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Characteristics of different sensors used for Distance Measurement

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Abstract - *This paper demonstrates the characteristics of different sensors such as IR proximity sensor; Ultrasonic sensor and LASER sensor is defined by measuring the distance of obstacle avoidance. Each sensor has different behavior for its own characteristics. Both ultrasonic and IR sensor are low cost sensors. This paper compares the sensor features which are suitable for obstacle detection for both indoor and outdoor environment.*

Keywords: IR sensor, Ultrasonic sensor, LASER sensor, LDR Detector ARDUINO UNO board, LED, Luminous meter.

1. INTRODUCTION

Nowadays many different sensors are used for distance measurement. In this paper the three different sensor features are described by testing it with ARDUINO UNO board. The C code has written in ARDUINO IDE software to check the different sensors. Hence there were many research were done to maintain the safety of the vehicle like vision based technique by using cameras, laser ranging, IR sensors, sound sensors etc., were considered. The ultrasonic waves are sound waves that have the frequency above the limit of a human audibility. Experiments were conducted on different sensors with different distances. All the three sensors have different distance limitations. So, with different measurement, which sensor is suitable for obstacle detection and which is having the maximum distance limitation.

2. HARDWARE AND SOFTWARE COMPONENTS

2.1 IR Sensor

IR sensor consists of two elements I.e. IR source, IR detector. Infrared source includes an LED and infrared detector includes photodiodes. The IR LED looks like normal LED but its radiation is invisible to human eye. The IR transmitter can be constructed using an IR LED current limiting resistor and power supply. The IR sensor is as shown in fig 1[1].

The principle of IR sensor as shown in fig 2 and The IR sensor works as an object detection sensor that consists of IR LED, IR photodiode together, they are called as photo coupler or opto coupler. Now the IR transmitter emits radiation and falls on the object [2]. The object reflects some of the radiation back to the IR receiver or IR detector. Based on the intensity of the reflected signal the output of the sensor is defined [3]. In theoretical this IR sensor distance ranges up to 30cm and operating voltage is 5V.

Fig-1: IR Sensor (FC 51)

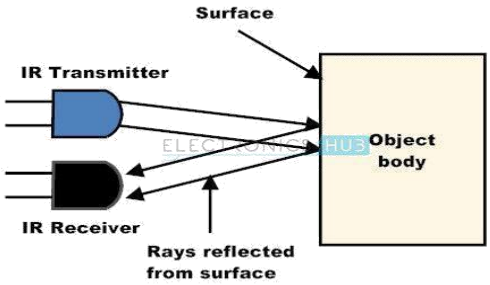

Fig-2: Working principle of IR sensor

2.2 Ultrasonic Sensor

Ultrasonic sensor (HC-SR04) utilizes sonar to measure the range of an object. Its range is to find the distance of any object from 2cm to 400cm. This sensor uses sonar to detect the objects. This sensor widely used in robotics to build the robots, aircrafts, in order to avoid the obstacle. The hardware component consists of both ultrasonic transmitter and receiver module. The sensor module consists of 4 pins namely: trigger, echo, power supply and ground.

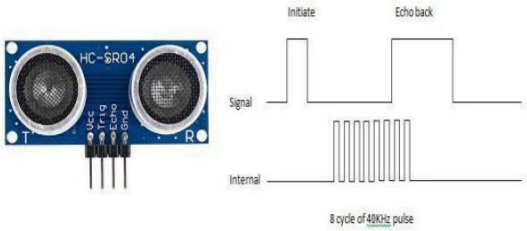

Fig-3: (a) Ultrasonic sensor HC-SR04, (b) Working principle of Ultrasonic Sensor [3]

The figure 3 shows ultrasonic image and working principle of ultrasonic sensor. The distance between the source and target of echo pin and time taken to reflect back from echo pin considered. The ultrasonic sensor requires a pulse of high (5V) for 10µS. This sequentially initiates the ultrasonic sensor and it sends 8 cycles of 40 kHz. Then, it waits to receive the reflected ultrasonic signal from the obstacle [4]. To obtain the distance of the object the width of echo pin is measured as follows: Time=Width of Echo pulse in microseconds or the speed of the sound may also be considered.

- Distance in centimeters = Time / 58,
- Distance in inches= Time / 148.

2.3 LASER Sensor

The LASER sensor (KY-008) gives a small intern beam or emits a dot shaped, red laser beam. The figure 4 shows laser sensor. This module has three pins i.e. From left to right pin 1 is signal output, pin number 2 is +5 volts (DC), and pin 3 is GND. Using this system, we have experimented a laser sensor which has both transmitter and receiver units into one module [5]. This sensor theoretically measures up to 1000 cm or 10000 mm.

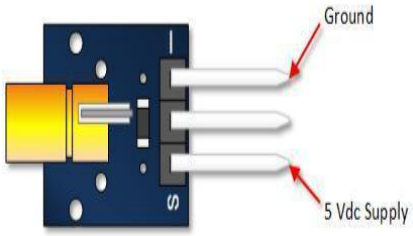

Fig-4: Laser sensor (KY008)

Laser is basically concentrated on light source. LDR detector (Light Dependent Resistor), Photo diode & photo transistors are used to detect lasers.

2.4 LDR detector

To detect a laser, a light dependent resistor (LDR) is needed [6]. An LDR is a device which has a resistance that varies according to the amount of light falling on its surface. The LDR detector is as shown in fig 5.

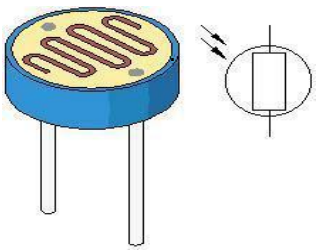

Fig-5: LDR and circuit symbol

When light hits the LDR, the LED will light up. The variable resistor is used to fine tune the amount of light needed to activate the LDR detector.

2.5 ARDUINO UNO Board

- **HARDWARE**

Arduino board designs use a variety of microprocessors and controllers. It consists of 14 input/output pins, 6 analog inputs, 16MHz crystal oscillators, USB connections, a power jack and reset button. The Arduino Uno is microcontroller is based on the Atmega328.

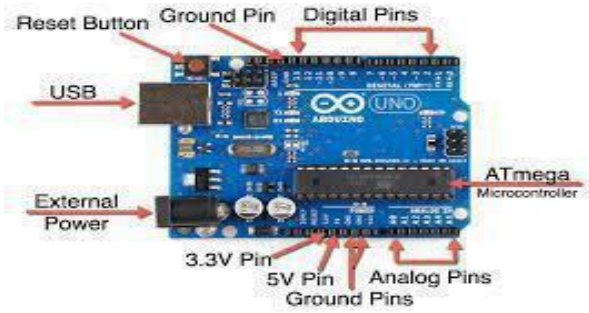

Fig-6: ARDUINO UNO board [6]

The Arduino Uno board is as shown in figure 6. The Arduino Uno can power via the USB connection or with an external power supply. However, the pin may supply less than 5V and the board may be unstable. If using more than 12V the voltage regulator may over heat and damage the board. The Arduino Uno power pins are Vin, 5V, 3V and GND.

- **SOFTWARE**

Arduino Uno is open source project to which any hobbyist can connect for Atmega chips. In this software code can be written in either c or java script. A program is written on the IDE Arduino is called a sketch.
Arduino programs are divided into 3 parts

- Structure
- Values
- Functions

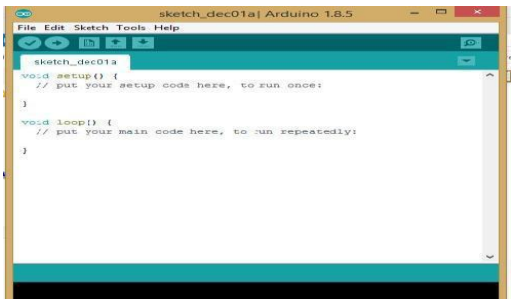

Fig-7: Sketch window for Arduino IDE

The fig 7 shows sketch window used to write the code for Arduino IDE. The header files can be included in this window [7]. The Arduino Uno board is renamed with a specified name and saved in the Arduino file. It is compiled, if any errors are occurred it is corrected and this corrected and this code is further uploaded to the Arduino Uno board [8].

3. IMPLENTATION OF SENSORS

The simple realization of all sensor work done by ARDUINO UNO with IDE software. The implementation process is mentioned below with all the sensors.

3.1 Implementation of Ultrasonic sensor

The below fig 8 shows the block diagram of Arduino Uno board is connected with ultrasonic sensor. Ultrasonic sensor sends the sound pulse through trig pin to an object and receives back from echo pin and passes to Arduino board.

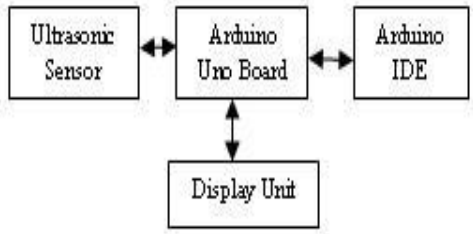

Fig-8: Block diagram of ultrasonic sensor

The algorithm has developed to find the distance of an obstacle in the IDE software. Once the algorithm is developed, the code is verified and uploaded to the board using IDE software. The LED is connected with Arduino to glow if any obstacle is present or not. In practical, the ultrasonic sensor measures the distance range up to 315 cm and the angle is 30 degree and operating voltage from 3.3V to 5V.

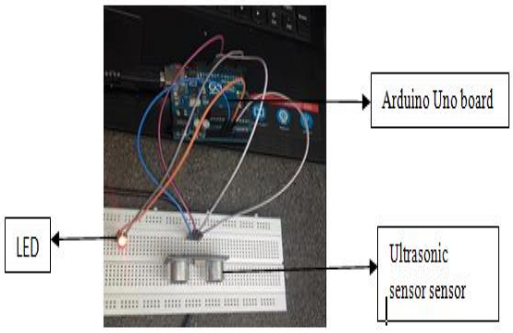

Fig-9: Experimental setup of ultrasonic sensor

3.2 Implementation of IR sensor

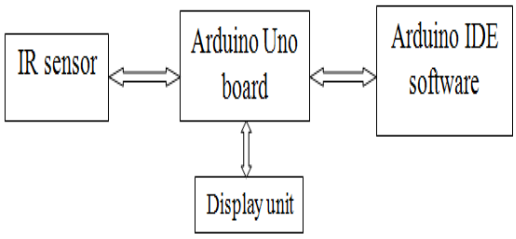

Fig -10: Block diagram of IR sensor

The below fig 10 shows block diagram of IR sensor and Arduino board. The IR sensor has both transmitter and receiver. Transmitter LED sends the signal which will find the obstacle and reflected back from the receiver LED. The below figure 11 shows an Experimental setup of IR sensor. The algorithm was developed for finding the distance of an object. The code was verified and uploaded through IDE software. The IR sensor measures the distance up to 30cm or 300mm and operating voltage from 3.3V to 5V.

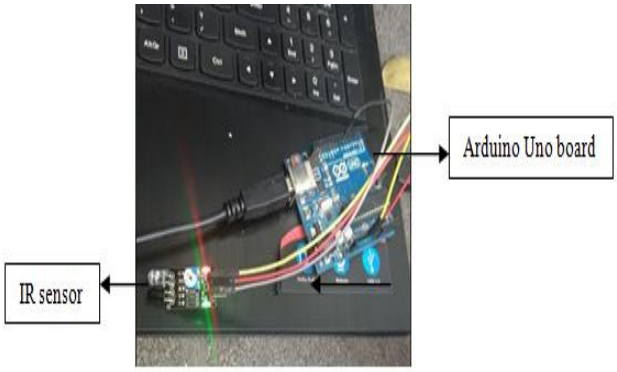

Fig-11: Experimental setup of IR sensor

3.3 Implementation of LASER sensor

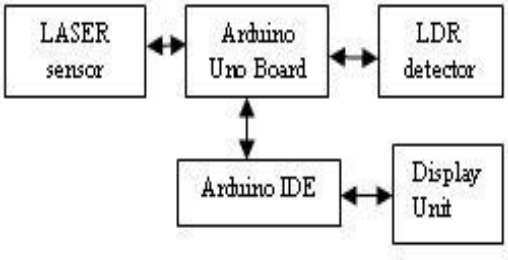

Fig-12: Block diagram of laser sensor

The above figure 12 shows block diagram of laser sensor using Arduino board. LASER sensor has both sensor and detector for finding the obstacle. The LASER light has to fall on the LDR detector.

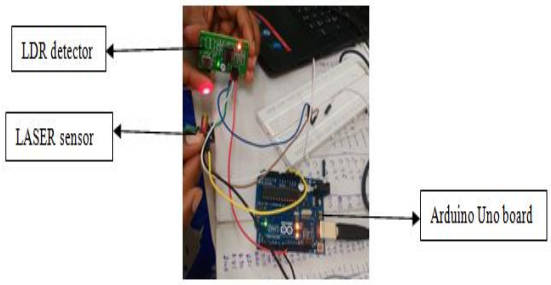

Fig-13: Experimental setup of LASER sensor

The figure 13 shows experimental setup of LASER sensor. This sensor gives digital output like 0 or 1. If the obstacle is present, the output will be 1 and if the obstacle is not present the output will be 0. The output is monitored through the serial monitor of the Arduino IDE software. The laser will not sense the obstacle in wider angle. It is a narrow angle detector. It measures the distance up to 1000cm or 10000mm.

The table 1 shows all sensors features like ultrasonic sensor, IR sensor, LASER sensor.

Table-1: Features of distance measurement sensors

Features	Ultrasonic sensor	IR sensor	LASER sensor
Model name	HCSR04	FC 51	KY008
Wavelength	75nm	700nm to 1mm	650nm
Power Delivered	+5 V DC	3.3V-5V	5V(DC)
Operational Current	15mA	at 3.3 V ,~23 mA at 5.0V: ~43 mA	30mA
Frequency	40KHz	35KHz	30 KHz
Efficient Angle	<15^0	<15^0	<15^0
Calculating Angle	30^0	45^0	0^0
Pulse Width of Trigger Input	10µS	-	+ve single TTL pulse
Aspect	45mm x 20mm x 15mm	4.5cm (L) x 1.4 cm (W) x 0.7cm (H)	18.5mm x 15mm

4. RESULTS AND DISCUSSION

The results were discussed by comparing all the sensors output with respect to distance for both indoor and outdoor environment. The light intensity is measured through the luminous meter (lux) for all the sensors with distance. The results were plotted.

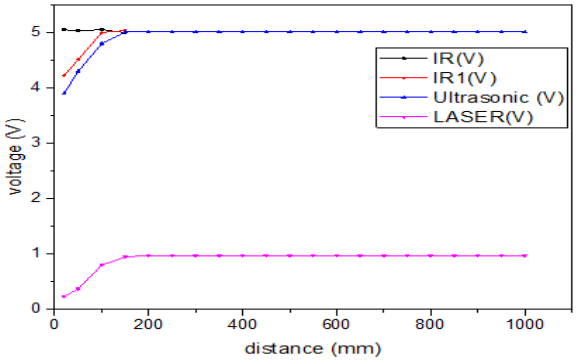

Chart-1: Distance measured with Voltage

The chart-1 shows the comparison of voltage and distance for all the three sensors. To check which sensor is more suitable for distance measurement, the light intensity is measured for both indoor and outdoor environment. So, those results show that the ultrasonic sensor is more suitable for both indoor and outdoor environment to measure the distance. With that value the results were plotted for both indoor and outdoor environment.

5. CONCLUSION

By comparing all the sensors this paper explained that ultrasonic sensor with respect to distance and voltage is more suitable for obstacle detection in quad copter for both indoor and outdoor environment. In practical the ultrasonic sensor measures up to 315 cm or 3150 mm with angle 30 degree. The disadvantages of IR sensor measured less distance and the LASER sensor measured up to 1000 cm, but the angle is narrow. To connect LASER sensor two Arduino board is required. Because of this reason the LASER sensor is less used for obstacle detection. So, compared to both IR and LASER sensor the Ultrasonic is more suitable for obstacle detection.

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