RADAR SYSTEM USING ARDUINO AND ULTRASONIC SENSOR

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1 Abstract

A technology called a radar system uses radio waves to find and follow objects. It operates by sending out a radio frequency signal and timing how long it takes for the signal to return after colliding with an item. Calculations are made using the returning signal, also referred to as an echo, to determine the location, speed, and distance of the item. Applications for radar systems include air traffic management, weather prediction, military defense, and surveillance. A radar system using an ultrasonic sensor typically works by emitting high-frequency sound waves and measuring the time it takes for the waves to bounce back after hitting an object. The distance, speed, and location of the object are then calculated using the echoes that were received. Short-range radar applications, such as vehicle obstacle detection and avoidance, industrial automation, and security systems, frequently employ ultrasonic sensors. The system operates by emitting ultrasonic waves from the sensors and measuring the time it takes for the waves to bounce back. The Arduino then uses the returned echoes to calculate the distance, speed, and location of the object.

Keywords : Radio frequency signal, Ultrasonic waves, Arduino

2 Introduction

The term "radar" is a shortened version of "radio detection and ranging," and it was chosen to reflect the focus of the early developers on creating a device that could detect the existence of a target and calculate its distance RADAR is a contraction of the words Radio Detection and Ranging Systems. It is an electronic system that detects and locates objects by transmitting a specific type of wave, like a pulse-modulated sine wave, and evaluating the characteristics of the returned echo signal. It serves to enhance our senses, particularly our vision, by providing information beyond what our eyes can perceive. Despite its limitations in resolution and color recognition compared to human vision, radar has the advantage of being able to penetrate conditions that obstruct normal vision, such as darkness, fog, rain, and snow, and measure the range to an object, which is its key attribute. Everything generates sound waves due to its effect on the flow of air and its natural frequency. These frequencies are beyond the range of human hearing. Ultra-sonic waves, with a frequency range of around 20,000 Hz, can be detected by an ultrasonic sensor, providing us with valuable information. The ultrasonic sensor is a proximity sensor that is used to measure distance of a target or object. The servo motor is a simple DC motor that can be controlled for specific angular rotation with the help of additional servomechanism. This motor will only rotate as much we want and then stop. The servo motor is a closed-loop mechanism that uses positional feedback to control the speed and position.

3 DESIGNING THE RADAR SYSTEM

3.1 BLOCK DIAGRAM

Figure 1: Block Diagram

3.2 COMPONENTS:

- ARDUINO UNO 3 :- The Arduino UNO is a microcontroller board that features the ATmega328P chip. It has 14 digital input/output pins, of which 6 have PWM capability, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. All the components needed to support the microcontroller are integrated into the board, and it can be connected to a computer via USB or powered with an AC-to-DC adapter or battery. With the UNO, you can experiment freely without the fear of damaging it as the chip can be easily replaced for a low cost in case of any accidents.

- ULTRASONIC SENSOR:- The name "ultrasonic" refers to the chirp that ultrasonic sensors typically generate between 23 kHz and 40 kHz, which is substantially higher than the 20 kHz audible range for humans. They gauge how long it takes for sound to bounce off an item using this chirp. This is based on the same fundamental echolocation concepts that bats utilise to locate their prey. Given that sound travels at a speed of 343 metres per second in air at room temperature, the distance between the object being sensed and the source of the ultrasonic chirp may be simply calculated.

- SERVO MOTOR :- A servo motor is a kind of motor that has extremely precise rotational capabilities. This type of motor typically has a control circuit that gives feedback on the motor shaft's present location. This feedback enables the servo motors to rotate very precisely. A servo motor is used to rotate an object at predetermined angles or distances. It consists of of a straightforward motor that drives a servo mechanism. Servo Motor Mechanism It consists of three parts : 1. Controlled Device 2. Output Sensor 3. Feedback Sensor

  It is a closed-loop system that employs a positive feedback mechanism to regulate motion and the shaft's ultimate position. A feedback signal created by comparing the output signal with the reference input signal in this case controls the device.

- RASPBERRY PI :- Raspberry Pi is a series of small, single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and developing countries. The Raspberry Pi can be used for a variety of projects such as media centers, gaming devices, and home automation systems. It is popular among hobbyists, students, and educators due to its affordability, versatility, and ease of use.

- 7 INCH RASPBERRY PI SCREEN :- The Raspberry Pi 7-inch touchscreen display is a popular accessory for the Raspberry Pi single-board computer. It features a resolution of 800 x 480 pixels and connects to the Raspberry Pi using a ribbon cable. The display is compatible with all Raspberry Pi models and provides a convenient, compact, and portable way to interact with the Raspberry Pi without requiring a separate keyboard or mouse. It can be used for a variety of projects such as digital signage, home automation interfaces, and portable gaming devices. The display is also relatively easy to set up and configure, making it a great option for beginners and experienced users alike.

- POWERBANK :- A power bank is a portable battery pack that can be used to supply power to electronic devices. It is a convenient and versatile power source for electronics projects that require mobility or are located in areas without a reliable power source. Power banks are available in a variety of capacities, sizes, and shapes, and can be charged through a USB port or wall outlet. When selecting a power bank for an electronics project, it is important to consider the voltage, current, and capacity requirements of the project to ensure compatibility and sufficient power supply. Power banks can also be useful for powering mobile phones, tablets, and other portable devices on-the-go.

- LCD DISPLAY :- Liquid Crystal Display (LCD) is a type of flat screen that operates using liquid crystals. These displays have become a staple in various consumer and business products, including smartphones, televisions, computer monitors, and control panels. They are an improvement over previous display technologies like LED, gas-plasma displays, and cathode ray tubes because they are thinner and consume less power. Unlike LED displays, which emit light, LCD displays produce an image by blocking light with the use of a backlight and liquid crystals.
- BREADBOARD: - A breadboard is a plastic board with a series of small holes. These holes serve as a convenient way to insert electronic components and construct a preliminary version of an electronic circuit. The circuit may include a battery, switch, resistor, and an LED, which is a type of light-emitting diode. The breadboard is an essential tool for prototyping electronic circuits.
- 3-D PRINTED BASE : We've opted for a personalized 3D printed foundation to contain both the servo and ultrasonic sensor.

3.3 WORKING PRINCIPLE:

The purpose of this project is to determine the location and speed of an object in relation to an ultrasonic sensor. The ultrasonic sensor uses a servo motor to rotate and send ultrasonic waves in various directions. These waves travel through the air, reflect off of objects, and are captured by the sensor. The data from the reflection is analysed, and the results are displayed on the screen, including the distance and position of the object. The Arduino IDE is utilized to write and upload the code that monitors the position of the servo motor and sends the information, along with the distance of the nearest object, to the serial port. The processing software is then used to display the final output on the screen.

3.4 CIRCUIT DIAGRAM :

3.5 ALGORITHM :

ALGORITHM 1 - FOR THE DISPLAY AND ARDUINO TO WORK :

1. Include the Servo and LiquidCrystal libraries.
2. Declare the pins used for the LCD and Ultrasonic sensor as global variables.
3. Create an instance of the LiquidCrystal class.
4. Define the trigPin and echoPin for the Ultrasonic sensor.
5. Declare variables for duration, distance, distanceCm, and DistanceSec.
6. Create an instance of the Servo class and attach it to the corresponding pin.

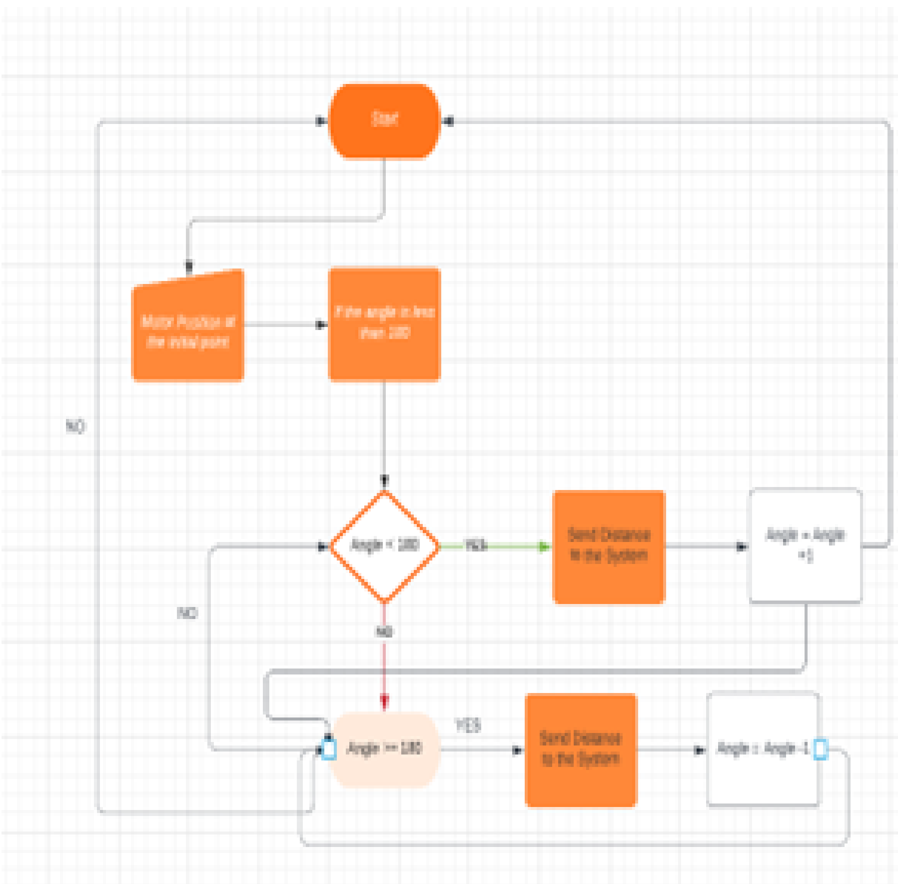

Figure 2: Flowchart Mechanism

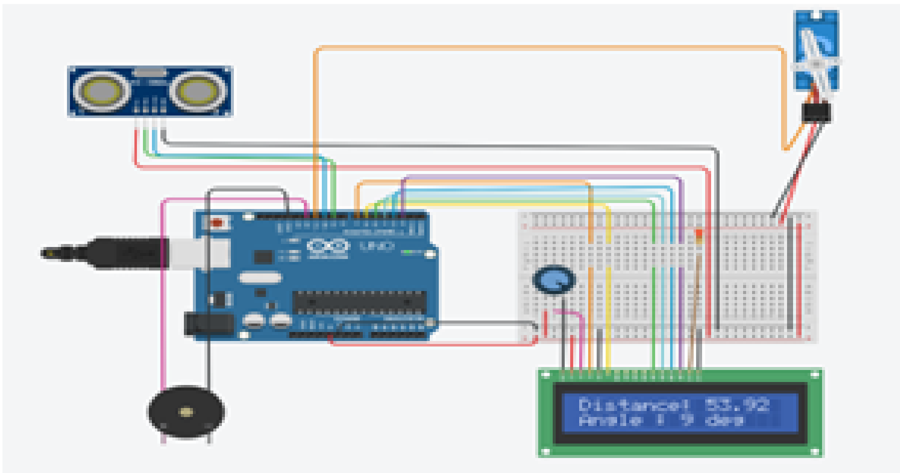

Figure 3: Circuit Diagram

7. In the setup() function:
• Set the trigPin as an output and the echoPin as an input.
• Begin the serial communication at a baud rate of 9600.
• Initialize the LCD object and set the number of columns and rows.
• Set the DistanceSec variable to 20.
8. In the loop() function:
• Use a for loop to rotate the servo motor from 15 to 165 degrees in steps of 1 degree.
• Inside the for loop, call a function called calculateDistance() to calculate the distance measured by the Ultrasonic sensor.
• Send the current degree and distance values over the serial port.
• Calculate the distance in centimeters and store it in the distanceCm variable.
• If the distance is less than or equal to the DistanceSec variable:
• If the distance is less than or equal to half of the DistanceSec, display the distance and angle on the first row of the LCD and wait for 2 seconds.
• Otherwise, display the distance and angle on the first row of the LCD and wait for 2 seconds.
• If the distance is greater than the DistanceSec, display the distance and angle on the first row of the LCD and wait for 80ms to read the position of the LCD.
• Use a for loop to rotate the servo motor from 165 to 15 degrees in steps of -1 degree.
• Inside the for loop, call the calculateDistance() function, send the current degree and distance values over the serial port, and display the distance and angle on the first row of the LCD based on the same conditions as before.

9. Define the calculateDistance() function:
• Set the trigPin to LOW for 2 microseconds.
• Set the trigPin to HIGH for 10 microseconds.
• Set the trigPin to LOW.
• Measure the duration using the pulseIn() function.
• Calculate the distance using the formula: distance = duration * 0.034 / 2.
• Return the distance value.

ALGORITHM 2 - PROCESSING CODE :

1. Import the libraries "processing.serial.*", "java.awt.event.KeyEvent", and "java.io.IOException".
2. Define the object "myPort" of the Serial class and create variables for angle, distance, and data as strings. Also, create variables for noObject, pixsDistance, iAngle, iDistance, index1, index2 as float and integers respectively. Define the font "orcFont".
3. Define the function "setup()" to set up the size of the canvas, to start the serial communication, and to read the data from the serial port up to the character ".".
4. Define the function "draw()" to draw the radar, line, object, and text on the canvas.
5. Define the function "serialEvent()" to read the data from the serial port up to the character "." and to convert the string variables angle and distance into integers.
6. Define the function "drawRadar()" to draw the arc lines and angle lines of the radar.
7. Define the function "drawObject()" to draw the object according to the angle and distance received from the Arduino board.
8. Define the function "drawLine()" to draw the line according to the angle received from the Arduino board.
9. Define the function "drawText()" to draw the text on the canvas showing the range of the object detected.
10. Call the functions "pushMatrix()" and "popMatrix()" to translate and rotate the shapes as required.
11. Use the "translate()" function to move the starting coordinates of the shapes to a new location.
12. Use the "stroke()" and "fill()" functions to set the color of the shapes.
13. Use the "line()" function to draw a line between two points.
14. Use the "arc()" function to draw an arc of a circle with a specified angle and radius.
15. Use the "text()" function to draw the text on the canvas.

4 RESULT :

The system described in the study report is composed of three main components: a servomotor, an ultrasonic sensor, and a microprocessor (Arduino). Its objective is to monitor the distance and orientation of objects and present this information in a graphical form. The output of the system is a graph generated by processing software, which gives an indication of its performance. By observing the graph, we can see how efficiently the radar recognizes and detects objects at different distances and levels. The monitor screen displays the results of the sensor's rotation and detection of obstacles, with the red region indicating the presence of an obstacle and the angle and distance.In the beginning, the processing code was executed on the Raspberry Pi, and the results were shown on the Raspberry Pi 7-inch screen. However, because of the Raspberry Pi Model 3b+ serial communication restriction, the code is now being run on a Linux machine instead. The obtained result is shown below:

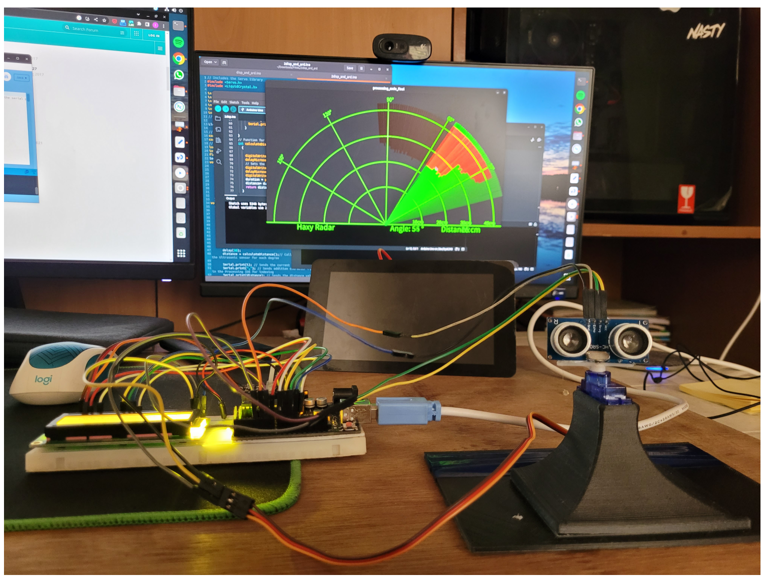

Figure 4: Circuit Diagram

5 CONCLUSION :

This paper outlines the creation and implementation of a short-range radar system that utilizes Arduino as the microcontroller. The system is capable of detecting objects and measuring their distance, making it a cost-effective and straightforward device for distance measurement. The simulation results were verified through manual examination and were found to provide accurate distance calculations with appropriate accuracy and resolution. The information is then transformed into a visual representation. This radar system has potential for further development and use in long-range applications.

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