
Development of an Enhanced Obstacle Detection System Using Arduino Mega 2560

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ABSTRACT

This paper presents the development of an enhanced obstacle detection system using Arduino Mega 2560 embedded system development board and tools. The enhanced obstacle detection system consists of a HC-SR04 ultrasonic proximity sensor, an intelligent YJD1602A liquid crystal display (LCD), an electronic alarm system which incorporates a 25-Watt audio amplifier as well as an Arduino Mega 2560 development as the main interfacing platform. The obstacle detection is accomplished using the HC-SR04 ultrasonic proximity sensor. The performance of the proposed enhanced obstacle detection system has been verified as it has been able to measure and display the distances of objects (obstacles) with range from 0 to 4 meters with simultaneous triggering of the electronic alarm system when an object is detected while the alarm is off when no object is detected. The complete experimental setup and the computer program for the implementation of the enhanced obstacle system are presented. The proposed EOD system can be adapted and deployed for obstacle detection and avoidance system design for robotics and mechatronics applications.

Keywords: Arduino Mega2560, audio power amplifier, embedded system, enhanced obstacle detection (EOD), ultrasonic proximity sensor.

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1. Introduction

Ultrasonic proximity sensors are designed for non-contact measurement of distance and they are made of transmitter and receiver or transreceiver which is capable of transmitting and receiving ultrasonic sound. The essence is to measure the time of fly of ultrasonic wave from sensor to the target. The term "ultrasonic" applied to sound refers to anything above the frequencies of audible sound, and nominally includes anything over 20,000 Hz. Ultrasonic transmitter transmit at a frequency above 20 kHz in and at a speed of 344 m/s and the receiver receives the reflected sound from the target. The distance between the object and the transmitter is simply calculated by considering the time it takes for the ultrasonic wave to travel from the transmitter and be received back by the receiver [1–3].

Ultrasonic sensors are characterized by a low-cost and by the possibility of been used in environments and situations where it is not possible to use more complex sensors as cameras systems and laser systems [4–7]. While, ultrasonic proximity sensors are widely used in obstacle avoidance system; they are capable of performing distance measurement on transparent, shiny and dark surface objects. This ability allows ultrasonic to detect materials ranging from clear glass bottles to black rubber tyre. It can also work in tough environmental conditions such as noisy, dusty or dark areas. However, they do not function well with small targets against large backgrounds.

Different authors have analyzed the behavior of sonar sensors based on the time of flight evaluation for estimating the distance of the nearest objects [8–10]. In order to assist the visually impaired and blind pedestrian who need help of guidance, Nawer and co-worker [11] made use of an ultrasonic sensor to detect obstacles. The method employed allows the microcontroller to obtain information from the ultrasonic waves and then it alerts the blind pedestrian through voice messages.

Ultrasonic sensors have also been used in the robotic field, both in industrial applications and autonomous vehicle applications. In industrial applications, genetic algorithms such as neural networks are used in identifying objects found on conveyer belts, their orientation, and other features [12]. Brudka and Pacut [12] outlined a system which uses an array of 40 ultrasonic sensors in order to achieve high enough resolution. By using certain algorithms, inexpensive ultrasonic sensors can be used in controlled industrial applications.

In 2015, Saraswathi and co-workers [13] developed an obstacle detecting robot using arduino and sensor. The robot was made using IR sensor, wheel encoder and it was controlled by an arduino microcontroller. The IR sensor was attached to the front portion of the robot which senses the obstacles and navigates its pathway to choose an obstacle free path. The data collected from the sensor is compared by the microcontroller to decide the movement of the robot wheel.

The desired objective of this research is to develop an obstacle detecting system to detect an obstacle within a stipulated range and then give an alarm sound for notification. This paper attempts to: *1).* develop an obstacle detecting system that is capable of measuring the distance between objects and the ultrasonic sensor; *2).* develop an alarm system for alerting the user. The system comprises of HC-SR04 ultrasonic sensor, an arduino mega 2560 microcontroller, resistors, jumper wires, LEDs and buzzer. The ultrasonic sensor comprises of the transmitter and the receiver together. The transmitter sends the ultrasound wave to the surrounding. The ultrasonic receiver receives the reflected wave when the wave transmitted it's a target. The Arduino mega 2560 microcontroller processes all information received from the ultrasonic sensor and based on the input gives out the desired out. The LEDs are used as indicator to show if the target is within the stipulated range or not. The resistors are connected in series to the LEDs to limit the current in LED to a safe value.

Table 1: The enhanced obstacle detection system nomenclatures and parameter definitions

Parameters	Definition	Parameters	Definition
LED	Light emitting diode	AC	Alternating current
UART	Universal Asynchronous Receiver-Transmitter	DC	Direct current
USB	Universal Serial Bus	GND	Ground
ICSP	In-Circuit Serial Programming	SCK	Serial clock
SPI	Serial Peripheral Interface	SS	Slave select
V	Volts	MISO	Master-In Slave-Out
IOREF	In/Out reference	MOSI	Master-Out Slave-In
mA	Milliamperes	PWM	Pulse-width modulator
μs	Microsecond	SDA	Data line
cm	Centimeter	SCL	Clock line
m	Meters	TWI	Two wire interface
TX	Digital pin 1 (Transmit)	RX	Digital pin 0 (Receive)
IDE	Integrated development environment	PCB	Printed circuit board
IR	Infrared	SRAM	Static random access memory
EEPROM	Electrically Erasable Programmable Read-Only Memory	TTL	Transistor-transistor logic
OS	Operating system	DTR	Data terminal ready
IC	Integrated circuit		

The paper is organized as follows. Background knowledge together with an overview of the study and the historical overview of ultrasonic sensors as well as State-of-the-Art in Ultrasonic Technology Developments and Applications are presented in Section 2. The architecture of the proposed enhanced obstacle detection system in the context of the HC-SR04 ultrasonic sensor and the Arduino Mega 2560 is detailed in Section 3. The development, implementation and deployment of the enhanced obstacle detection are discussed in Section 4 together with the design of an alarm system incorporating an audio power amplifier. Section 5 concludes the paper with some highlights on future directions as part of recommendations on the way forward.

2. Literature Review

2.1 Overview of the Research

This work presents the development of an obstacle detection system capable of detecting an object within a stipulated range irrespective of the weather condition of the surroundings using a HC-SR04 ultrasonic sensor. An amplifying circuit is been designed to amplify the output signal when it comes across an obstacle within a stipulated range. The desired objective is for the proposed obstacle detection system to trigger an alarm system which will produce an audio signal when it comes across an object within the range of 0–4 metres. The Arduino Mega 2560 microcontroller has been used as the brain of the device system due to its low-cost, reliability and availability. This research work is expected to: *1).* Measure the distance between objects; *2).* Alert its users when it comes across an object within the range of 0–4 metres; and *3).* The design system can be used for developing a security alarm system. Ultrasonic sensors have been used in a wide variety of applications and still sonar systems are under research to produce more near to nature sensors. The following sub-sections highlights the work done in the field of sonar sensing.

2.2 Historical Overview of Ultrasonic Technology

The history of ultrasonic starts with Lazzaro Spallanzani (1729–1799), an Italian physiologist and priest who designed a set of experiments to explain how bats were able to fly at night. By studying the bat's ability to see and hear, Spallanzani noted that if a bat was blinded, it was still able to fly confidently through space; however, when a bat was made deaf, even in one ear, it could not fly safely in the experimental environment. Based on these findings, Spallanzani hypothesized that bats relied on sound, not their vision, to navigate [14].

Piezoelectricity (from the Greek word *piezen*, meaning to press or squeeze) was first discovered by brothers Jacques (1856–1941) and Pierre (1859–1906) Curie. They demonstrated that crystals of tourmaline, quartz, topaz, cane sugar, or Rochelle salt can generate electricity under pressure and that when a voltage is applied to these crystalline materials, pressure waves can be generated. The capacity of these crystals to both generate and receive pressure waves in the range of megahertz frequencies allowed the development of modern-day transducer technology [15].

2.3 State-of-the-Art in Ultrasonic Technology Developments and Applications

The concept of ultrasonic sensor is to produce high frequency sound wave in cone shape by transducer and receive back after the reflected off the target. Sensor will calculate the time between sending and receiving echo to determine the accurate distance from the object or target. It can estimate with a precision of less than 1cm and up to 4 m in distance measurement. Ultrasonic sensors are capable of performing distance measurement on a transparent, shiny and dark surface object. This ability allows ultrasonic sensors to detect material ranging from clear glass bottle to black rubber tyre. It can also works in tough environment such as noisy, dusty or dark area.

Kuc and Siegel [16] present a method for discriminating planes, corners and edges using sonar data gathered at two positions. Two significant follow-ups are the work of [8, 17] which differentiates planes and corners with multiple transducers at a single position. Followed by [18] which considered differentiates planes and corners with one transducer at two positions.

In [19], a real time world model based on data from onboard ultrasonic transducers is constructed and statistical methods are used to transform the digital map into a topographical map; a path planner based on the Virtual Force Field method is employed.

Ohya and co-workers [20] used a system of one ultrasonic transmitter with two receivers to determine the normal of the detected surface. A vector map is used to reconstruct the environment. A similar approach, where form is considered rather than localization is presented in [21].

Fuzzy logic had used to solve the fundamental processes of perception and navigation [22]. The robot collects data from its sensors, builds local maps and integrates them into the global maps so far reconstructed, using fuzzy logic operators. The inputs to the map-building phase are the range measurements from the ultrasonic sensors. Its Outputs are two updated fuzzy maps. Both convey information about the risk of collision at each point in the environment.

Ultrasonic sensors have been found to be useful in automotive applications in determining occupant position and occupant velocity during a crash. When combined with the vehicle's crash sensors, ultrasonic sensors add to the airbag control methodology [23].

The medical industry uses ultrasonic sensors to create two-dimensional images of the human body. Speed of sound, attenuation, and impedance depends on the body tissue the sound wave is passing through. By using these attributes a 2D image of the human body can be created [24].

Ultrasonic sensors are very useful in the marine industry to map the seafloor and to detect man-made objects such as mines [25]. Multiple sensors are used to recreate a three-dimensional scene. By adjusting the output frequency and amplitude, ultrasonic sensors can be used for long-range, two-dimensional object detection.

By creating an array of sensors in a circle around the vehicle, the overlap of cones allows for an increase in resolution on an autonomous vehicle [26]. The sensor array can then create a 360 degree view of the world around vehicle and the vehicle can make guidance decisions in real time.

Lee and co-worker [27] showed the use of multiple ultrasonic sensors employing the different beam-width sensors used simultaneously for mobile robot navigation purposes. The small beam-width sensor is good in resolution but for wider angular region, more number of sensors are required. The use of wide beam-width sensors results in fewer sensors while covering the detection area. However, it results in a poor resolution which is solved by fusing (stacking) the different beam width sensors to get better resolution and also larger covering area making navigation powerful in complex environments.

Using a single camera Jeongdae and Yontage [28] developed a mobile robot which avoided obstacles on its pathway. The objects were detected by Block Based Motion Estimation (BBME). In the method, an image is firstly divided into small blocks and then the motion of each block is searched by comparing two consecutive images. The method was verified by the indoor navigation experiment of a robot.

Another interesting work is shown in [29] employing ultrasonic sensor in measuring distance. The device system comprises of an ultrasonic transmitter circuit and a receiver circuit. A microcontroller AT89C205 was used which serves as the brain of the device system. The device was used to measure a distance of 2.5 m.

In tank level monitoring, Viswanath and co-workers [30] monitored the liquid content in a tank using ultrasonic sensor. The sensors was placed in a specified direction in the tank, calculating the level of liquid by time of flight of the ultrasonic wave and correlating with respect to the dimension of the tank to get more accurate values.

Recently, Vivekanadan and co-workers [31] designed a mobile robot with ultrasonic sensor for obstacle detection and avoidance, a flame sensor to detect fire and an arduino board for processing. A fire extinguisher was attached to the robotic arm of the robot. When the flame sensor detects fire, the robot moves towards the direction of the fire avoiding obstacles on its pathway. The fire extinguisher along with actuators is used to extinguish the fire which is been detected. A wireless monitoring system with camera is used to display the present scenario.

3. Architecture of the Proposed Enhanced Obstacle Detection System

3.1 The Proposed Research Methodology

The block diagram of the proposed enhanced obstacle detection (EOD) system with an electronic system based on the IoT technology is shown in Fig. 1.

An ultrasonic sensor interfaced with an Arduino Mega2560 embedded system development board initiates the obstacle detection process. The communication between the ultrasonic sensor is bidirectional so that real-time measurements can be updated once available and the corresponding measurement is displayed on an intelligent liquid crystal display also interfaced with the Arduino Mega2560 embedded system development board.

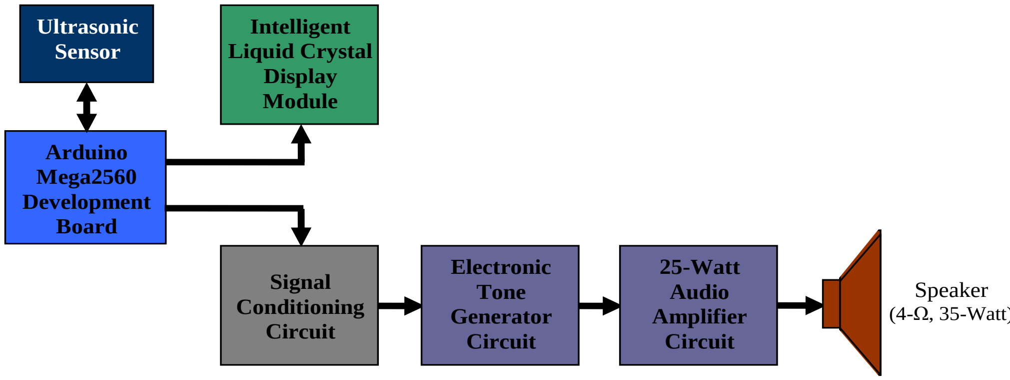

Fig. 1: The block diagram of the proposed enhanced obstacle detection system with alarm based on the Internet-of-Things (IoT).

In the proposed EOD design, when an object is detected within the range of 0 to 4 meter, an electronic alarm system is triggered on while in the absence of any object outside this range the alarm system is turned off. As shown in Fig. 1, the electronic alarm system consist of the signal conditioning circuit and an electronic tone generator circuit as well as an output 25-Watt audio amplifier circuit which drives a 4-Ω 35-Watt speaker.

3.2 Architecture of the HC-SR04 Ultrasonic Sensor

An ultrasonic sensor is a device that is capable of measuring the distance to an object by using sound waves as depicted in Fig. 2(a) and (b). It measures by sending a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object [32].

The HC-SR04 module is a four pin sensor. Two pins ensure the power supply whereas one pins is for transmission and one for echo reception. It works on a 5 V voltage supply. The ultrasonic sensor of Fig. 3 has both transmitter and receiver on the same chip as illustrated in Fig. 2(a) and (b). When given a high pulse to the transmit pin of the sensor, it triggers a chirp signal, which gets reflected from the object and received by the echo pin.

Typically, the HC-SR04 ultrasonic sensor has the following specifications: *1).* It works on a power supply of 5V DC; *2).* Frequency of operation is 40 kHz; *3).* Typical Quiescent current is less than 2 mA; *4).* Typical operating current is 15 mA; *5).* Range is from 2cm to 400 cm; *6).* The typical measuring angle is 300 where it can deviate depending upon the surface; *7).* Maximum effectual angle is 150; and *8).* It generates a trigger pulse of 10 µS.

3.3 Architecture of the Arduino Mega 2560 Development Board

The Arduino Mega 2560 embedded systems development board shown in Fig. 4 is a microcontroller board based on the ATmega2560 [33]. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Decimals. The ATmega2560 on the Mega 2560 comes preprogrammed with a bootloader that allows you to upload new code to it without the use of an

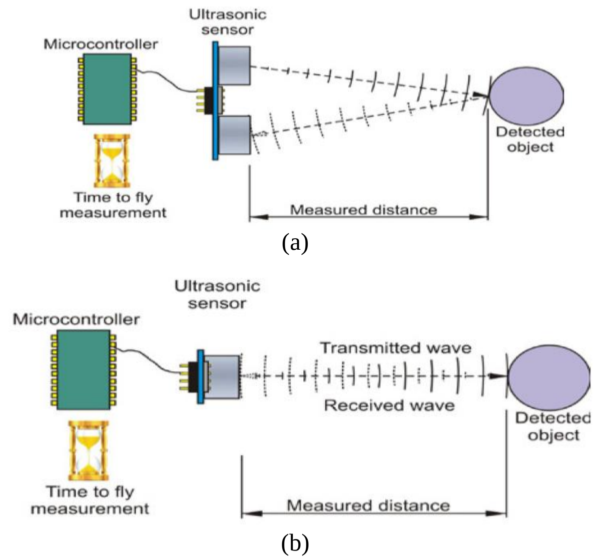

Fig. 2: The basic working principle of the ultrasonic sensor: (a). top view and (b). side view.

Fig. 3: The HC-SR04 ultrasonic sensors.

external hardware Programmer. It communicates using the original STK500 protocol (reference, C header files).

Fig. 4: The top view of Arduino Mega 2560 embedded development board.

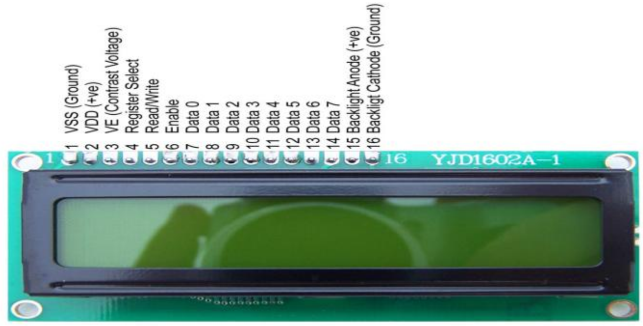

Fig. 5: The physical picture and pin definition of the YJD1602A-1 16-by-2 LCD display module.

Table 2: Absolute maximum ratings for normal operation of the ADM1602K-NSW-FBS/3.3V liquid crystal display (LCD) module

S/N	Item	Symbol	Standard			Unit
			Minimum	Typical	Maximum	
1.	Power voltage	V_{DD} - D_{SS}	0	-	7	V
2.	Input voltage	V_{IN}	V_{SS}	-	V_{DD}	
3.	Operating temperature	V_{OP}	0	-	+50	°C
4.	Storage temperature range	V_{ST}	-10	-	+60	

Table 3: Interface pin description for the ADM1602K-NSW-FBS/3.3V liquid crystal display (LCD) module

S/N	Pin Number	Symbol	External Connection	Function Symbol
1.	1	V_{SS}	Power supply	Signal ground for LCM
2.	2	V_{DD}		Power supply for logic for LCM
3.	3	V_0		Contrast adjust
4.	4	RS	MPU	Register select signal
5.	5	R/W	MPU	Read/write select signal
6.	6	E	MPU	Operation (data read/write) enable signal
7.	7 – 10	DB0 ~ DB3	MPU	Four low-order bidirectional three-state data bus lines used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation
8.	11 – 14	DB4 ~ DB7	MPU	Four high-order bidirectional three-state data bus lines used for data transfer between the MPU
9.	15	LED+	LED BKL power supply	Power supply for BKL
10.	16	LED–		Power supply for BKL

3.4 YJD1602A-1 16-by-2 LCD Display Module

The LCD used in this work is the YJD1602A-1 16-by-2 LCD display module shown in Fig. 5 with the physical picture and pin description. The absolute maximum ratings for normal operation is shown in Table 2 while the pin description for interfacing the YJD1602A-1 16-by-2 LCD display module is given in Table 3 [34].

4. Development, Implementation and Deployment of the Enhanced Obstacle Detection System with Electronic Alarm Unit

In the Section, the development, implementation and deployment of the proposed EOD are presented. The developmental architecture of the proposed EOD is illustrated in Fig. 7. The expanded block diagram shown in Fig. 7 closely follows the proposed block diagram shown in Fig. 1. An Arduino Mega 2560 interfaced with an HC-SR04 ultrasonic sensor and the YJD1602A 16-by-2 LCD display module together with an electronic alarm system. The LEDs are used to indicate if the ultrasonic proximity sensor receive a reflected wave when an object is within the stipulated range of 0–4 meters. Male and female jumper wires are used for connections between the microcontroller and the ultrasonic sensor.

4.1 Development of the Enhanced Obstacle Detection System with the Electronic Alarm Unit

The block diagram of the proposed EOD system based on IoT with additional interfacing as well as signal conditioning circuits is shown in Fig. 7 while Table 1 shows the pins connection for interfacing the Arduino board to the HC-SR04 sensor, YJD1602A LCD module and the electronic alarm system. The pin 26 and 25 of the Arduino Mega 2560 embedded development board are connected to the Trigger and Echo pin of the HC-SR04 respectively to receive signal. (Please refer to Tables 4 and 5 for more detailed inputs and outputs programming). When the sensor detects an obstacle within a range of 0–4 m, the pin 15 of the Arduino board is energized and the yellow LED lights up. When there are no obstacles detected within the range, the red LED lights up.

The Arduino integrated development environment (IDE) is a cross-platform application written in Java and most of the Arduino programs are written in C or C++. It can run on all operating systems like Windows, Mac OS, and Linux. It is designed to introduce programming skills to artists and other newcomers who are unfamiliar with software development or hardware programming. It includes a code editor with common developer software features like syntax highlighting, brace matching, and automatic indentation. It also provides functions that are capable of compiling and uploading programs to the Mega2560 development board via USB. It is a user-friendly interface for everyone from beginners to professionals to learn or use.

4.2 The Electronic Alarm Unit

The complete circuit diagram for the proposed enhanced obstacle detection system together with the electronic alarm unit is shown in Fig. 8. The electronic alarm unit is built around two NE555CN timer ICs and a TDA2050 audio amplifier IC. Following the discussions above, whenever an obstacle is detected, RED LED comes and consequently the electronic alarm system is triggered simultaneously.

In order to protect the Arduino Mega 2560 output ports, the

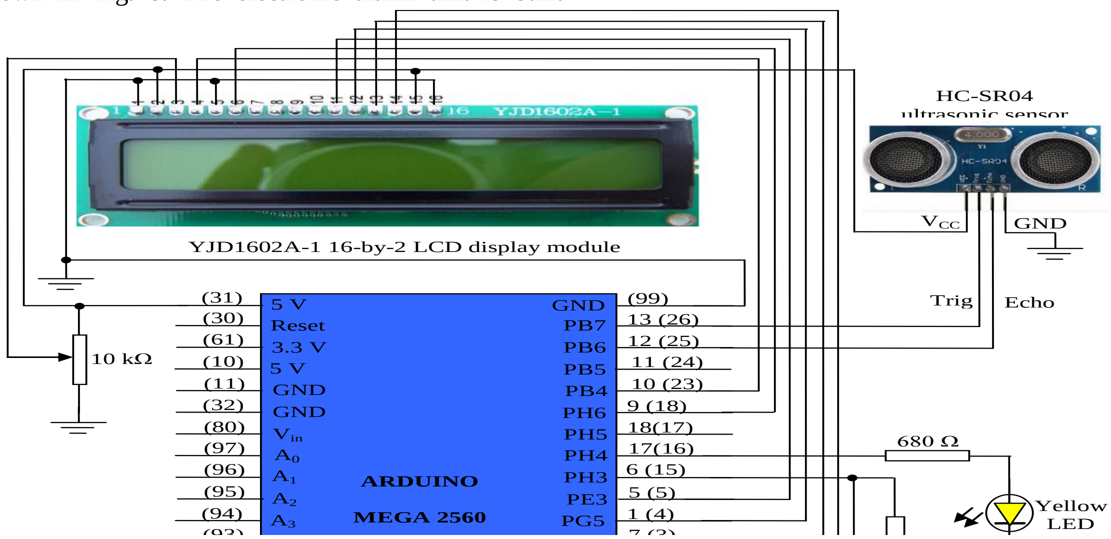

Table 4: Arduino Mega 2560 pin connections defined for the proposed EOD system design

S/N	Pins on Arduino	Connections	Remarks
1.	26	Trigger pin of HC-SR04 sonar sensor	Trigger input of Sensor
2.	25	Echo pin of HC-SR04 sonar Sensor	Echo output of Sensor
3.	31	VCC terminal of HC-SR04 sonar sensor	5 V supply
4.	99	Ground terminal of HC-SR04 sonar sensor	Ground supply (GND)
5.	15	Positive of red LED.	Goes ON when it detects an obstacle within range of 0 to 4 m
6.	16	Positive of yellow LED	Goes ON when no obstacle is been detected between 0 to 4 m
7.	23	Register Select Pin of LCD	Selects Command Register when Low; and Data Register when High
8.	18	Enable Pin of LCD	Sends Data to Data Pins when a High to Low pulse is given
9.	5	Data 4 Pin of LCD	
10.	1	Data 5 Pin of LCD	
11.	7	Data 6 Pin of LCD	
12.	6	Data 7 Pin of LCD	

Fig. 9: Photograph of the EOD system experimental setup and performance evaluation.

output pin 15 is used to bias transistor Q1 (TIP 41 NPN transistor) via 5.6 kΩ which delivers +12 V which serves as power supply voltages to the circuit of IC1. The circuit of IC1 is a NE555CN timer wired as an astable multivibrator. The output taken at pin 3 of IC1 is high for one half of a cycle for one second and goes low for the next half cycle [35, 36]. When the output is low, IC2 is inhibited and the loud-speaker is off. During the next half cycle the output is high. Thus, the output of IC2 oscillates at 1 kHz and this oscillating signal was amplified by a 25 Watts audio power amplifier built around IC3, TDA2050 [36], and passed to the speaker situated on the far right bottom of Fig. 7. When this electronic alarm is on, it however signifies that an intruder or obstacle has been encountered. The sound level (i.e. the volume) of the audio amplifier is regulated by the 100 kΩ potentiometer (R_{VOL}).

4.3 Performance Evaluation of the Proposed EOD System

The performance evaluation of the proposed EOD system with a view to ascertaining the functionality of the designed EOD system is investigated in this Sub-Section. Based on the fabrication and construction of the complete design shown in Fig. 7 and Fig. 8, the complete program listed in Table 5 was implemented. The experimental setup for the performance evaluation of the proposed EOD is shown in the photograph of Fig. 9.

The electronic alarm system was initially off with object outside the range of 4 m. However, the proposed EOD system has been able to detect any object with the range of 0 to 4 meters with the simultaneous triggering of the electronic alarm system and displaying the corresponding object distance on the YJD1602A LCD.

Table 5: The complete program for the implementation of the proposed enhanced obstacle detection (EOD) system

```
/*
HC-SR04 ultrasonic distance sensor]
VCC to arduino 5v GND to arduino GND
Echo to Arduino pin 13 Trig to Arduino pin 12
Red POS to Arduino pin 11
Green POS to Arduino pin 10
560 ohm resistor to both LED NEG and GRD power rail
*/
#include <LiquidCrystal.h>
LiquidCrystal lcd(10, 9, 5, 4, 3, 2); // Initializes the LCD Ports
#define trigPin 13
#define echoPin 12
#define led 7 // Triggers Yellow LED
#define alarm 6 // Triggers Red LED and the Electronic Alarm System

void setup() {
  Serial.begin (9600);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(led, OUTPUT);
  pinMode(alarm, OUTPUT);
}
void loop() {
  float duration, distance;
  digitalWrite(trigPin, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trigPin, HIGH);
//  delayMicroseconds(1000); - Removed this line
  delayMicroseconds(10); // Added this line
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
 distance = (duration/2) / 29.1;
  if (distance < 100) {  // This is where the LED On/Off happens
    digitalWrite(led,HIGH); // When the Red condition is met, the yellow LED should turn off
  digitalWrite(alarm,LOW);

  lcd.begin(16, 2);
  lcd.print("within range  ");
  lcd.setCursor(0,1);
  lcd.print("limit  ");
    delay(500);
}
  else {
    digitalWrite(led,LOW);
    digitalWrite(alarm,LOW);

    lcd.print(distance);
    lcd.print(" cm ");
    delay(2000);
  }
  if (distance >= 100 || distance <= 0){
    digitalWrite(led,LOW); // When the Red condition is met, the Green LED should turn off
  digitalWrite(alarm,HIGH);
  lcd.print(" obstacle alert ");
    delay(500);
  }
  else {
    digitalWrite(led,HIGH); // When the Red condition is met, the Green LED should turn off
  digitalWrite(alarm,LOW);
  lcd.print(distance);
    lcd.print(" cm");
    delay(500);
  }
 delay(500);
  lcd.clear();
}
```

5. Conclusion

The paper has presented a technique that can be used to design a circuit that is capable of detecting an obstacle within a range of 0–4 meters and alerting its users by triggering an electronic alarm system incorporating an audio power amplifier. The objective was met since the system works effectively for object detection at various distances up to a maximum of 4 m. When an obstacle is within a range of 0 to 4 m, the system triggers an alarm signal indicating an obstacle on its path or detected. When there are no obstacles detected, a yellow LED is switched ON whereas when an obstacle is detected a red LED is switched ON and the alarm system is triggered while the yellow LED turns OFF.

This system can be of great help in both domestic and industrial settings to detect obstacles especially for visually impaired persons who require guidance. The system can also be used to deter personnel from moving to a particular section since it gives an alarm signal when it comes across any obstacle within a range.

The cost of implementing this system is relatively low since the components used are relatively cheap and are easily available in the market. The single microcontroller can be used to interface several sensors with alarms located in different locations as long as more pins are freed for multiple inputs multiple outs.

The safety of personnel is a very crucial aspect in both domestic and industrial settings; hence the use of ultrasonic sensors is inevitable in addition to other more sophisticated security systems. This system should be placed in a cool and dry place to ensure a longer life span.

REFERENCES

[1] D. Xie, Y. Xu, and R. Wang, "Obstacle detection and tracking method for autonomous vehicle based on three-dimensional LiDAR", *International Journal of Advanced Robotic Systems*, March-April 2019, pp. 1 – 13. DOI: 10.1177/1729881419831587.

[2] X. Yu and M. Marinov, "A Study on Recent Developments and Issues with Obstacle Detection Systems for Automated Vehicles", *Sustainability*, vol. 12, no. 3281, 2020, pp. 1 – 26. DOI:10.3390/su12083281.

[3] S. Ahmed, B. Qiu, F. Ahmad, C. Kong and H. Xin, "A State-of-the-Art Analysis of Obstacle Avoidance Methods from the Perspective of an Agricultural Sprayer UAV's Operation Scenario", *Agronomy*, vol. 11, no. 1069, 2021, pp. 1 – 35. Available [Online]: https://doi.org/10.3390/agronomy11061069.

[4] N. Fioraio and L. D. Stefano, "Joint Detection, Tracking and Mapping by Semantic Bundle Adjustment", [Online] Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.667.8755&rep=rep1&type=pdf, pp. 1 – 5, 2013.

[5] C. C. Chang, C. Y. Chang and Y. T. Cheng, "Distance Measurement Technology Development at Remotely Teleoperated Robotic Manipulator System for Underwater Constructions", *IEEE International Symposium on Underwater Technology*, pp. 333 – 338, 2004.

[6] M. Skoczeń, M. Ochman , K. Spyra, M. Nikodem, D. Krata, M. Panek and A. Pawłowski, "Obstacle Detection System for Agricultural Mobile Robot Application Using RGB-D Cameras", *Sensors*, vol. 21, no. 5292, 2021, pp. 1 – 17. Available [Online]: https://doi.org/10.3390/s21165292.

[7] C. R. Reddy, G. R. Reddy, B. S. Goud, N. Rajeswaran, and C. N. Kumar, "Passive Islanding Detection Methods for Integrated Distributed Generation System", *Journal of Power Technologies*, vol. 201, no. 3, 2021, pp. 127 – 134.

[8] L. D. Spedicato, N. I. Giannoccaro, G. Reina1 and M. Bellone1, "Clustering and PCA for Reconstructing Two Perpendicular Planes Using Ultrasonic Sensors", *International Journal of Advanced Robotic Systems*, vol. 10, pp. 1 – 10, 2013.

[9] P. Hyde, C. Ulianov, J. Liu , M. Banic, M. Simonovic and D. Ristic-Durrant, "Use cases for obstacle detection and track intrusion detection systems in the context of new generation of railway traffic management systems", *Proc. IMech Part F: Journal of Rail and Rapid Transit*, vol. 0, no. 0, 2021, pp. 1 – 10.

[10] C. He, J. Gong, Y. Yang, D. Bi, J. Lan and L. Qie, "Real-time Track Obstacle Detection from 3D LiDAR Point Cloud", *Journal of Physics: Conference Series, CATE 2021, IOP Publishing*, vol. 1910, pp. 1 – 6.

[11] A. Nawer, F. Hassain, F. and G. M. Anwar, "Ultrasonic Navigation System for the Visually Impaired and Blind Pedestrian", *American Journal of Engineering Research*. vol. 4, pp.13 – 18, 2015.

[12] M. Brudka and A. Pacut, "Intelligent Robot Control Using Ultrasonic Measurements", *IEEE Transactions on Instrumentation and Measurement*, vol. 51, no. 3, pp. 454 – 459, 2002.

[13] A. Saraswathi, A. A. Abass, S. I. Mathi and A. Eswaran, "Obstacle detecting robot using arduino and sensor", *International Journal of soft Computing and Artificial Intelligence*, vol. 3, 2015.

[14] D. Kane, W. Grassi, R. Sturrock and P. V. A. Balint, "Brief history of musculoskeletal ultrasound: 'From bats and ships to babies and hips", *Rheumatology (Oxford)*, vol. 43, no. 7, pp. 931 – 933, 2004.

[15] A. Manbachi and R. S. Cobbold, "Development and application of piezoelectric materials for ultrasound generation and detection", *Ultrasound*, vol. 19, no. 4, pp. 187 – 196, 2011.

[16] R. Kuc and M. W. Siegel, "Physically based simulation model for acoustic sensor robot navigation", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 9, no. 6, pp. 766 – 778, 1987.

[17] K. A. Kaproth-Joslin, R. Nicola and V. S. Dogra, "The History of US: From Bats and Boats to the Bedside and Beyond", *Radio Graphics*, vol. 35, no. 3, 2015.

[18] O. Bozma and R. Kuc, "Building a sonar map in a specular environment using a single mobile sensor", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 13, no. 12, pp. 1260-1269, 1991.

[19] F. Schneider, H. Wolf and K. Holzhausen, "Acquisition and display of a world model using an autonomous mobile robot", *In Proceedings of the IEEE International Conferences on Intelligent Robots and Systems*. vol. 2, pp. 769 – 775, 1994.

[20] A. Ohya, Y. Nagashima and S. Yuta, "Exploring Unknown Environment and Map Construction Using Ultrasonic Sensing of Normal Direction of Walls", *In Proceedings of the IEEE International Conference on Robotics and Automation*, vol.1, pp. 485 – 492, 1994.

[21] G. Dudek, P. Freedman and I. M. Rekleitis, "Just-in-time sensing: efficiently combining sonar and laser range data for exploring unknown world", *IEEE International Conference on Robotics and Automation, Minneapolis*, pp. 667 – 672, 1996.

[22] A. K. Shrivastava, A. Verma and S. P. Singh, "Distance measurement of an object or obstacle by ultrasound sensors using P89C51RD2", *International Journal of Computer Theory and Engineering*, vol. 2, no.1, 2010.

[23] D. Breed, V. Castelli, W. Johnson, W. DuVall and R. M. Patel, "Vehicle Occupant Position and Velocity Sensor", *US Patent No. 5,653,462*, 1997.

[24] J. U. Quistgaard, "Signal Acquisition and Processing in Medical Diagnostic ultrasound", *IEEE Signal Processing Magazine*. vol.14, pp. 67 – 74, 1997.

[25] V. Murino and A. Trucco, "Three-Dimensional Image Generation and Processing in Measurements", *IEEE Transactions on Instrumentation and Measurement*, vol. 51, no. 3, 2000.

[26] D. Bank, "A novel ultrasonic sensing system for autonomous Mobile systems", *IEEE Sensors Journal*, vol. 2, no. 6, pp. 597 – 606, 2002.

[27] K. Lee, N. L. Doh and W. K. Chung, "An exploration strategy using sonar sensors in corridor environments", *Intelligent Service Robotics*, vol. 3: pp. 89 – 98, 2010 .

[28] K. Jeongdae and D. Yontage, "Moving obstacle avoidance of a robot using a single camera", *International Symposium on Robotics and Intelligent Sensors*, vol.41, pp. 911 – 916, 2012.

[29] S. Monisha, R. Ratan and S. K. Luthra, "Design and Development of Smart Ultrasonic Distance Measuring Device", *International journal of innovation Research in Electronics and Communication*, vol.2, pp. 19 – 23, 2015.

[30] S. Viswanath, M. Belcastro, J. Barton, B. Oflynn, H. Holmes and P. Dixon, "Lower-power wireless liquid monitoring system using ultrasonic sensors", *International Journal on Smart Sensing and Intelligent System*, vol. 8, no. 1, 2015.

[31] S. Vivekanadan, G. Santhosh, S. J. kumar, S. S. Shankar and S. V. Kumar, S.V. (2016). "A novel camera based mobile robot with obstacle avoidance and fire extinguish control", *International Journal of Engineering Research and Applications*, vol. 6, no 4, pp. 5 – 7, 2016.

[32] Elec Freaks (2021), HC-SR04 Ultrasonic Sensor User Guide. Retrieved on the 12th of August 2021. [Online] Available: www.elecfreaks.com.

[33] ArduinoMega (2021, September17). [Online] Available: https://www.arduino.cc/en/Main/arduinoboardmega.

[34] 16x2 LCD Module (2021). Retrieved on the 16th of September 2021. Available [Online]: https://components101.com/16x2-lcd-pinout-datasheet.

[35] D. V. Hall, *Digital Circuits and Systems*, Singapore: McGraw–Hill,1989.

[36] V. A. Akpan and M. T. Babalola, "The development of a Model automatic electromechanical vending machine", *Journal of Science & Technology Research*, vol. 8, no. 3, pp. 121 – 131, 2009.

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