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Navigation Aid for Blind People

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ABSTRACT

Globally blind and partially sighted people had the limited freedom to move forward alone outside of their residence due to some limitation of their supported guideline. But the time has been change and their supported guideline also improving day by day. In this paper proposed some logical technological idea which is implementable for making them more independence in outside environment. Two ultrasonic sensors will give the position (left or right) of the obstacle and LIDAR lite indicates them staircase and small height object through recognizable feedback through vibration motor and buzzer. Push button switch for SMS/call sending system help them to inform their family member in emergency situation. With the help of color sensor one specific line followed by them with predefine color will help them to go near buss top or shop which is very close to their house. For security issue a wireless door lock switch is placed on the stick. Identify their house door a color circle also recommended to fix in front of their house door. The main aim of this work is make their lifestyle smooth with the help of updated technology.

Keywords: *Navigation stick, obstacles detector, color detector, emergency communication, secure house.*

1. INTRODUCTION

There were many related work done by others related to navigation stick for blind people, which can detect obstacles and give some feedback to avoid obstacles for better walking. In addition, some of these sticks also ensure the safety and security for that people in any emergency situations. Time to time those technologies included or improved some of its features to make it more accurate and reliable. All these works mainly based on the several sensors which are more efficient now days. NavBelt was a device, which is like a belt to ware in waist. It was based on advanced mobile robot obstacle avoidance technology which warns the blind through stereo headphones by providing audio signals to guide the blind person on their environment. But the limitation of the system was difficult to follow the instruction in fast walking time and Eight ultrasonic sensor placated in the belt only for obstacle detection. Feedback method only stereo phonic headphones which is difficult who have hearing problem. The system doesn't have small height obstacle identification method [1]. "Blind Assist" project was based on ATOM processor (controller) includes ultrasonic sensor, Bluetooth, GSM internet and GPS. From that device the user will get feedback about the obstacle, acknowledgement for request, update of time and date, and also low battery notification [2]. But the drawback of the system was not possible to identify the position of the obstacle by using this system. So user cannot estimate the distance of the obstacles. In secure navigation system was mainly designed to avoid obstacles near to head. Hence the other part of the body remains unprotected [3]. In intelligent walking stick was based on four main modules, consist of PCB unit and RFID sensor, visually impaired persons android application, server, and monitoring user android application. Like the Blind assist device it is also have the same limitation, which is distance measurement between user and obstacles [4]. Navigation tool for blinds which was used text to speech or speech to text algorithm technique and image processing technique. The system can identify those objects which have predefined in the system only. Not identify the disturbance position [5]. Advanced guide cane device was based on GPS base navigation system and obstacles detection by using ultrasonic sensors. GPS navigation method is pre-program for specific area which compares the live data with it. The limitation of the system did not identify the position of the obstacle. Feedback method is only voice feedback (ear-piece is connected) which have problem with noisy environment [6]. The blind guide was design for outdoor navigation application based on the android mobile application and GPS. It can make a shortest path by talking targeted destination from the blind user, detect obstacle on the user and also give guide line to the user to the target destination. But it has the limitation to identify the position of the obstacle and cannot run without android mobile phone. If the server fails then all system will be fail, because obstacle information provide only through server [7]. Autonomous walking stick has the same problem like blind guide. That system cannot run without android mobile phone. Special mobile apps need to be developing for this purpose [8]. Recent research papers related to smart wireless networks and smart mechatronic devices are referred to in [9], [10], [11], and [12].

From those navigation aids found that most of the system have some special advantage but also have some limitations. Major problem is identifying the position of the coming obstacles in front of the user. Some navigation system using more sensors for only obstacle detection, no emergency contact system with their families, not recognize small height object. For reducing that problem, a special design crutches are introducing with more advantage by the help of few sensors. Only two sensors is using for detecting obstacle position and staircase (upper/lower/pothole) for reducing those problem. Obstacles identification feedback method change depends upon the user convenient. Color sensor for follow specific color line, push button SMS module and security purpose a door lock/unlock switch is more convenient, which is not available other crutches.

2. SYSTEM DESCRIPTION

2.1 System Overview

Simple block diagram of every systems are combined together to make a complete structure of the device. Figure 2.1 shows the functional block diagram of the overall system. From this diagram it is easy to realize how the system is connected with a central controller and individual functions of each section.

More elaborately, step by step internal functions of each section are indicated also interface with Arduino shown with feedback connections. The main system stands for four subsystems i.e. a) ultrasonic unit, b) LIDAR lite, c) color sensing unit and d) GSM module. All of the systems are synchronous triggered by Arduino. It is also give feedback to the user by depend upon some special algorithms for each. The door lock are not includes in this diagrams as because it’s an independent device means it can operate without any help of Arduino. To get more precious understanding of the working flow of the system a flowchart is shown in Figure 2.2.

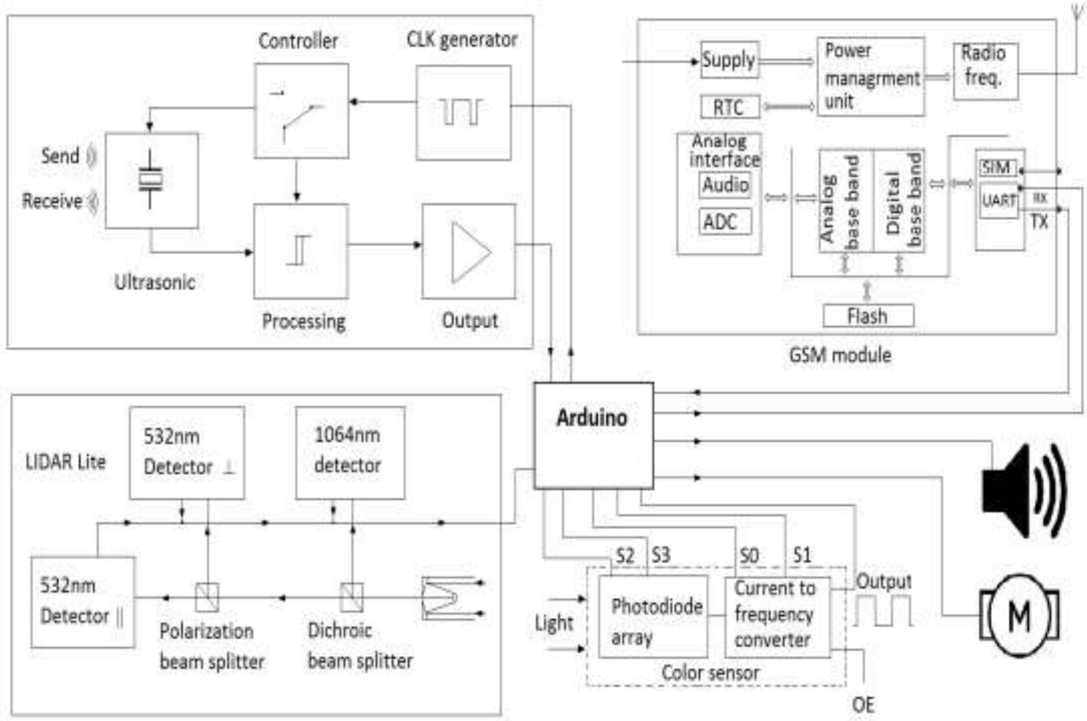


Figure 2.1 Functional block diagram of the system

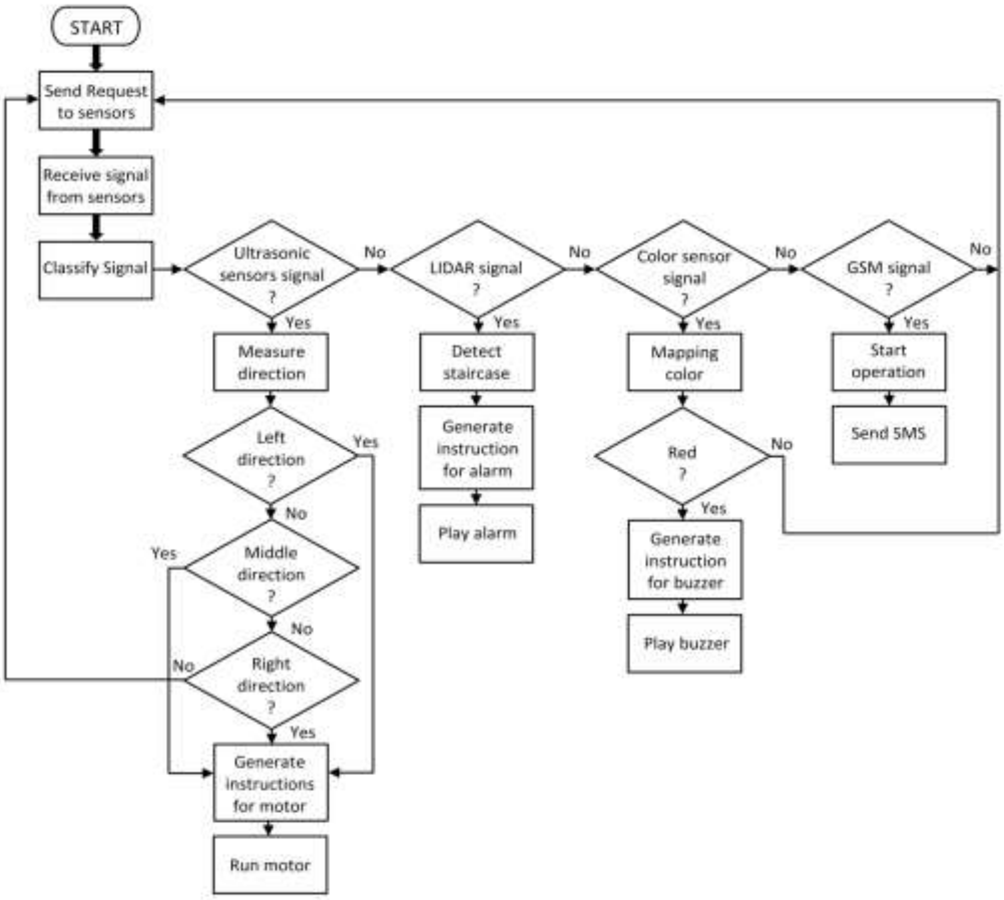


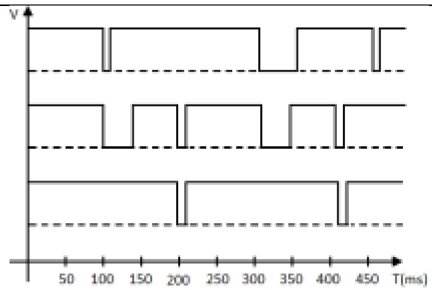
Figure 2.2 Flowchart of the system

2.2 Sensor working system

2.2.1 Ultrasonic for detecting long distance obstacles

The ultrasonic module HC-SR 04 can be able to measure the object distance from (2-400) cm and the accuracy level up to 3 mm can be achievable. It gives a better result up to 30 degree angle for identify the position of the obstacle from the sensors. Two ultrasonic sensors are used for getting the proper direction and position of the incoming obstacles. The transmitter of ultrasonic sensors is produce ultrasonic sound wave and receiver will detect that wave reflect back when obstacles come across in the range of it. After receiving the receiver converts those echo pulse into electrical signals. When one pulse spread over air then the second pulse will transmitted, but the cycle period of the pulse can be define in the sensors. Distance of the obstacle is proportional to the echo pulse width. By depend on the distance of the disturbance the microcontroller will generate corresponding vibrations for motor. Table 2.1 shows the different vibration cases for separate distance and direction.

Table 2.1 Case for vibration motor

Cases	Condition	Obstacle position	Pulse for motor Feedback
Case 1	Distance between 30cm to 100cm from left ultrasonic	Obstacles from left	
Case 2	Distance between 30cm to 100cm from right ultrasonic	Obstacle from right	
Case 3	Distance between 30cm to 100cm from both ultrasonic	Obstacle from middle	

2.2.2 LIDAR lite for short distance obstacles detection

LIDAR is a sensor based on laser lite reflection technique. LIDAR can be implementing with PWM or standard 12C in communication and it can be measure distance of obstacles up to 40 m under typical environment. Also capable to read 500 times per second and provide very good regulation from the scanning object. At first the LIDAR transmit laser pulse to the surface and the time is recorded at the same time. Then the reflection pulses time from the receiver is also recorded.

The distance can be calculated by the constant speed of light and the delay time. The LIDAR is fixed to the crutches as normally 52 degree angle with respect to the ground axis for detecting objects nearby it. For LIDAR currently we have defined only two cases for special alarming and it represents in the table 2.2.

Table 2.1 Case for buzzer alarming

Cases	LIDAR echo pulse duration	Detection result	Feedback
Case1	Value between 75 to 100	No obstacle/ no stairs (upper or lower)	No alarming
Else	Values except 75 to 100	Obstacles detected / stairs (upper or lower)	Continuous alarming

2.2.3 Working principle of color detection system

TCS 3200 module is a color detecting device which can detect visible color within boundless range. It has photo detector array and each have either red filter, green filter or blue filter or without filter. The filter for every colors are distributed in a way so that, it can bias among the colors to eradicate the location. Inside the sensor an oscillator is connected to get output in a squire wave form and the relation between the frequency and intensity of the selected color is proportional. Those unique square wave signals now feed to Arduino to identify the color and its intensity. It contains an array of photodiodes with four different filters which are sensitive to specific color wavelength. For detect the intensity of different colors need to choosing the photodiode filter and their readings. A buzzer is attached to the microcontroller for giving feedback at the presence of predefines color wavelength frequency in range. Filter selection of color sensor and Frequency scaling of color sensor are shown in table 2.3 and 2.4.

Table 2.3 Filter selection method for color sensor

Selector		**Type of photodiode**
S2	**S3**	
Low	Low	Red
Low	High	Blue
High	Low	No filter (clear)
High	High	Green

Table 2.2 Frequency selection method for color sensor

Selector		**Output frequency scaling**
S0	**S1**	
L	L	Power down
L	H	2 %
H	L	20 %
H	H	100 %

After configuring the filters and scaling the frequency, the output frequency from sensor can analyze and detect the corresponding color through Arduino coding. The serial monitor in Arduino application shows different frequency values (some certain range) for red, blue and green color. For a specific distance between sensors to object color, it is possible to find the frequency range for the certain color. When the sensor face any color, it produce its corresponding value based on that color which is compared with predefine values in order to identify the actual color in front of it. The microcontroller give feedback to a buzzer when the value in desired range representing the presence of particular color.

2.2.4 Emergency messaging system

SIM 900 provides a compact wireless communication system using Arduino AT command. It is also friendly for all Arduino model and others microcontroller. Basically GPRS provide a communication media through the GSM cell phone network. This module communicates through AT commands and sends SMS, MMS, GPRS, Phone call and Audio. It has 12 GPIOs, ADC and 2 PWM. Through a push switch, GSM module and Arduino SMS or phone call will be send in a predefine number.

Connections between Arduino and SIM 900 GSM module with switch are shown in Figure 3.9. For this purpose the SIM card should be unlock before insert into the GSM module. The important term for the GSM shield needs to provide recommended power supply for proper operation, because the power could not be collected from Arduino. It's possible to check the status through serial monitor. For sending SMS, a button is defined in the system.

2.2.5 Door locking system

Simply door will open and close by using wireless switch which is based on infrared ray (IR) technology. Here LED is transmitting the infrared ray with a specific wavelength. The circuit diagram of transmitter is shown in Figure 2.4. IR transmitted signal will received by an IR receiver (TSOP38238). IR receiver module used for infrared remote control system where a PIN diode and preamplifier also used on the LED including an IR filter. This signal now transferred to a decade counter (CD4017), which is usually used for low range counting purpose. Based on the count a timer (NE555) can generate monostable clock pulse. Two timers IC generate two different pulses according to the input from counter. This monostable pulses send the signal for the motor driver (L293D) to run it either forward or reverse direction. L293D is an integrated motor driver contains two H-bridge circuit inbuilt which can drive two DC motor simultaneously (forward and reverse direction). The rotation of the motor can move a rod called lock back and forth with the help of a linear gear attached with its rotor gear. If the motor is run forward, the door will locked else if the motor is rotates other direction the door will open. Figure 2.3 shows the receiver circuit diagram of moor rotation control.

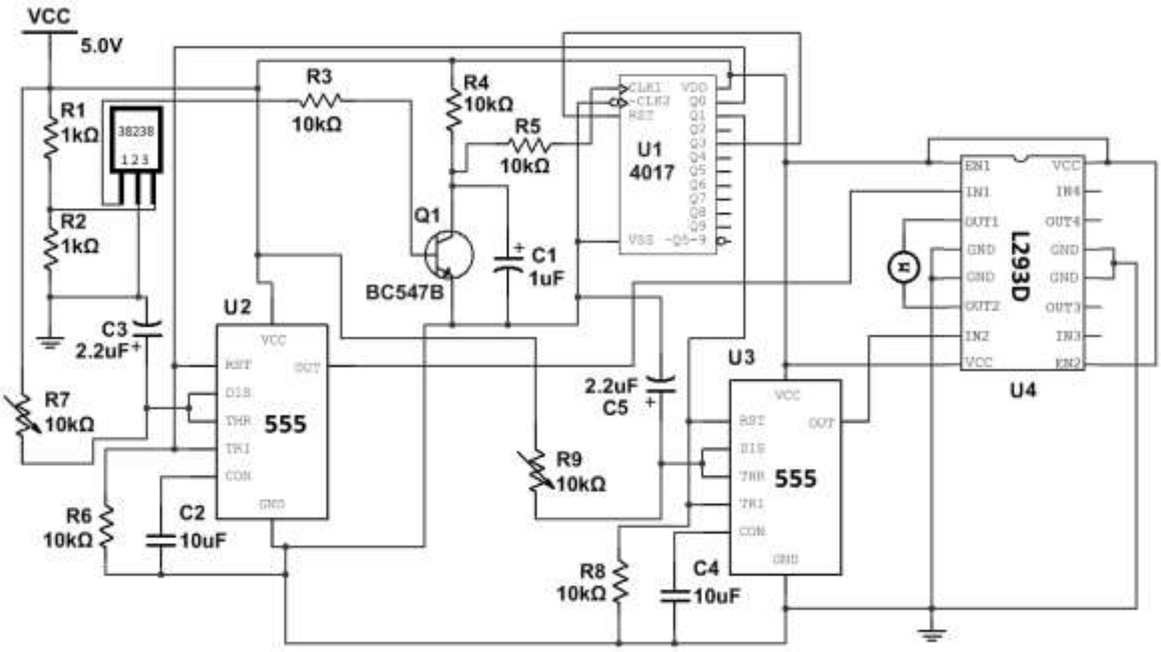


Figure 2.3 Receiver circuit diagram of moor rotation control

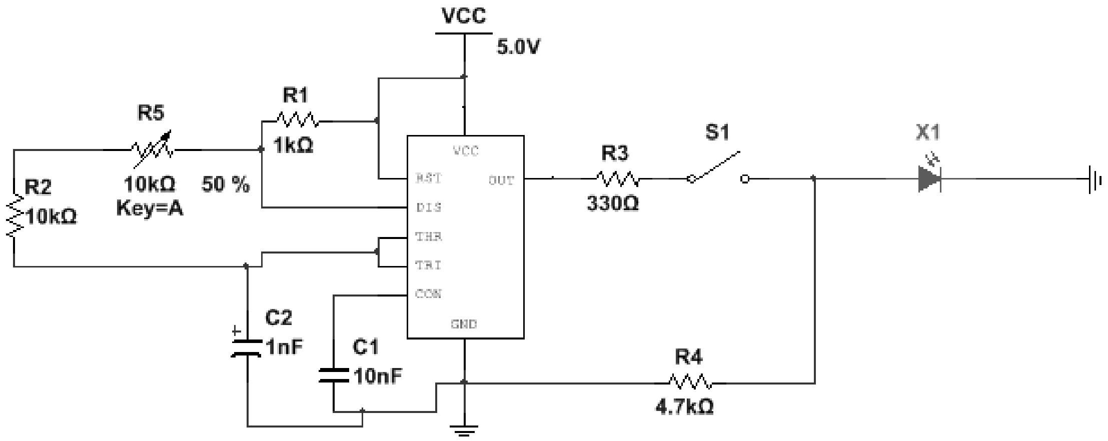


Figure 2.4 Circuit diagram of IR transmitter

2.3 Analysis

2.3.1 Output analysis of ultrasonic sensors

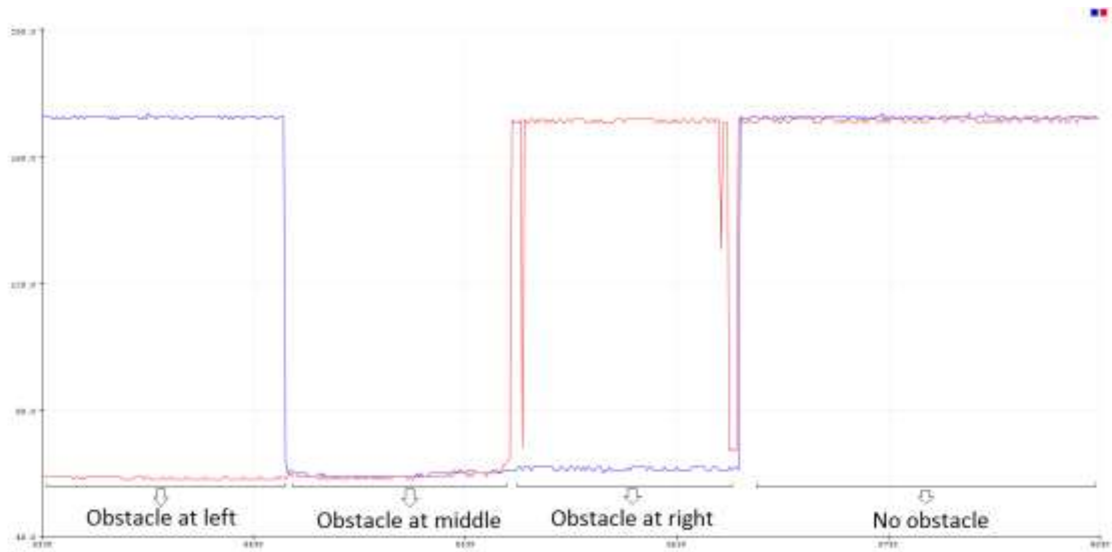


Figure 2.5 Serial plotter for ultrasonic sensor for obstacles distance at 60 cm

Above Figure 2.5 illustrate the presence of obstacles distance from 60 cm from the crutches, where red color wave represent obstacles coming from the left and blue color wave represent obstacles from right sensor. If there are no obstacle then both sensors output will high. In this case, when the sensors are getting obstacles on left or right side in range, then the value of that sensor decreases dramatically from 175cm to 60cm. If both sensors are getting obstacle that means it stands on middle position, for that the value of both sensor almost same and it is near 60cm.

For getting better results transmitters of the both sensors should be near and receivers should be far from each other. This is because if left sensor transmitter and right sensor receiver place closer, then the left sensor transmitted signal has the possibility to work like input for both sensors. Another way for getting better result is placement of sensor in slight angle with respect to middle position of the both sensors. Furthermore, from those above practical measurements it is found that, the better result was for closer distance of the crutches. Although in long distance range the sensor can recognize it, but closer distance is more accurate than far distance obstacles.

2.3.2 Analysis of LIDAR lite output

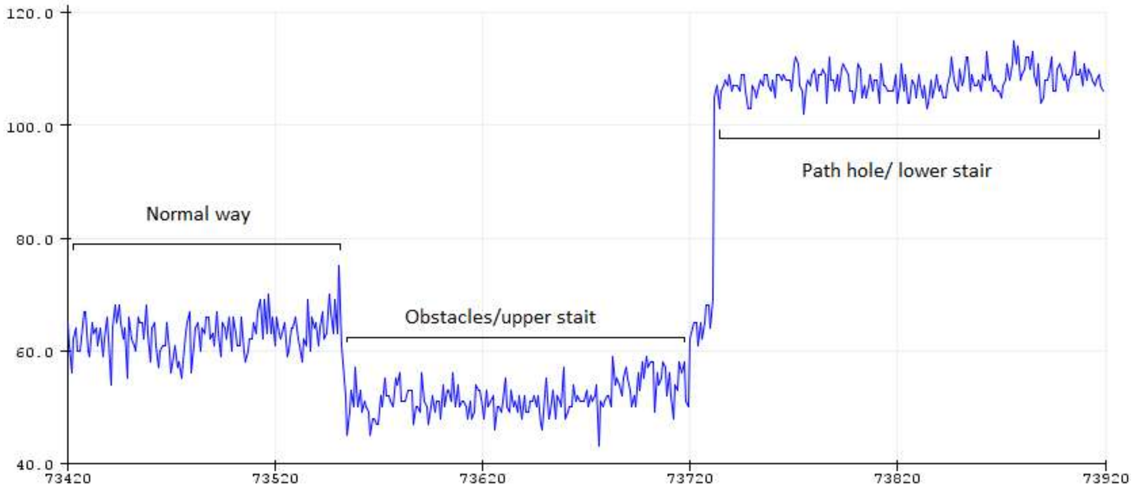


Figure 2.6 Serial plotter for small height obstacles or pothole at 31.58 degree

From the above Figure 2.6, a significant change observed when the sensor getting downstairs or path hole in front of it. In normal way when the signal corresponding echo pulse is close to 90 but, for the small height obstacle or upper staircase it decline to almost 50. If the lower stair or pothole found then it changes dramatically. Operating angle verses distance triangle of LIDAR for 31.580 is shown in Figure 2.7. Table 2.5 shows LIDAR angle and obstacle/pothole detection abilities up to maximum distance. Angle verses distance of LIDAR relationship graph shown in figure 2.8.

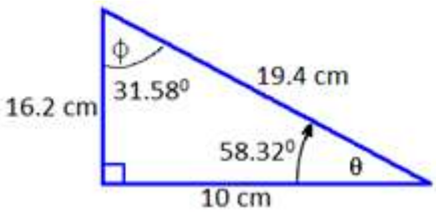


Figure 2.7 Operating angle verses distance triangle of LIDAR for 31.580

Table 2.5 LIDAR angle and obstacle/pothole detection abilities up to maximum distance

LIDAR angle	Maximum distance obstacle
31.58	10 cm
49.14	18.5 cm
54.72	22 cm
57.2	24 cm

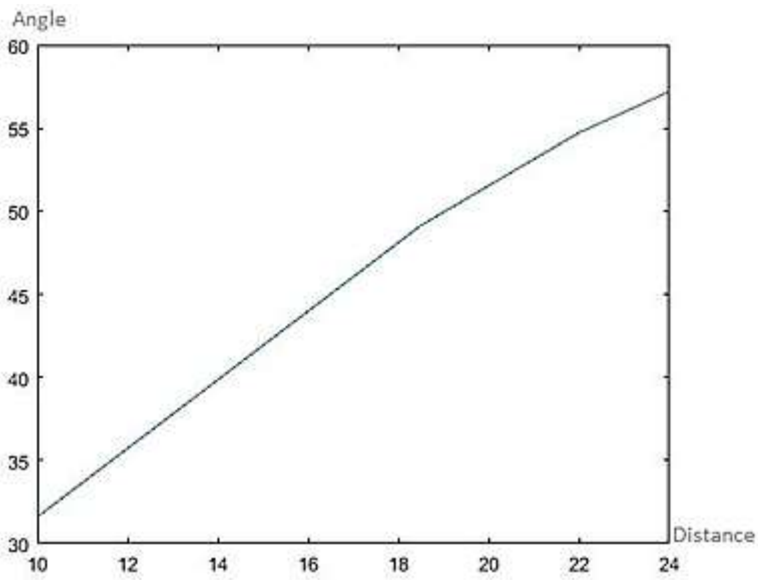


Figure 2.8 Angle verses distance of LIDAR relationship

From the table, it is found that LIDAR angle position is more important for the crutches. If the LIDAR angle is fixing at 30 degree then it can detect only very closer obstacle from the crutches and its value up to 10 cm from the crutches. For sensing obstacles closer than 20 cm distance the recommended angle is around 50 degree. Increasing the LIDAR angle it is possible to detect small height object from long distance.

2.3.3 Analysis of messaging system

To increase the efficiency and reduce power consumption of messaging system, the module should not be power on all the time, because for all time running GSM module needs continuous power which may the main cause for reducing battery life. As a result, the system needs to be design for overcome that problem. So the better solutions could be, after pressing the button, the GSM module will turn on automatically and send SMS to a predefine cell number, then after few second the module will turn off again. Appropriate rated power supply is more important for GSM module. The total process of sending SMS from Arduino serial monitor is shows in Figure 2.9.

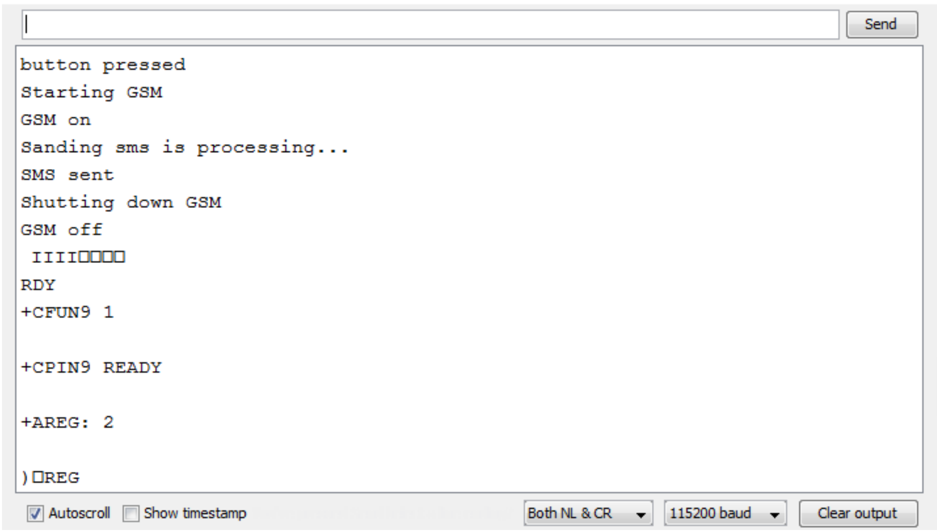


Figure 2.9 Arduino serial monitor status for sending SMS

2.3.4 Output analysis of color sensor

For calibrating the color sensor, it is require measuring the value from minimum 1 cm to maximum 3.5 cm from the sensor surface. The outputs of the sensor values represent corresponding time pulse (half) in micro second for each color. The serial monitor value for color mapping function from minimum to maximum is given below table 2.6.

Table 2.6 Output value of color sensor from 1 cm to 3.5 cm for mapping function

Color	Distance level	Value of Red	Value of Green	Value of Blue
Red	Minimum distance	28	130	100
	Maximum distance	167	786	640
Green	Minimum distance	82	53	84
	Maximum distance	436	330	556
Blue	Minimum distance	96	46	28
	Maximum distance	497	286	185

For distinguish between different color a RGB mapping function have built in the system (Called map ()). After setting that condition for specific color the sensor can detect the right object itself and shows the detected color in serial monitor. The system design such a way, if the sensor get only red color then it will give feedback through buzzer otherwise no feedback will be given.

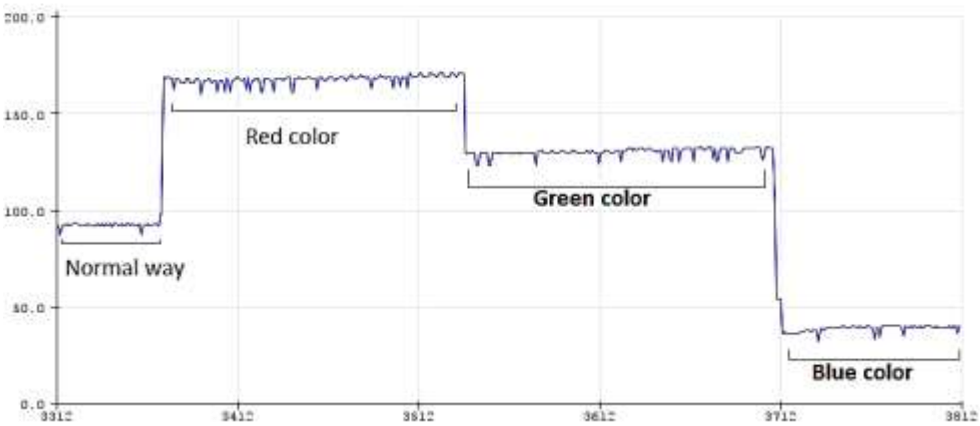


Figure 2.10 Serial plotter for distance 2 cm from color plane

Figure 2.10 show that, for 2 cm distances from the normal way (without red, green or blue color path) the corresponding wavelength is almost 90. The important change happened when the sensor fetches red, green or blue colors in front of it which is easily noticeable. For red, green and blue color the corresponding wavelength value is around 170, 130 and 40. Table 2.7 shows output values for different distance and colors.

Table 2.7 Output values of color sensor at different distance and different color

Distance	Normal way	Red color line	Green color line	Blue color line
2 cm	90	170	130	40
5 cm	500	1000	770	270
8.5 cm	1000	1800	1500	570
10 cm	1300	2200	1850	720
15 cm	2150	2950	2700	1300
20 cm	2500	3000	2800	1800

Graphically the comparison between each color characteristics depends on the distance is shown in Figure 2.11.

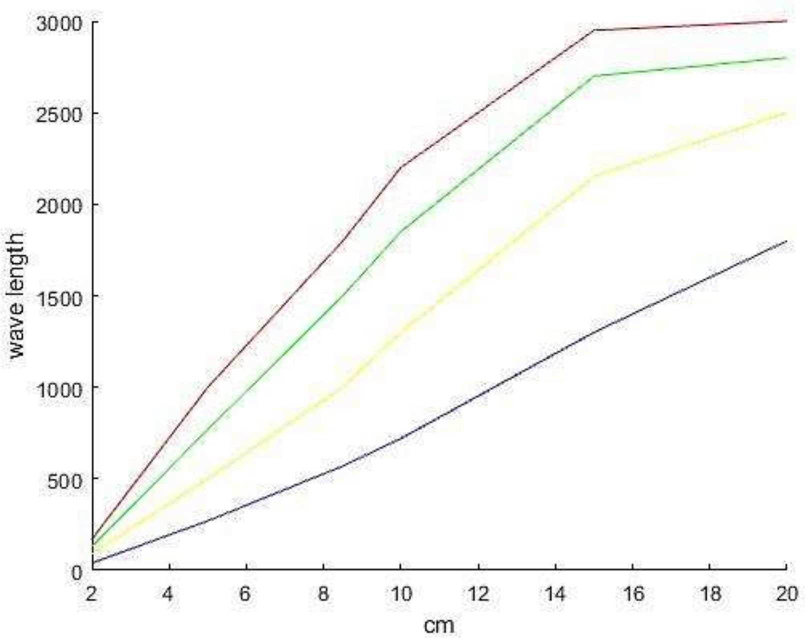


Figure 2.11 Characteristics of RGB colors with respect to distance

After analyzing the above results, it is found that the accuracy of the proper color detection is 2 cm up to 10 cm from the normal way. After 10 cm above from the ground, the sensor may not find any deference between red color and green color. But the blue color is detectable up to 20 cm from the surface.

2.3.5 Door lock motor rotation control

Basically rotor movement of motor depends on the pulse from the timer. Pulse duration can be calculated by the given formula.

Pulse duration (Tp) = 1.1 RTC2

Where, RT = R2 + R5 and C2 is triggering capacitor

Table 2.8 Angle and maximum working distance measurement practically

N.B.: Either R2 or R5 may be replaced with a variable resistor to tune the exact time of the timer hence motor rotations.

Table 2.8 Angle and maximum working distance measurement practically

Angle	**Maximum distance workability**
180°	253 cm
90°	320 cm
45°	258 cm
0° (face to face)	More than 18 m

From the experiment, it is found that the better performance is face to face position of LED and receiver. But in front of the door it work perfectly for any angle (0° to 180°) up to 250 cm distance.

2.3.6 Limitation of the study

The propose combination of several component might have possibilities to increase weight of the crutches. The accuracy of color sensor module will be affected in harsh weather (snow fall, dusty). All of these components may consume more power; as a result, the battery life cycle may affect

3. CONCLUSION

Travelling outside environment is more challenging for the blind people. This paper present some combination of existing technological, which are modifying for getting better support in walking time especially for the blind person. Firstly, here describe the major problem facing by them while movement. Secondly, find some general solution to reduce those difficulties. Thirdly proposed some required hardware components which is useable for the predefine problem solution. Fourthly, practical experiment and working principle are explained with easy way for the better understanding. Finally, output result investigation, find out limitation of the system and some recommendation are added for further development of the crutches. This work introduces a system design and smart concept which is simple and easy to understand for the blind people. Combination of different sensor and other device will ensure them more confident with proper identification and feedback in walking time. The proposed system design will secure them and their houses while going outside. The sensors and others device functionality can be modify for getting better performance of the crutches. Some of those technologies can be used for other disabilities person also for specific purpose.

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CONFLICT OF INTERESTS

I would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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