

# Radar and Missile Defense System using Arduino Uno

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## Abstract

Modern in that which defense technologies use is radar for early identification and tracking of aerial threats. But what we see in the real world is that radar and missile defense systems are very complex and of great financial scale which in turn makes them unavailable for academic research. In this paper we present our design and development of a low-cost prototype of a Radar and Missile Defense System which we used Arduino UNO for. We used an ultrasonic sensor which we put on a servo motor to do the job of angular scan which in turn simulates the radar-based object detection. Upon an object entering what we have defined as the threat range the system we have put in place is to activate what we have for safe and non-lethal response which is in the form of visual and audio alerts to simulate interception. The prototype we present is of real time detection, angular tracking and has in it automated response logic also we did this in a safe and very much educational way.

## 1. Introduction

Radar (which is Radio Detection and Ranging) plays a key role in national security, aviation safety, and surveillance. They do this by identifying objects, measuring distance, and tracking movement in real time. In the case of missile defense systems this is taken a step further by which they identify threats and put in counter measures.

Due to the high price and technical complexity of real radar and defense systems student and researcher often don't, have what they need for practical study. This project we are doing is to close that gap in access by way of a simplified radar defense prototype which

we are building out with Arduino Uno and ultrasonic sensors. We are not in the business of making weapons here but of academic simulation. The system we are putting together will safely demonstrate the principles of detection, tracking, decision making, and automatic response using low-cost electronics.

This research reports on the creation of a low cost, simple radar and defense simulation prototype that we developed out of a vacuum for greater theory to real world application. In this work's design we present a system that models basic object detection which is done by means of a time-of-flight principle we are not using electromagnetic waves, rather we are using ultrashort pulses of sound from the ultrasonic sensors. We are also including a servo motor component for the creation of a moving, full field of view as is characteristic of a radar. Finally, the prototype serves as a platform to present automated defense response we have included systems to indicate a threat without going into the realm of lethal means at the first report of preprogrammed risks. The prototype we have put together is able to perform radar sweep motion over a determined field of view with the help of a servo motor which does the job of angular scan. We have put in place automatic defensive features which trigger safe and non-lethal alert systems when an object enters into what we have defined as the threat zone. This project's aim is to present the basic engineering principles of detection, tracking.

## 2. Problem Statement

Typically, advanced radar and missile defense systems are prohibitively expensive for small research teams or class projects Most teaching tools are based on simple object

detection only and do not implement anything for an automated response.

The world now has a desperate need for an inexpensive radar prototype that can scan in real time, track angles, simulate defense response safely, and be small enough to carry anywhere.

This project offers a practical, portable radar-defense simulation system made of inexpensive, embedded hardware and fully functional. It is designed for students or researchers to experiment with radar and defense concepts without breaking the bank.

### 3. System Design and Methodology

#### 3.1 System Architecture

The structure of the system has three main components:

- Input Module – An ultrasonic sensor combined with a servo motor
- Processing Module – An Arduino Uno microcontroller
- Output Module – LEDs, a buzzer, and a display interface (optional)

#### 3.2 Radar Scanning Mechanism

A servo motor that can spin from  $0^\circ$  to  $180^\circ$  is placed above the ultrasonic sensor (HC-SR04). The time for the sound waves to bounce back from an object is recorded continuously. Using time-of-flight, distance is calculated. The motor provides the system with the ability to perform remote distance and angle measurements, in the form of polar coordinates angle measurements, in the form of polar

#### 3.3 coordinates., Threat Detection Logic

- A certain distance is set for the “threat zone” (e.g., 30 cm).
- If an object enters this zone:
- The sensor data is processed by the Arduino
- A buzzer sound
- LEDs are triggered to indicate an alert
- A simulated interceptor (servo mechanism) is activated
- This response is entirely non-lethal and is for educational simulation purposes.

#### 3.4 Data Visualization

The following can be used to create a radar-like visualization:

- Arduino Serial Plotter
- Analytics of Processing IDE
- A GUI (Graphical User Interface) in Python
- An LCD screen to show distance in real time
- This assists in the visualization of object tracking by the user, in the most dynamic fashion.

## 4. Implementation

### Hardware Components used

#### 1. The Arduino Uno

This prototype's brain is the Arduino Uno, which is the main microcontroller board. It performs all the functions, such as distance calculations, sensor data acquisition, and device activation (buzzers and LEDs), all of which require processing. This board operates like the prototype's central nervous system.



Arduino Uno

#### 2. HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor detects the distance of an object as it uses the time-of-flight principle for echo location. It does this by emitting sound waves and measuring the time it takes for the echo to return. This is how it objects are detected in the radar simulation.



Ultrasonic Sensor (HC-SR04)

#### 3. SG90 Servo Motor

The SG90 Servo motor ultrasonic sensor will rotate from  $0^\circ$  to  $180^\circ$  and therefore can be used for radar type scanning to detect and quantify objects within a wide angular range



Servo Motor (SG90)

#### 4. Buzzer

The system will detect an object and consider it a potential threat by triggering the buzzer that acts as an audio indicator.



**Buzzer**

#### 5. LEDES

Detection of an object will cause the LEDs to light up to indicate that an alert is in place or an interception simulation is active.



**LEDES**

#### 6. , Breadboard & Jumper Wires

To connect prototype circuits, you can use breadboards and jumper wires. They allow you to connect and disconnect circuits without soldering.



**Breadboard & Jumper Wires**

#### 7. USB/Battery Power Supply

The power supply is the prototype's source of electricity. It can be powered by a USB cable, or a battery, allowing it to be portable and user-friendly.



**USB/Battery Power Supply**

#### Software Tools

- Arduino IDE
- Embedded C Programming
- Optional: Processing IDE / Python GUI
- Thefirmwarewasdesigned to implement:
- Continuous scanning
- To reduce latency between detection and response was a priority.

#### 5. Results and Observations

Successful demonstrations included:

- Real-time object detection at 2 to 40 cm range
- Real-time servo angular sweep
- Instant alert activation on crossing the threshold Value of embedded systems for real-time control
- Functionality under controlled lab environment.

#### Performance Metrics

- Accuracy of Detection: High within short distance
- ResponseTime: Below 200 milliseconds
- False Alarm Rate: Low after calibration
- Power Usage: Low.

#### Limitations observed include:

- Short distance detection capability
- Surface sensitivity
- Environmental noise (temperature).

#### 6. Applications

While designed based on military principles, this sensor has wider application scope:

- Laboratory demonstrations
- Robotics obstacle sensors
- Automotivecollision prevention sensors
- Surveillance sensor devices
- STEM project demonstrations
- Safety systems for industries

## 7. Ethical and Safety

### Considerations

In this project, we do not design any weapon system.

Our project is strictly educational.

Our project only demonstrates some of the key aspects of radar, such as the radar principle, the way radar detects targets and tracks them, and how radar responds to different targets.

We do not develop any real weapon systems.

## 8. Conclusion

In summary, this project has been designed and successfully simulated using the Arduino Uno to design a radar and missile defense system at low cost. We have designed and simulated a system that mimics all of the key features of a radar,

including detection, tracking, and response functions. In this project, we have successfully bridged theory and practice. Our project will help students learn more about embedded systems and the fundamental principles of radar systems, which are widely used in many industrial applications. Even though our project only uses low-cost devices to simulate an efficient system, the system we have built gives us useful information on radar detection and responses. In addition, it can be developed further to simulate more complex surveillance and safety systems.

Despite the simplicity of this project in comparison to the practical applications of defense radar systems, the design has been successful in bridging the divide between theory and practice. The design provides the users of the technology hands-on knowledge of sensory technology, automated controls, and system optimization under limited resources. Furthermore, the design itself is scalable, which will allow for future upgrades like wireless communications and simple object classification.

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