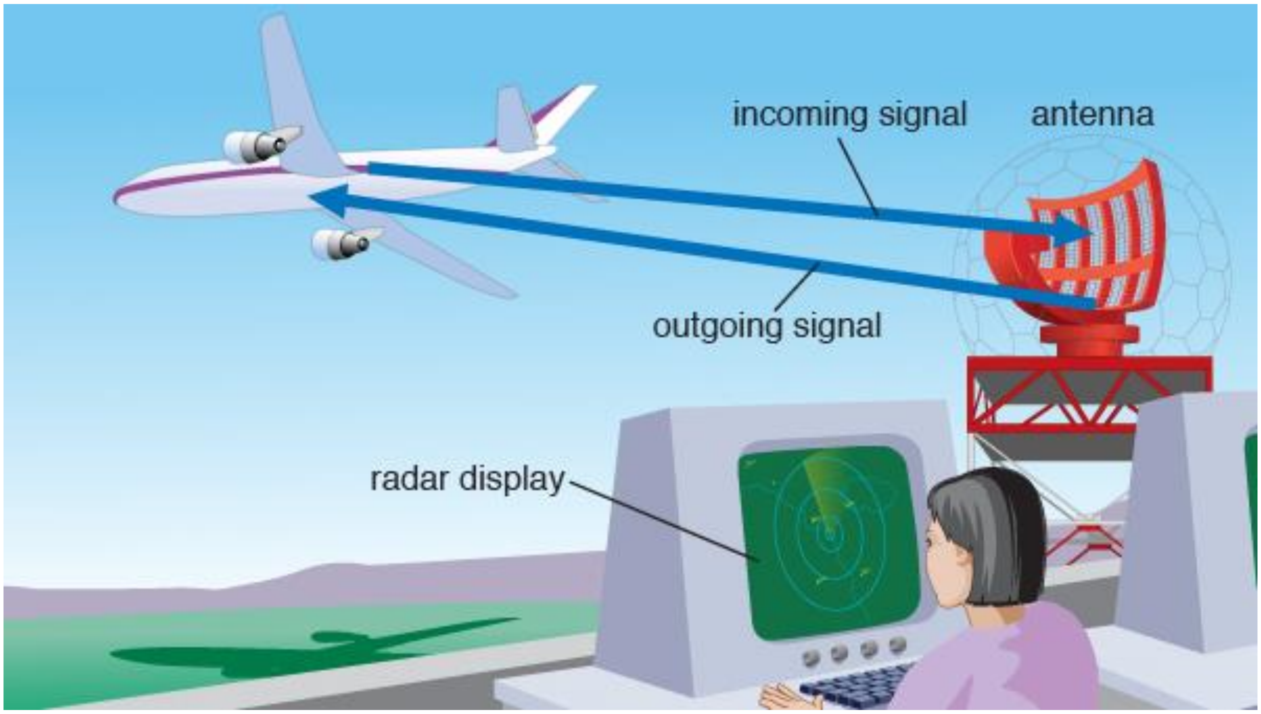

Final Project Report:

Radar System Using Arduino UNO and Ultrasonic Sensor

Table of Contents

Project Overview

This project focuses on developing a radar system using Arduino UNO and an ultrasonic sensor. The system can detect objects, measure their distance, and display their position on a screen. This project aims to provide a cost-effective, educational demonstration of radar technology principles.

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Introduction to Radar System

Radar is a long-range object detection system that uses radio waves to determine parameters such as range, speed, and position of an object. This project employs sonar technology using an ultrasonic sensor to detect objects within a specific range, simulating radar functionality.

Radar systems typically use microwaves to determine the range, altitude, direction, or speed of objects. These waves bounce off objects in their path, allowing the radar to detect and measure objects within its range.

Principle of Operation

Radar systems operate by transmitting a signal that reflects off an object and returns to the radar receiver. The time delay between transmission and reception, along with the angle of the returned signal, allows the system to calculate the object's distance and position. Doppler radar systems also measure the frequency shift of the returned signal to determine the object's speed.

Components and Their Description

Hardware

- Arduino UNO: A microcontroller used to process data and control the system.
    - Specifications: ATmega328P microcontroller, 14 digital I/O pins, 6 analog input pins, 32 KB flash memory.
    - Role: Acts as the brain of the radar system, processing input from the sensor and controlling the servo motor.

- HC-SR04 Ultrasonic Sensor: Measures the distance to objects using ultrasonic waves.
    - Specifications: Operating voltage 5V, measuring angle 15 degrees, ranging distance 2 cm to 400 cm.
    - Role: Sends out ultrasonic waves and receives the reflected waves to measure distance.

- Tower Pro SG90 Servo Motor: Rotates the ultrasonic sensor to scan the area.
    - Specifications: Operating voltage 4.8V-6V, torque 2.5kg/cm, rotation angle 0° to 180°.
    - Role: Moves the ultrasonic sensor to different angles for scanning.

- Mounting Bracket for Ultrasonic Sensor: Holds the sensor in place.
    - Role: Provides stability and positioning for the ultrasonic sensor.

- Jumper Cables + USB Cable (for Arduino): Used for connections and power.
    - Role: Facilitates the connection of components and power supply.

Software

- Arduino IDE: Platform for writing and uploading code to the Arduino.
    - Features: Code editor, serial monitor, integrated libraries for various sensors and actuators.
    - Role: Develops and uploads the control code to the Arduino UNO.
- Processing Application: Software for visualizing the radar data.
    - Features: Graphics library, serial communication capabilities, interactive display.
    - Role: Receives data from the Arduino and displays it in a visual format.

Ultrasonic Sensor

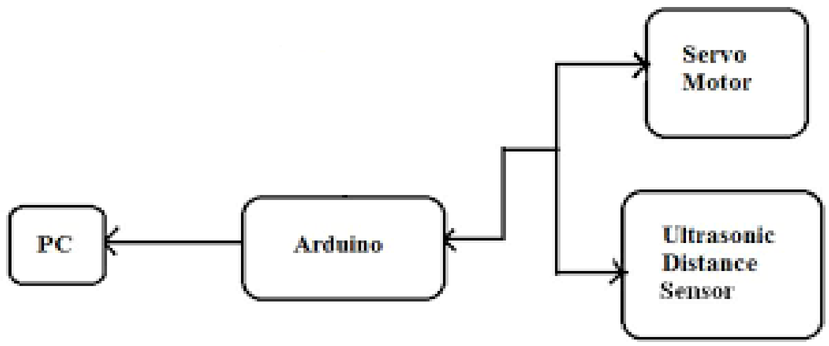
The HC-SR04 ultrasonic sensor determines the distance to a target object. It has a transmitter that converts electrical signals to ultrasonic waves and a receiver that converts the reflected waves back into electrical signals. It operates at 4 MHz and has a detection range of 2 cm to 400 cm.

Servo Motor

The Tower Pro SG90 servo motor operates on +5V and has a torque of 2.5kg/cm. It rotates between 0°-180° to allow the ultrasonic sensor to scan the area.

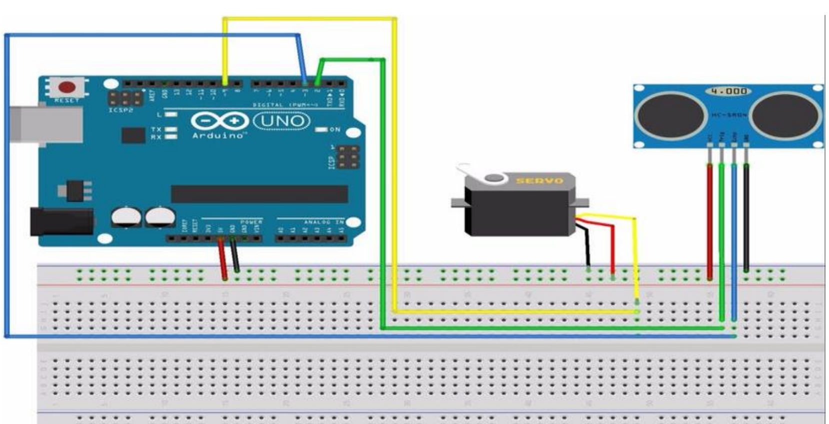
Block Diagram

Below is a simplified block diagram illustrating the connection between the components:



Circuit Diagram

Here is the basic circuit diagram for the radar system:



Working Principle

The system's objective is to determine the distance, position, and speed of obstacles. The ultrasonic sensor sends out waves and detects the reflected waves from objects. The Arduino processes these signals and determines the distance and angle of the object. This data is displayed on a screen using the Processing application.

Detailed Working Steps

1. **Initialization:** The Arduino initializes the servo motor and sets the ultrasonic sensor pins as input and output.
2. **Scanning:** The servo motor rotates the ultrasonic sensor from 0° to 180°, pausing at each step to take a distance measurement.
3. **Distance Measurement:** At each step, the ultrasonic sensor sends out a 40 kHz pulse. The time taken for the echo to return is measured.
4. **Data Processing:** The Arduino calculates the distance based on the time delay and sends this data, along with the angle, to the Processing application via serial communication.
5. **Visualization:** The Processing application plots the distance and angle on a polar coordinate system, creating a real-time radar display.

Arduino Code

```
#include <Servo.h>

#define TRIG_PIN 9
#define ECHO_PIN 10
#define SERVO_PIN 11

Servo myServo;
int pos = 0;

void setup() {
  Serial.begin(9600);
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  myServo.attach(SERVO_PIN);
}

void loop() {
  for(pos = 0; pos <= 180; pos += 1) {
    myServo.write(pos);
    delay(20);
    long duration, distance;
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    duration = pulseIn(ECHO_PIN, HIGH);
```

```
    distance = (duration / 2) / 29.1;
    Serial.print(pos);
    Serial.print(",");
    Serial.println(distance);
    delay(100);
  }

  for(pos = 180; pos >= 0; pos -= 1) {
    myServo.write(pos);
    delay(20);
    long duration, distance;
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    duration = pulseIn(ECHO_PIN, HIGH);
    distance = (duration / 2) / 29.1;
    Serial.print(pos);
    Serial.print(",");
    Serial.println(distance);
    delay(100);
  }
}
```

Processing Code

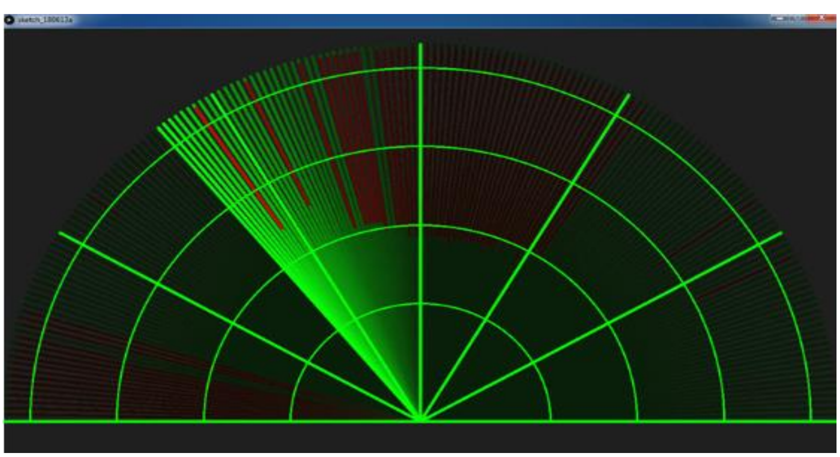
```
import processing.serial.*;

Serial myPort;
String data;
float angle, distance;

void setup() {
  size(800, 800);
  myPort = new Serial(this, "COM3", 9600); // Adjust COM port as necessary
}

void draw() {
  background(0);
  fill(0, 255, 0);
  translate(width/2, height/2);
  ellipse(0, 0, 10, 10);
  if (myPort.available() > 0) {
    data = myPort.readStringUntil('\n');
    if (data != null) {
      data = trim(data);
      String[] values = split(data, ',');
      if (values.length == 2) {
        angle = float(values[0]);
        distance = float(values[1]);
        float x = cos(radians(angle)) * distance;
        float y = sin(radians(angle)) * distance;
        ellipse(x, y, 10, 10);
      }
    }
  }
}
```

Problem Statement

With the invention of airplanes, there arose a need for an instrument to detect their location and time. Radar systems were developed to detect aircraft in the air, and these systems are now crucial for defense, air-traffic control, and many other applications. Early radar systems were large, expensive, and limited in functionality. Modern radar systems have evolved to be more compact, cost-effective, and versatile, but there remains a need for educational tools to demonstrate the basic principles of radar technology in an accessible manner.

Key Points and Improvements

- **Integrated Power Supply:** Instead of providing a different voltage source for operating the ultrasonic sensor and servo motor, we have used supply from the microcontroller. This reduces the cost and complexity of additional voltage supplies.
- **Improved Output Display:** The output screen now shows the accurate distance as well as the angle of the object, displayed using a polar coordinate system, which is much more precise compared to previous versions.



Applications

Radar is an electromagnetic system for the detection and location of target objects such as aircraft, ships, spacecraft, vehicles, people, and the natural environment. It uses electromagnetic radio waves to determine the angle, range, or velocity of objects. The modern radar system is more advanced, and the uses of radar are highly diverse, including:

- **Air Traffic Control:** Ensuring the safe and efficient movement of aircraft.
- **Defense Systems:** Detecting and tracking potential threats.
- **Weather Monitoring:** Tracking weather patterns and predicting storms.
- **Automotive Safety:** Providing features like adaptive cruise control and collision avoidance.

Future Enhancements

- **Enhanced Range and Accuracy:** Upgrading the ultrasonic sensor to one with a higher range and accuracy.
- **Multiple Sensors Integration:** Using multiple sensors to cover a larger area and provide more detailed data.
- **Advanced Data Processing:** Implementing machine learning algorithms to predict the behavior of detected objects.
- **Real-Time Data Transmission:** Integrating wireless communication modules to transmit data to remote systems in real-time.

Conclusion

This project demonstrates the basic principles of radar technology using cost-effective components and open-source software. By integrating an ultrasonic sensor with Arduino UNO and displaying the data using Processing, we have created a functional radar system capable of detecting and measuring the distance and position of objects. This project serves as an educational tool for understanding radar technology and its applications.

References

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