by using Surface Mount Device (SMD) LED which can make the lighting brighter. In addition, by using IoT system such as GSM module that can send the notification or message to parents or indoor playground guard if the vehicles are out of the area. This could lead the prototype to be more versatile.

Acknowledgement

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