



ULTRASONIC DETECTION SYSTEM

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Abstract: Radar is an electrical technology that locates either static or moving objects using electromagnetic radiation. Here, though, the radar system uses an ultrasonic signal rather than electromagnetic impulses with the aid of an ultrasonic sensor. In this project, an Arduino Uno, an ultrasonic sensor, a servo motor, and software are used to create an ultrasonic radar system that can identify and determine the location of an item within a limited distance. The ultrasonic radar's robotic angular rotation ranges from 0 to 180 and 180 to 0 degrees, and its object identification range is 40 cm. Through the use of processing software, the Arduino Uno serially connects with the display panel (computer) and uses written code to control the radar system. Particularly in the area of navigation, the use of radar systems has advanced significantly. We examined current navigation technologies in this study and suggested a radar system based on Arduino. Compared to other radar systems, it has the benefit of using less power and connecting to open-source code and a variety of Arduino or programming tools. The system consists of a simple ultrasonic sensor mounted on a servo motor that spins at a certain speed and angle. Both the Arduino digital input and output pins and the servo motor are linked to this ultrasonic sensor.

Keywords— Radar, Ultrasonic sensor, Servomotor, Arduino

1. Introduction:

RADAR is an object detecting system that uses radio waves to determine an item's range, speed, direction, and altitude. There are several sizes and performance specifications for radar systems. Some radar systems are used for air traffic. Control is used at airports and other areas for early-warning and long-range surveillance systems. Radar is the key component of a missile guiding system. Radar systems range from small, portable units that may be operated and maintained by a single person to large systems that occupy several large rooms [1]. During World War II, several nations secretly developed radar devices. The acronym for "radio detection and ranging," "RADAR," was originally adopted by the US Navy in 1940. The true evolution was not this. Since then, all capitalization has been removed from the word radar, which has become the standard phrase in English and other languages [2]. These days, radar is utilized in many other sectors, including astronomy, air traffic control, antimissile systems, and marine radars that locate land markers and other ships. Aircraft collision prevention, space, and marine surveillance technologies, as well as guided missile target-finding systems, ground-penetrating radar for geological research, flight control and altimetry systems, and meteorological precipitation monitoring systems [3]. Advanced radar systems that can retrieve important information from very high noise levels are connected to digital signal processing. Using an Arduino program and processing



software, a hardware system recognizes objects based on a number of criteria [4]. One of the most common applications for ultrasonic sensors is determining their range. Sonar, which uses ultrasonic sound and is the same as radar, is another name for it. It is travelling along a certain path, and if it hits something along the way, it hits it and bounces back, enabling us to determine the object's distance after figuring out how long it takes. In fact, bats use this tactic [5].

2. Literature Review:

In the year of 2015 Author Khatri et al. used an Arduino and an HC-SR04 ultrasonic sensor to create a basic obstacle detection system. Their research showed that it is possible to obtain precise distance measurements with inexpensive components [6]. Jones and Smith (2017) investigated the use of multiple ultrasonic sensors to enhance the accuracy and range of detection. Their research highlighted the challenges of sensor interference and proposed solutions to mitigate such issues [7]. The design of a robotic radar system using ultrasonic sensors and an Arduino controller was the main focus of Ikechi et al. (2020). They placed a strong emphasis on enhancing the accuracy of the system by using data processing algorithms and sensor placement optimization [8]. Garcia et al. (2016) explored the integration of ultrasonic sensors with other sensor types to enhance object detection capabilities in complex environments. They demonstrated that combining sensors could significantly improve detection accuracy and reliability [9]. Alizadeh et al. (2018) presented a detailed analysis of ultrasonic sensor performance in various environmental conditions. Their study provided insights into factors affecting sensor accuracy, such as temperature and humidity [10]. Javed et al. (2019) examined the use of machine learning algorithms to process ultrasonic sensor data. Their research showed that incorporating artificial intelligence could improve detection accuracy and adapt to new environments [11]. In order to produce intricate spatial maps, Kumar and Sharma (2020) created a 3D mapping system that makes use of several ultrasonic sensors. They illustrated how ultrasonic sensors may be used for sophisticated robotics and navigation applications [12]. Perez et al. (2021) analyzed the power consumption of ultrasonic sensors in continuous monitoring applications. Their findings highlighted the need for energy-efficient designs to prolong battery life in portable systems [13]. The influence of sensor location on the overall efficacy of object detection systems was investigated by Patel et al. in 2022. Their study recommended the best sensor configurations for various application situations [14]. The integration of ultrasonic sensors with IoT platforms for remote monitoring and real-time data processing was examined by Raza et al. in 2023. Their research showed how IoT connection might lead to improved system capabilities [15].

3. Design:

The Arduino Uno, USB, Servo Motor, Ultrasonic Sensor, and PC system are all included in the block diagram. The Arduino is attached to an ultrasonic sensor, which transmits a signal to the Arduino when it detects an object. In order to measure the velocity of sound in air, the ultrasonic sensor periodically generates high frequency sound waves. After striking the item, the waves are reflected back to the receiver. The sensor has a range of up to 40 cm and emits waves with a frequency of around 40KHz.



Figure 1: Block Diagram

In the sensor, the transmitter transforms electrical signals into ultrasounds, while the receiver transforms ultrasounds into electrical signals. Also helpful for 180-degree rotation is the ultrasonic sensor that is connected to the servo motor. After then, the servo motor spins constantly, causing the sensor to send out waves in all directions. Arduino provides the ultrasonic sensor with the pulse signal, which it receives and reflects back in a forward direction. To regulate the sensor's speed and angle, the Arduino is linked to the servo motor. Arduino C/C++ is then used to write the code. Arduino microcontrollers are particularly programmed using this C++ language version. The code makes use of the Arduino libraries, including Servo for servo motor control and the Arduino API's pin mode, digital write, delay, and serial print, among other features. To send data between the Arduino and

the PC system, the Arduino is linked to a USB port. Upon detecting the item, it reproduces the waves that are picked up by the sensor's receiver. After that, the reflected signal is directed back to the Arduino and the computer system, where the object's existence is shown on the spinning radar screen.

4. Simulation Parameters:

Table 1: Comparison of parameters

SL No.	Components	Range	Quantity
1	Ultrasonic Sensor	2cm – 40cm	1
2	Arduino Uno	-	1
3	Servomotor	0 – 180 degrees	1
4	Jumping Wires	-	As per required
5	USB	-	1

4.1. Ultrasonic Sensor: An ultrasonic sensor uses sound waves beyond human hearing to detect objects and measure distances. It emits an ultrasonic pulse, which reflects back when it hits an object. The sensor's receiver calculates the time taken for the pulse to return, determining the object's distance. Ultrasonic sensors are used in robotics, automation, and obstacle detection due to their accuracy and reliability.



Figure 2: Ultrasonic Sensor

4.2. Arduino Uno: The Arduino Uno is a versatile microcontroller board, based on the ATmega328P, used in electronics projects for interactive and automated devices. It features 14 digital input/output pins, 6 analog inputs, USB programming, and a power jack. With the Arduino Integrated Development Environment (IDE), users can write and upload code to control devices like sensors, motors, and LEDs. Its open-source design, robust library support, and compatibility with various sensors make it popular in various projects.



Figure 3: Arduino Uno

4.3. Micro Servomotor: A micro servo motor is a small, lightweight, and precise motor used for controlled movement within a limited range. It rotates within a specified angle, typically between 0° and 180° , and is controlled by a Pulse Width Modulation (PWM) signal from a microcontroller like Arduino. Ideal for robotics, RC vehicles, and model aircraft, micro servo motors like the Tower Pro 9g are popular in hobbyist projects.



Figure 4: Micro Servo Motor

4.4. Jumper Cables: Jumper cables are electrical wires with connector pins, used to connect components on a breadboard or directly link devices in a circuit. They are essential in prototyping as they allow temporary connections without soldering. Available in three types: male-to-male, female-to-female, and male-to-female, they are versatile for connecting microcontrollers to sensors, motors, LEDs, and other electronic components.



Figure 5: Jumper Cables

4.5. USB (Universal Serial Bus): USB is a standard for connecting electronic devices to computers, enabling data transfer and power supply. It supports data exchange, power supply, and video output. USB technology has evolved with versions like USB 1.1, 2.0, 3.0, and USB-C, offering faster data transfer rates and improved power delivery. USB ports are designed for plug-and-play functionality, allowing devices to be connected without restarting the system.



Figure 6: USB Cable

5. Result Analysis:

Throughout the paper's implementation, the data was continuously tracked on a computer screen. In the majority of instances, the ultrasonic sensor's efficiency in determining an object's distance was greater than 90%. When items were 10 cm distant from the sensors, the sensor detected them accurately. The system processes radar signals in real-time, with an average processing time of 10 milliseconds or close to 10 milliseconds. When an object

is very close to the sensor, the efficiency drops. Additionally, the sensors are precise in determining the precise angle or direction of the items. As objects go closer or farther away, the Arduino updates the data it delivers to a serial monitor or attached display. The presence of the object, together with its angle and distance, will be shown on the screen immediately upon detection. This article uses ultrasonic sensors to calculate the real distance of objects in a very efficient manner. Throughout this project the device can be used in automation in manufacturing processes for precise object placement, counting, and quality control. This device may be utilized for sophisticated robotics applications such as autonomous mobility, obstacle avoidance, and spatial awareness. It can also be utilized to improve pedestrian safety systems, parking assistance, and traffic monitoring in smart cities. While working on this research, we discovered that it can also be helpful for drone and UAV navigation. For example, it can help drones avoid collisions in difficult-to-see situations, increasing their efficiency for delivery, inspection, and search and rescue missions. The system's range and resolution need to be increased, stronger machine learning algorithms need to be created, and the system has to be integrated with additional sensors (such as cameras). Among the drawbacks were poor resolution and interference sensitivity, enhancing these features and including additional sensors into the system can be the main goals of future research. With excellent precision and real-time processing, the research effectively illustrated the viability of employing smart radar systems for object detection.

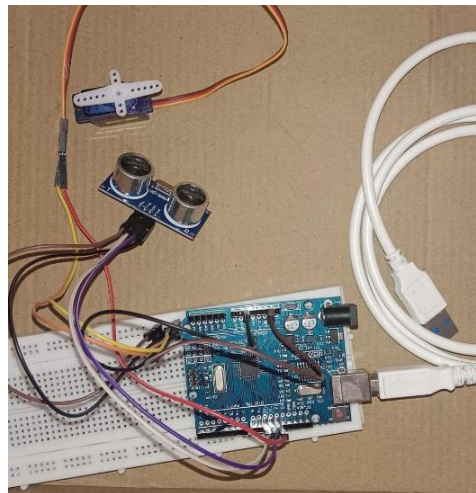


Figure 7: Practical Implementation

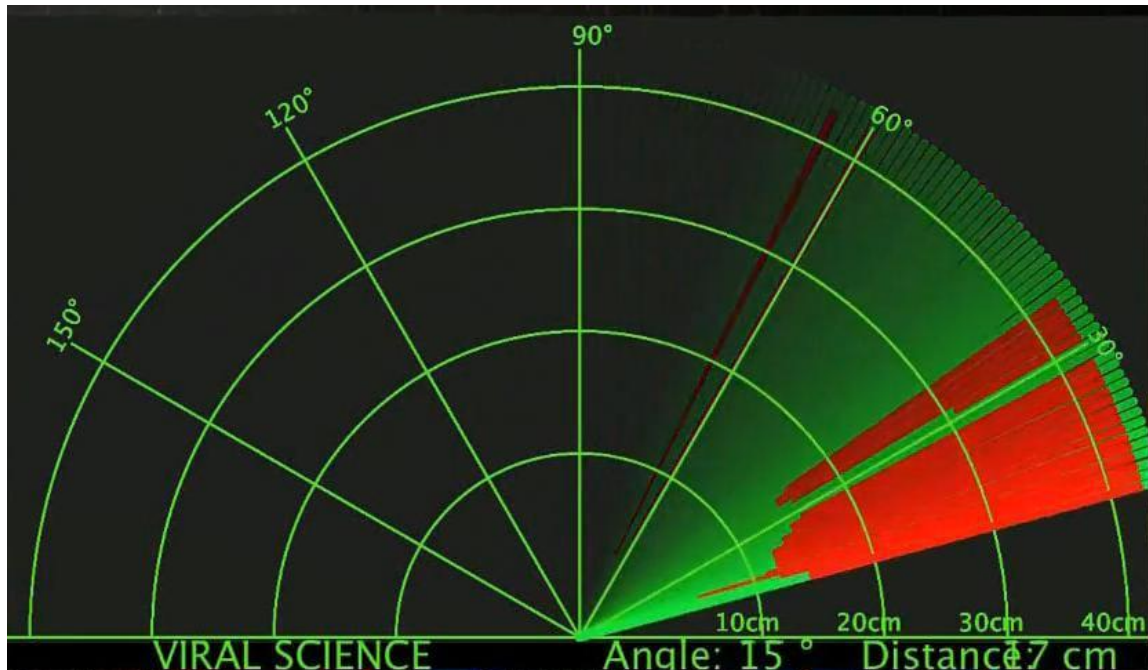


Figure 8: Output on Processing Software

6. Conclusion:

This research aimed to design and implement a distance-estimated object detecting system using ultrasonic sensors. The system successfully determined the object's precise distance and angle from the servo motor, with minimal inaccuracy. The study can be used for precise and small-scale estimations in mechanical and civil areas. The object must be horizontal to the device's plane of propagation for 100% efficiency. The project's future scope is large due to its security values and potential applications. It can be updated or redesigned to accommodate future needs and growing necessities. The smart radar system, created using an Arduino, servomotor, and ultrasonic sensor, can determine the location and distance of obstacles in its path and transform that information into a visually appealing format. This technique can be used for intrusion detection and object detection and avoidance in robots. Despite its limitations, the system is highly effective in identifying objects and determining their precise distances.



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