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# ULTRASONIC SONAR SYSTEM FOR DEFENSE APPLICATION USING IoT

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## ABSTRACT

The Ultrasonic Sonar System controlled by Arduino and ESP32 cam is designed to detect objects within its range. It consists of two ultra-sonic sensors, a servo motor, an ESP32 cam controller, and an IoT interface. The ultrasonic sensor is attached to the servo motor, which rotates 180 degrees on either side, covering a 360-degree field of view. The system provides a visual representation of objects' angles, positions, and distances on a software called Processing IDE, based on Java programming.

The system is controlled through Arduino, which interfaces with the sensor and display device. The ESP32 cam, an IoT-based microcontroller with a built-in Camera Module, sends live streaming to a local IoT server. The system also includes an automatic laser shooting mechanism.

The Ultrasonic Sonar System has applications in navigation, positioning, object identification, mapping, spying or tracking, shooting, and other fields. It is suitable for indoor applications and is a cost-effective solution for those looking to implement obstacle-detection systems. Overall, this system provides an effective solution for detecting objects within a defined range.

Keywords: Arduino Nano, Ultrasonic sensors, ESP32 Cam, Servo motor, Lasers, LEDs.

## I. INTRODUCTION

We know everything produces sound waves just by the existence and effect flow of air around them with their natural frequency. These frequencies are beyond the hearing range of humans. An ultrasonic wave is a wave with a frequency range of 20Khz or less that may be detected by an ultrasonic sensor and used to obtain various pieces of information. An Ultrasonic detector usually has a transducer that converts sound energy into electrical energy and electrical energy into sound energy. They are used to measure object orientation and positioning, as well as in collision avoidance and surveillance systems. Ultrasonic technology alleviates challenges such as linear measurement problems by allowing users to obtain non-contact measurements of the distance between an object and its surroundings. The speed of travel of sound waves depends upon the square root of the ratio between medium density and stiffness. Also, the property of the speed of sound can also be changed by natural environmental conditions like temperature. In essence, an ultrasonic sensor emits ultrasonic waves that travel through the air and are reflected when they strike an item. By evaluating the property of the reflected wave, we can learn about an object's distance, position, and speed. Processing and Arduino software is used in conjunction with the hardware system to detect the object's numerous parameters. One of the most common applications of the ultra-sonic sensor is range finding. It is also known as sonar, which is similar to

radar in that ultrasonic sound is sent in a specific direction and if there is any item in its route, it impacts it and is reflected back, allowing us to calculate the distance of an object. Bats utilize this technique in the dark.

## II. EXISTING SYSTEM

The radar system described is limited in its ability to detect objects, as it can only scan within a range of 0 to 180° due to the constraints of the servo motor. However, an alternative

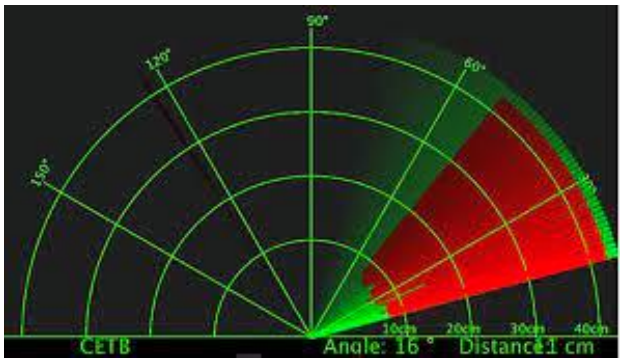


Fig.1 180 degrees radar sketch

system that can map an environment more comprehensively is the ultrasonic radar system. This system employs sensors to collect information about the environment and then uses this data to create a visual representation of the surroundings. The system is designed using an Arduino Uno, a servo motor, and an ultrasonic sensor. The ultrasonic sensor is capable of detecting obstacles in its field of view and converting this information into a visually representable form. The system can be used for applications such as obstacle avoidance in robotics or mapping environments in industrial settings, where a comprehensive understanding of the surroundings is critical.

## III. DESIGN IMPLEMENTATION OF ULTRASONIC SONAR SYSTEM

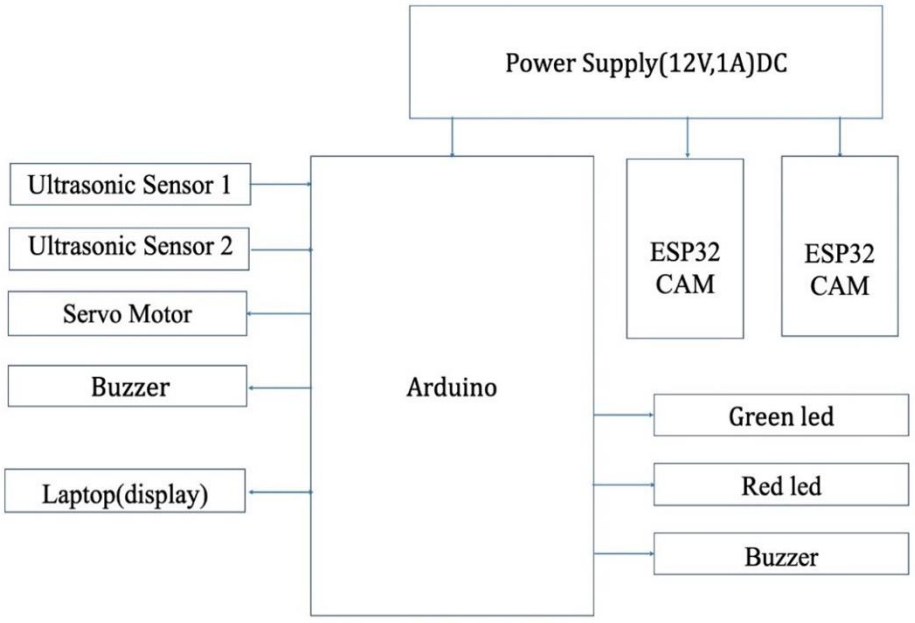


Fig.2 Block diagram of Ultrasonic sonar system

## A. Design of the hardware system for the Arduino

Three main parts make up the hardware system: an Arduino Nano, a servomotor, and an ultrasonic sensor. A servo motor is supported by an ultrasonic sensor, allowing it to move and act as a turning mechanism. Arduino is used to powering and operating both the servo motor and the ultrasonic sensor. The servo motor and ultrasonic sensor are both powered by Arduino and an external power supply.

## B. System circuit design

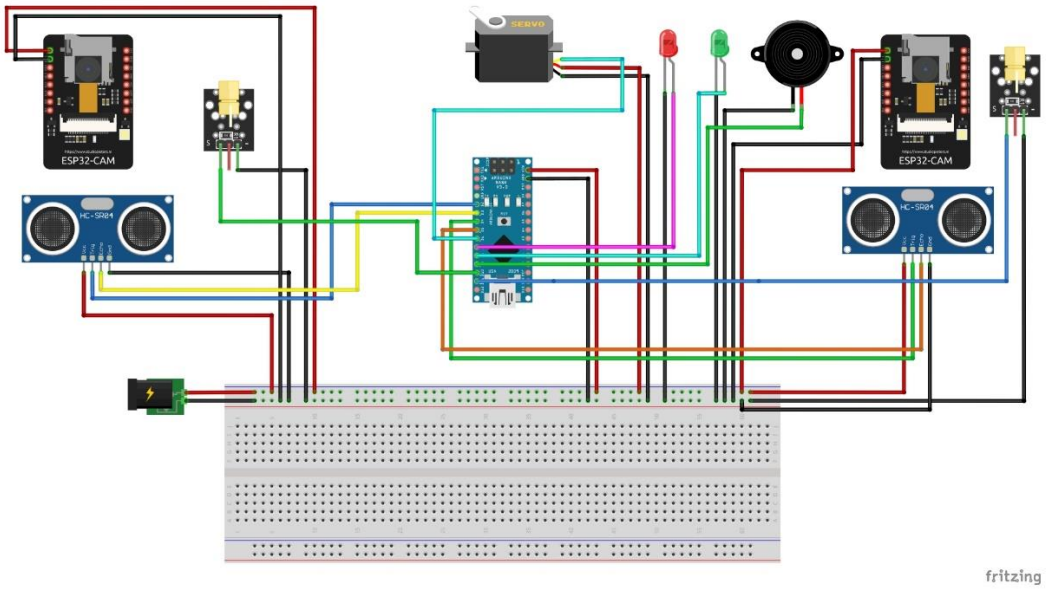


Fig.3 Schematic diagram

The figure shows the hardware system design which was designed using fritzing environment. It shows the connection of different electronic components.

## C. System circuit implementation

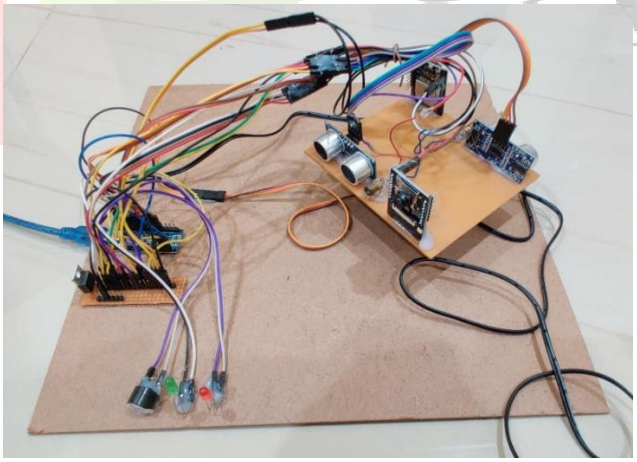

Fig.4 Circuit diagram

## D. Hardware system testing

For the purpose of component communication, an Arduino board was connected via cable to a laptop. We were able to get results in the monitor thanks to the Arduino IDE.

### E. GUI system design and implementation:

GUI was built using Java programming, Processing IDE gives the visual representation and also the angle or position of the object.

## IV. WORKING

### FLOW CHART

- When we give the power supply, the servo motor starts to rotate from 0 to 180 degrees.
- At the same time, the two ultrasonic sensors start to work and scan the areas within their range and detect the objects by sending sound waves.
- The US1 rotates from 0 to 180 degrees and the US2 rotates from 180 to 0 degrees covering a total of 360 degrees.
- The two ESP32 Cam placed on either side comes with a built-in camera module that sends the live streaming to a local IoT server.
- If the object is in the range of the ultrasonic sensor i.e. 40cm then the green led goes off and the red led lights up if the object comes too close then the buzzer starts to ring and indicates the angle and distance of the object in the Processing IDE.
- If the object is not in the range of the ultrasonic sensor i.e. 40cm then the green led is on, and the red led is remain off and this process continues.

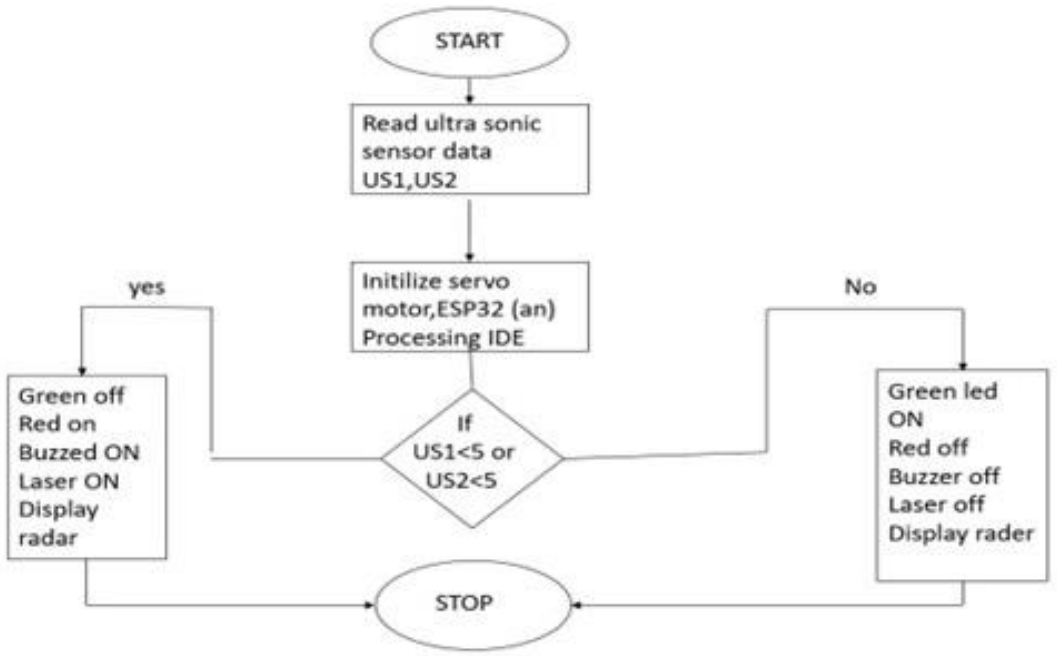


Fig.5 Flow chart

## V. PROPOSED SYSTEM

The ultrasonic sonar system is an effective way to identify objects within its field of view. By using sound waves, an ultrasonic sensor can detect the presence of objects in the environment. In this system, two ultrasonic sensors are placed on opposite sides of a servo motor, providing complete 360° coverage. The data collected by the sensors is processed using the Processing IDE, which creates a visual representation of the environment. Additionally, the system includes an ESP32 Cam with a built-in camera module that sends live streaming to a local IoT server. This feature can be used for remote monitoring or surveillance. Finally, the system includes an alerting mechanism that can be triggered if an object is detected within a certain range. The ultrasonic sonar system has a wide range of potential applications, including robotics, security, and environmental monitoring.

# VI. HARDWARE DESCRIPTION

## SERVO MOTOR

A servo motor is a type of rotary actuator that allows for precise control of angular position, velocity, and acceleration. It uses feedback to accurately position the motor shaft, making it an ideal choice for applications that require precise and repeatable movement. A servo motor consists of a DC motor, a control circuit, and a position feedback device such as a potentiometer. The control circuit receives signals from a controller and adjusts the motor's rotation to achieve the desired position. Servo motors are widely used in robotics, automation, and other industries that require precise control of motion.

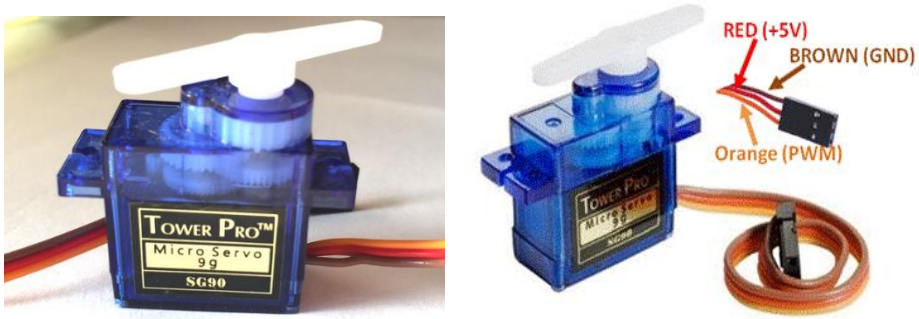


Fig.6 Servo motor

## ULTRASONIC SENSOR

An ultrasonic sensor is a device that uses sound waves at a frequency higher than the human ear can detect to measure distance or detect objects. It emits a high-frequency sound wave and then measures the time it takes for the wave to bounce back after hitting an object, which can be used to determine the distance to that object. Ultrasonic sensors are commonly used in industrial automation, automotive, and security systems for object detection, obstacle avoidance, and distance measurement. They are reliable, accurate, and can detect objects regardless of their color or transparency.


Fig.7 Ultrasonic sensor

## ARDUINO NANO

Arduino Nano is a small and compact microcontroller board that is based on the ATmega328P microcontroller. It is similar to the Arduino Uno but is smaller in size and comes with a surface-mount USB port, making it more suitable for projects where space is a constraint. The board has 14 digital input/output pins, 6 analog inputs, and a 16MHz clock speed. It also has a built-in voltage regulator, allowing it to be powered by a variety of sources, such as a USB cable, battery, or an external power supply.

Arduino Nano can be programmed using Arduino Software (IDE), which is a free, open-source software platform for programming microcontrollers. It has a wide range of applications and can be used for various projects, such as robotics, automation, and sensing.

Fig.8 Arduino Nano

**ESP32 CAM**

ESP32 Cam is a powerful IoT-based microcontroller with a built-in Camera Module, making it ideal for projects that require video streaming or image capturing. It is based on the ESP32 chip and comes with a variety of built-in features, such as Wi-Fi and Bluetooth connectivity, GPIO pins, and a dual-core processor with a clock speed of up to 240 MHz.

One of the key features of the ESP32 Cam is its ability to stream live video over the internet. It can be programmed using the Arduino IDE or the ESP-IDF (Espressif IoT Development Framework), making it easy to get started with. Additionally, it comes with a variety of software libraries and tools that make it easy to connect to sensors and other peripherals.

ESP32 Cam has a wide range of applications, such as surveillance systems, remote monitoring, and video conferencing. It can also be used for object detection and recognition, face detection, and other machine-learning tasks.


Fig.9 ESP32 Cam

## VII. RESULT

**ULTRASONIC SENSOR OUTPUT**

- Ultrasonic sonar sensors work on the principle called Trigger and Echo, the transmitter sends a bunch of pulses and gets reflected if any object is detected.
- We can calculate the distance of the object by using the formula Distance=(speed*time)/2.

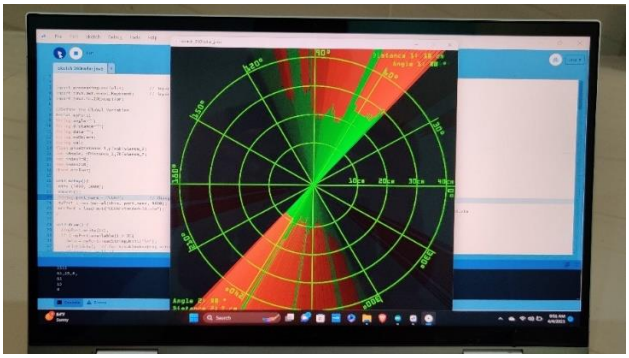

Fig.10 360degree sketch radar

- The position and angle of the object are indicated on the laptop screen with the help of Processing IDE.

**ESP32 CAM OUTPUT**

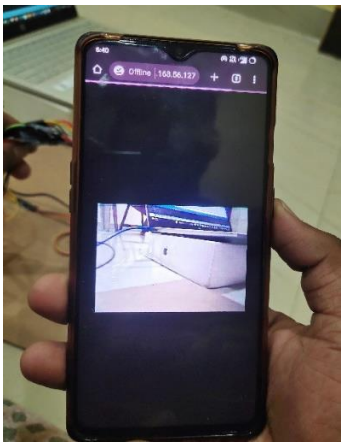

Fig.11 ESP32 CAM live streaming

- ESP32 Cam is an IoT-based microcontroller with a built-in Camera module that sends live streaming to a local IoT server.

**LED OUTPUT**

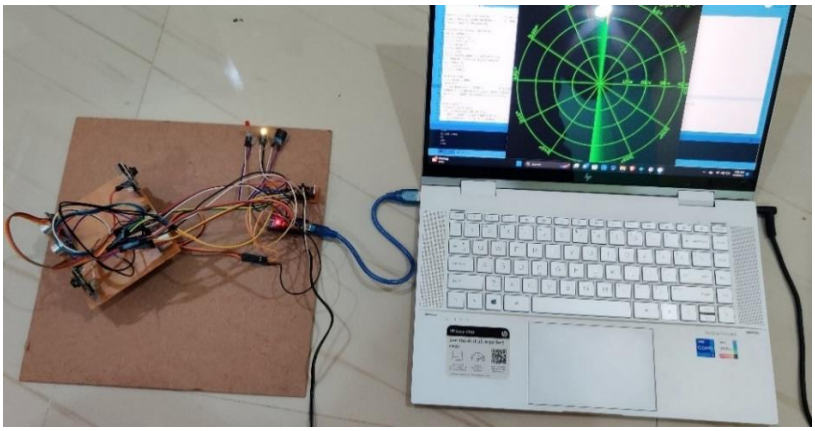

Fig.12 Green led on (safe state)

- The green led indicates the object if it comes near 40cm and if the object comes further closer like 10cm then the red led gets on and the buzzer rings.

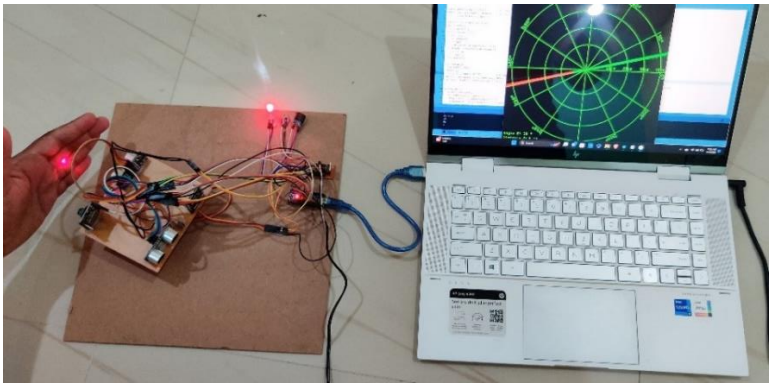

Fig.13 Red led on (Danger)

## VIII. ADVANTAGES

1. Ultrasonic sonar systems can operate in all weather conditions and have a long range.
2. They are effective in detecting underwater objects and can be used for reconnaissance.
3. They use IoT technology can enhance their performance and enable real-time monitoring.
4. Not affected by the color or transparency of objects.
5. Low-cost option and can be used in dark environments

## IX. CONCLUSION

In conclusion, the use of ultrasonic sonar sensors with IoT technology can offer significant benefits for defense applications such as surveillance, reconnaissance, and border security. The proposed project provides a cost-effective solution that leverages off-the-shelf hardware and software components, making it accessible for defense forces to implement. Incorporating additional features such as machine learning algorithms for anomaly detection and predictive maintenance can further enhance the system's capabilities. The Ultrasonic sonar sensor for defense applications using IoT projects has the potential to improve the security of the nation and strengthen the capabilities of defense forces.

## X. FUTURE SCOPE

There is significant potential for future developments and applications of ultrasonic sonar systems in various fields. The proposed project has the potential to be further developed and improved with advanced technologies such as AI and ML algorithms to enable automated threat response. Integration with drones can also enhance the capabilities of the system for aerial and underwater surveillance and reconnaissance. Additionally, future advancements in IoT and sonar technology can lead to more accurate detection and classification of underwater objects, including submarines. Networked sensors can also be deployed in a synchronized configuration to provide comprehensive coverage of an area. Overall, there are various opportunities for the proposed project to be further developed and expanded, making it an exciting area for future research and innovation.

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