

Classifying Object Size in an Arduino-Based RADAR System Using an IR Sensor and I2C-LCD

Mohammad Iftekher Uddin¹, Robin Barua²

^{1,2} Electrical and Electronic Engineering, Chittagong University of Engineering and Technology, Chattogram, Bangladesh

¹ email: iftekher7eee@gmail.com

[submitted: 01-09-2025 | review: 08-10-2025 | published: 31-10-2025]

ABSTRACT: The radio detection and ranging (RADAR) system uses electromagnetic waves to measure the distance and direction of an object. The IR (infrared) sensor uses infrared light to detect an object. This study uses the IR sensor to classify the size of an object in an Arduino-based RADAR system. A binary logical method classifies the size of an object as either long or small. The result is displayed on a liquid crystal display (LCD). An I2C module is used to easily connect the LCD to the Arduino. The system has been simulated in Proteus software to verify the Arduino code. The Arduino-based RADAR system with size classification has been implemented using two IR sensors, an ultrasonic sensor, an LCD, and a servo motor. Two IR sensors have been used at different heights to classify the size of an object. A Java application is used to visualize the RADAR system on a PC in a graphical user interface (GUI), which shows the moving object in real-time. The ultrasonic range is programmed at 40 cm to detect objects. The system can detect objects in the 40 cm range and between 0 and 180° angles.

KEYWORDS: Distance, Ultrasonic, Microcontroller, IR Sensor, Echolocation

I. INTRODUCTION

To enable remote detection, healthcare monitoring, and security applications, the RADAR system has received attention [1]. The civil applications of this system are air traffic control, earth mapping, autonomous vehicle guidance, ocean surveillance, etc. Echolocation, also known as biosonar, is a biological sonar system used by various animal species in both air and water [2]. Bats, wonderful creatures but blind from the eyes, use the echolocation technique, where they make an ultrasonic sound (not audible to humans) in their flying direction and wait for the echo to detect obstacles. The ultrasonic sensor [3], a low-cost electronic device, provides an easy way to measure the distance between moving or stationary objects using the echolocation technique. It can measure the distance of an object in air without any damage. Arduino Uno is an easily programmable microcontroller with signal input-output features. A. Megananda [4] et al. developed an Arduino Uno-based digital distance measurement system using an ultrasonic sensor, enabling students to measure distance with a minimum resolution of 1 cm in physics experiments. Like ultrasonic sensors, IR sensors use invisible (to human eyes) light reflection to detect an object's existence. It can determine object height [5]. S.K. [6] et al. have developed a RADAR system with an ultrasonic sensor, servo motor, and PIR sensor to detect an object. The ultrasonic & IR sensors consume low power and are cheap and easy to implement. A.K. et al. [7] designed an Arduino-based

low-cost RADAR system that gives an alarm when an object is detected. But the size classification has not been included. N Gupta [8] et al. have designed a system to track and show an object in a virtual environment, but the object's size has not been classified. A.E. et al. [9] have implemented a RADAR system with a GUI monitoring system using the Java programming language, but the object's size has not been classified. So, a RADAR system has been implemented using ultrasonic, IR, and Arduino Uno to track the distance and angular position of an object with size classification.

A. SYSTEM DESCRIPTION

Fig. 1 shows the block diagram of tracking and classifying the size of an object.

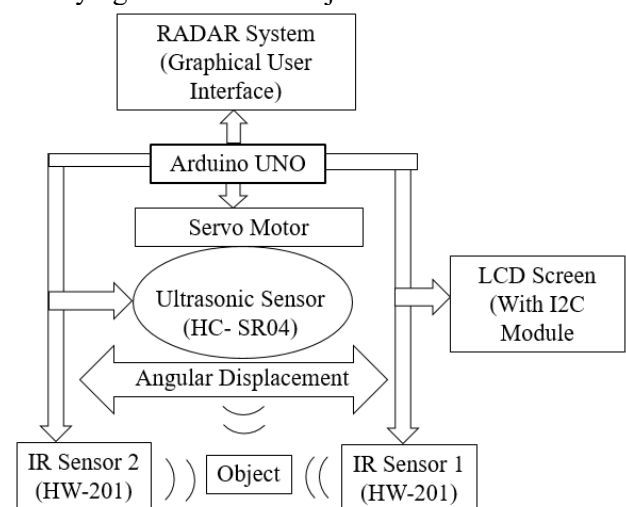


Fig 1. Block Diagram of Detecting an Object with Size

An ultrasonic sensor (HC-SR04), connected to a servo motor, moves left or right in a circular path to detect an object. An angular displacement sensor measures the rotation angle of the servo motor from 0 to 180°. An Arduino Uno microcontroller receives and processes the information from sensors and shows the results in the GUI RADAR system. Two IR sensors (HW-201) determine the height (long or small) of an object. An LCD with an I2C module shows the size of the object.

B. IR SENSOR

An IR sensor, shown in Fig. 2, has three terminals: Vcc, Gnd, and Output. The output is high or low. The distance adjustment knob varies the threshold voltage as well as the sensing distance.

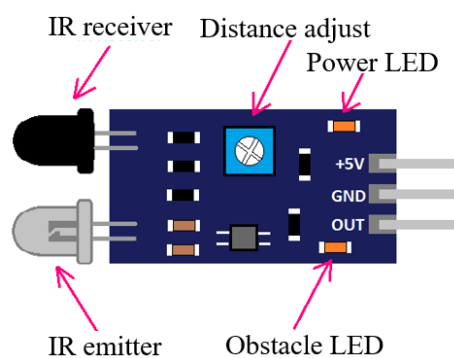


Fig 2. IR Sensor

The IR emitter emits light in air, and when reflected by an object, its resistance decreases and it starts to conduct current. Hence, the voltage drop exceeds the threshold voltage, and the output is high. When an obstacle is detected, the obstacle LED turns on. The power LED indicates the IR sensor is active.

C. I2C MODULE

An I2C module, in Fig. 3, enables connecting an LCD to an Arduino with only two pins [10]. It can be connected to a 16x2 or 20x4 display. The module is equipped with a PCF8574 I2C chip which converts serial data to parallel data for the LCD.

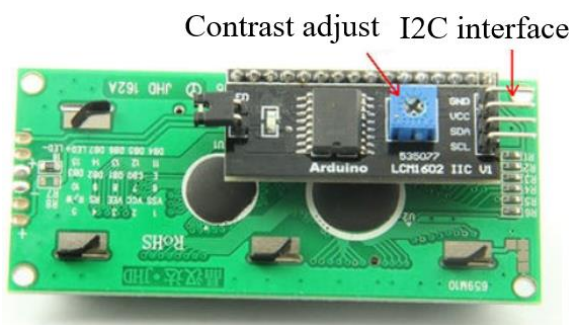


Fig 3. I2C Module

The specification with the pin diagram of the I2C module is given below:

- Pin : VCC, GND, SDA, SCL

- Power supply : 5V
- Potentiometer : Contrast adjustment

II. DESIGN METHODOLOGY

A. DISTANCE CALCULATION

The distance between the ultrasonic sensor and object can be determined by the following equation 1:

$$Distance(m) = \frac{speed\ of\ sound\ (m/s) * time(s)}{2} \quad (1)$$

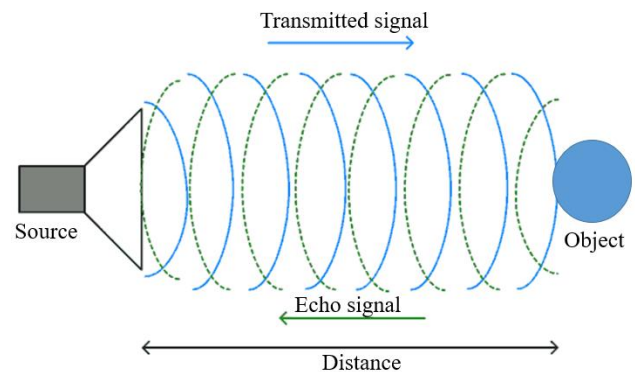


Fig 4. Distance Measurement with Ultrasonic Sensor

In equation 1, the distance (from ultrasonic sensor to object and object to ultrasonic sensor) is divided by 2 because sound has travelled two times. An ultrasonic distance measurement technique is shown in Fig 4. When transmitted signal hits an object, it returns to its source as an echo signal. Measuring the times when signal is transmitted and received, the distance is calculated. In this system, the sound travel time has been calculated by Arduino Uno's micros () function, which provides the number of microseconds (one-millionth of a second) that have elapsed since the Arduino began executing the current program [11]. The approximate sound velocity in air is about 340 m/s (1/29.412 cm/μs). So, the simple object distance equation in centimeters can be written as:

$$Distance(in\ cm) = \frac{\frac{1}{29.412}(cm/\mu s) * time(\mu s)}{2} \quad (2)$$

The 'sonar.ping_cm()' function is used to call the distance value [12].

B. SIZE CLASSIFICATION

The size has been classified using a binary logical method (1 or 0). There are two outputs from the IR sensor: High (1) and Low (0). The output 'HIGH' indicates that there is an obstacle and the 'LOW' indicates that there is no obstacle. The four outputs from the two IR sensors have been used to classify the object's size as small, long or no object, as shown in Tbl 1.

Tb1 1. Object Classification Using Binary Logical Method

Sl.	IR Sensor 1	IR Sensor 2	Result
1.	0	0	No Object
2.	0	1	-
3.	1	0	Small
4.	1	1	Long

The output 0-1 (Sl. 2) is possible when an object flies in front of sensor 2 without interrupting sensor 1, but as the system identifies an object which moves through the ground, Sl.2 indicates no result.

C. SYSTEM FLOWCHART

The system flowchart has been shown in Fig 5. The Arduino microcontroller receives the information from the IR sensors and determines as there is any object or not. Using the binary logical method the object's size is classified.

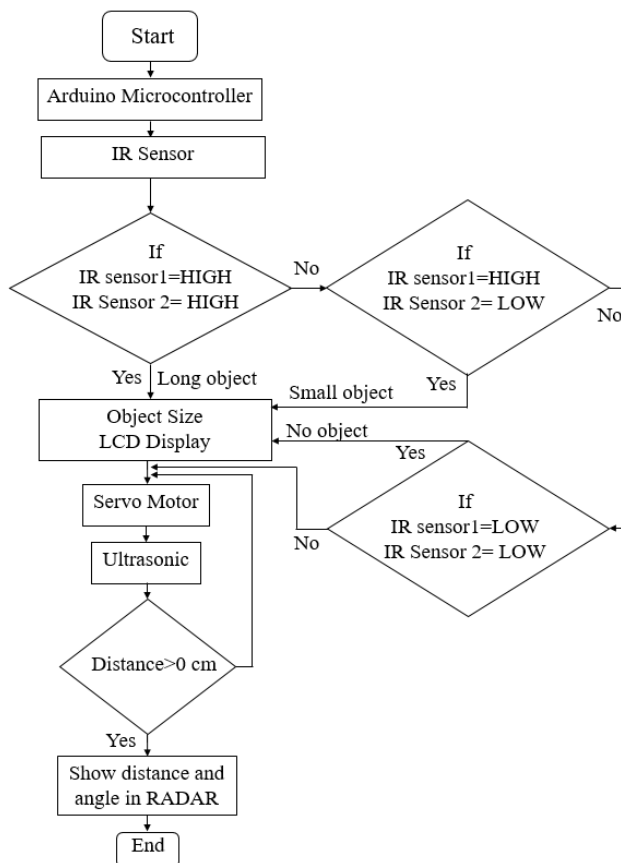


Fig 5. Flowchart of Tracking and Size Classifying of an Object

The LCD shows the classified object's size. The servo motor and ultrasonic sensor rotate between 0° and 180°. The ultrasonic sensor transmits a signal and waits for an echo. If an echo is detected then distance is calculated. When the distance value exceeds 0 cm, the information is sent to the GUI to show object's distance and angle in the RADAR system.

D. OBJECT DETECTION AND CLASSIFICATION PROCEDURE

The methodology for tracking and classifying the size of an object is given below:

1. When an object enters the range of the ultrasonic sensor, both the ultrasonic sensor and angular displacement sensor send data to the Arduino Uno.
2. When an object enters the range of the IR sensor, the IR sensor sends data to the Arduino Uno.
3. The Arduino Uno processes the incoming data. Using a binary logic method, it classifies the object's height as either long or small and sends the result to the I2C module for display.
4. The travel time of the ultrasonic signal is determined by measuring the interval between transmission and reception.
5. The Arduino calculates the object's distance based on the measured travel time.
6. The servo motor's rotation angle is determined using the angular displacement sensor readings.
7. The radar system displays the real-time distance and angular position of the object, while the LCD shows the object's height as either long or small. The servo motor, carrying the ultrasonic sensor, continuously rotates clockwise and counterclockwise between 0° and 180°.

E. SYSTEM SIMULATION

To check the programming code and connections of the system components, Proteus simulation software is used for circuit simulation.

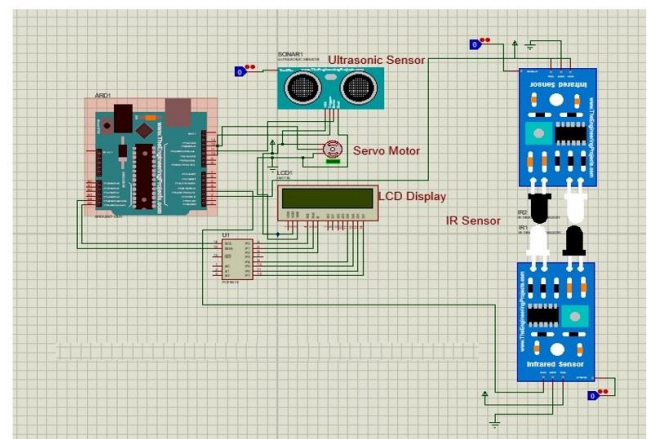
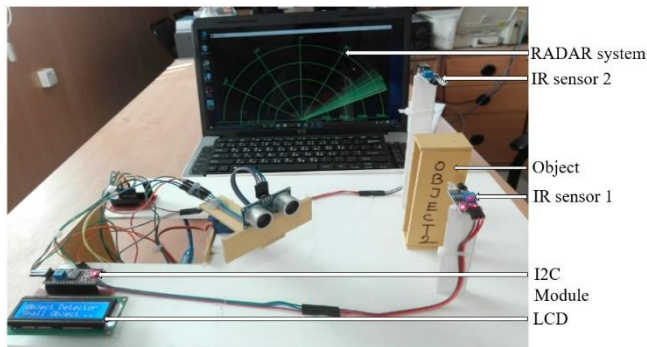


Fig 6. System Simulation of the Proposed System

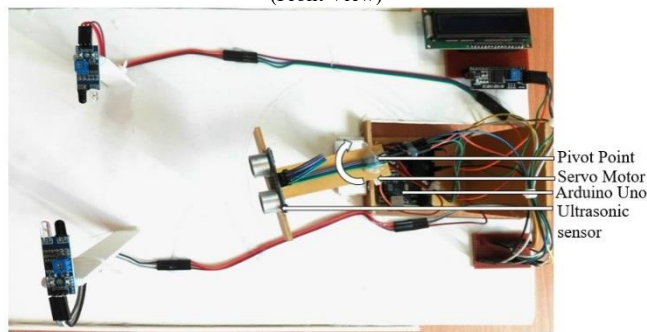
The circuit diagram of the simulation is shown in Fig 6. Arduino Uno is the main controller which controls the sensors, motor and LCD. The servo motor rotates with the ultrasonic sensor to scan the area. The LCD, ultrasonic sensor, IR sensor and servo motor work properly and the code shows no errors.

III. HARDWARE IMPLEMENTATION

The experimental setup of the proposed system is shown in Fig 7. In the front view, the RADAR system on a computer screen is shown. The system includes one ultrasonic sensor, two IR sensors, two demo objects, one servo motor with angle sensor, one LCD with I2C module and one Arduino Uno board. The ultrasonic sensor is attached to the servo motor and rotates clockwise or anti-clockwise from the pivot point.



(Front View)



(Top View)

Fig 7. Experimental Setup of Arduino Uno-based Object Detection with RADAR System

IV. RESULTS AND DISCUSSION

Fig. 8 shows that the maximum range of the RADAR system is 40 cm. The angle of rotation is 0-180°. In Fig 8(a), the green area indicates there is no obstacle at 153°. In Figure 8(b), the red line indicates that there is an obstacle at 78° and 6 cm away from the system.



(a)



(b)

Fig 8. Graphical scanning of RADAR system: (a) No object detected at 153° angle represented by green lines, (b) Object detected at 78° angle at 6 cm distance (marked by blue and red)

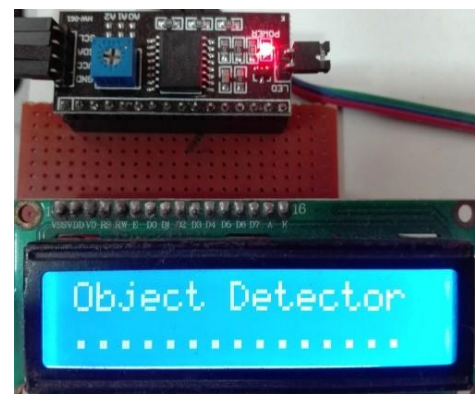


Fig 9. No Object Detection showing 'Object Detector'

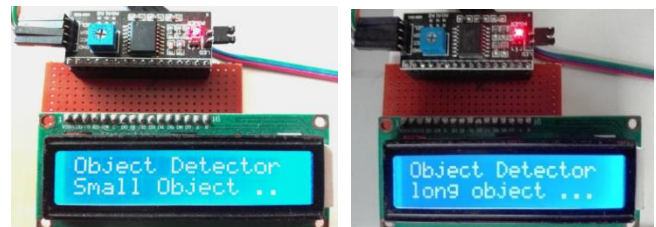


Fig 10. Small (left) and Long (right)

Tb1 2. Experimental Results of the Ultrasonic RADAR System			
Sensor	Maximum Range (cm)	Detection Result	System response
Ultra-sonic	40	No object detected at 153°	Confirms free space with green line
		Obstacle detected at 78°, distance= 6 cm	Indicate obstacle with red line
IR sensor	30	Object classified as Long or Small	Display only 'Object detector' if no object

The single ultrasonic sensor detects objects in a wider range with the use of the servo motor. 'Object Detector' indicates no object is detected, as shown in Fig. 9. 'Small object' indicates the first demo object, while 'Long object' indicates the second demo object in Fig. 10. Tbl 2 shows the overall system response with ultrasonic and IR sensors. The maximum detection range of the ultrasonic sensor is 400 cm. In the prototype system, the max range is selected at 40 cm. The IR sensor is selected for full range (30 cm).

V. CONCLUSION

The system successfully tracked an object without real contact with the physical world. In the 40 cm range, the system is able to detect objects successfully. The GUI is able to show the object in between 0 and 180° angles. The system has succeeded in classifying the size of the two demo objects. The RADAR system showed objects' positions in the virtual environment, which was easy to monitor. The system is easily programmable with Arduino Uno. The I2C module ensures a simple connection between Arduino and LCD. To use the system in full range, the ultrasonic sensor should be selected at 400 cm.

REFERENCES

- [1] P. Ebrahim, N. Tom, D. N. Gençoglan, Ş. Çolak, and M. R. Yuce, "Radar and Non-Contact Sensing," in *Encyclopedia of Sensors and Biosensors*, R. Narayan, Ed., 1st ed., Elsevier, 2023, pp. 287–307, doi: 10.1016/B978-0-12-822548-6.00083-2
- [2] Animal echolocation, Available: https://en.wikipedia.org/wiki/Animal_echolocation. [Accessed: Aug. 8, 2025].
- [3] HC-SR04 Ultrasonic Sensor Datasheet, SparkFun Electronics. [Online]. Available: <https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf>
- [4] A. Megananda, E. Muzayyanah, H. P. Darmayanti and Z. I. Priana, "Development of Digital Distance Measurement Instrument Based on Arduino Uno for Physics Practicum," *Impulse: Journal of Research and Innovation in Physics Education*, vol. 1, no. 2, pp. 80–88, 2021.
- [5] ETechnoG, "IR Sensor Circuit, Connection Diagram, Project," *ETechnoG*, Jun. 2021. [Online]. Available: <https://www.etechnog.com/2021/06/ir-sensor-circuit-connection-diagram.html>
- [6] S. C. T, A. P, K. Sumathi, and C. U. Varshini, "Design of an Arduino Based Radar System," *International Journal of Engineering Research & Technology (IJERT)*, vol. 10, no. 11, ICEI – 2022, 2022.
- [7] A. K. Benjamin, P. K. Ainah, and B. A. John, "Design and Implementation of a Low-Cost Ultrasonic Radar System using an Arduino Microcontroller," *International Journal of Scientific Research and Engineering Development*, vol. 3, no. 4, pp. 295–302, Jul.–Aug. 2020.
- [8] N. Gupta and A. K. Agarwal, "Object Identification using Super Sonic Sensor: Arduino Object Radar," 2018 International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2018, pp. 92–96, doi: 10.1109/SYSMAST.2018.8746951.
- [9] A. E. Onoja and A. M. O. Abdusalaam, "Embedded System Based Radio Detection and Ranging (RADAR) System Using Arduino and Ultra-Sonic Sensor," *American Journal of Embedded Systems and Applications*, vol. 5, no. 1, pp. 7–12, 2017, doi: 10.11648/j.ajes.20170501.12
- [10] RoboticsBD, "I2C LCD Adapter Module," Robotics Bangladesh, product page. [Online]. Available: <https://store.roboticsbd.com/display/433-i2c-lcd-adapter-module-robotics-bangladesh.html>. [Accessed: Aug. 20, 2025].
- [11] Arduino *micros()* Retrieved August 8, 2025, Available: <https://docs.arduino.cc/language-reference/en/functions/time/micros/>
- [12] NewPing Library, Arduino Documentation, Arduino, [Online]. Available: <https://docs.arduino.cc/libraries/newping/>. [Accessed: Aug. 8, 2025].

AUTHORS BIOGRAPHY



Mohammad Iftekher Uddin, is a student of Electrical and Electronic Engineering at Chittagong University of Engineering and Technology (CUET), Bangladesh. He was born in Chattogram, Bangladesh. He is currently pursuing his PhD in EEE at CUET. His research interest includes control systems, electrical machines, and optimization techniques in power and control engineering.



Robin Barua, is a student of Electrical and Electronic Engineering at Chittagong University of Engineering and Technology (CUET). He was born in Betagi, Rangunia, Chattogram (Chittagong). He is currently pursuing a PhD in EEE at CUET. His research interest includes control system, vehicle dynamics and optimization techniques.