

# Real-Time Surveillance using Ultrasonic Sensing and GPS Localization (RADAR)

V. YAMUNA<sup>1</sup>, M. VARSHINI<sup>2</sup>, M. BHARATHI<sup>3</sup>, K. SRIJA<sup>4</sup>, P. YUVA KIRAN<sup>5</sup>

<sup>1</sup>Assistant Professor, Department of Electronics and Communication Engineering, N.B.K.R. Institute of Science and Technology, Vidyanagar, A.P.

<sup>2,3,4,5</sup>UG Scholars, Department of Electronics and Communication Engineering, N.B.K.R. Institute of Science and Technology, Vidyanagar, A.P.

**Abstract:** *The proposed system presents a smart and automated radar surveillance solution using Moving Target Indication (MTI) and GPS technologies for real-time object detection and tracking. A Raspberry Pi acts as the core processing unit, integrating an ultrasonic sensor, servo motor, USB camera, GPS module, and buzzer. The system continuously scans the environment, detects moving objects, captures images, and determines their precise geographical location. Upon detection, alerts along with images and GPS coordinates are sent to authorized users, enabling quick response. This system improves surveillance efficiency by reducing human intervention, enhancing accuracy, and providing a cost-effective and portable security solution suitable for real-world applications.*

**Index terms -** *Moving Target Indication (MTI), Radar Surveillance, Raspberry Pi, Ultrasonic Sensor, GPS Tracking, Real-Time Monitoring, Object Detection, Embedded Systems, IoT Surveillance, Security System*

## I. INTRODUCTION

Radar surveillance systems play a crucial role in monitoring and tracking objects in various environments such as defense, transportation, and security applications. Traditional surveillance methods mainly depend on static cameras and human monitoring, which are often inefficient in detecting moving objects and providing real-time responses. To overcome these limitations, Moving Target Indication (MTI) techniques are used to distinguish moving objects from stationary background clutter, thereby improving detection accuracy.

In addition to object detection, location tracking has become an essential requirement in modern surveillance systems. The Global Positioning System (GPS) provides precise real-time location information,

enabling better situational awareness and faster decision-making. By integrating MTI with GPS, surveillance systems can not only detect motion but also accurately identify the geographical position of detected objects.

With the advancement of embedded systems, devices like Raspberry Pi enable the development of compact, low-cost, and efficient surveillance solutions. In this proposed system, an ultrasonic sensor and servo motor are used to scan the surroundings and detect movement, while a USB camera captures real-time images. The GPS module provides location data, and alerts are generated using a buzzer and email notifications.

This integrated approach offers a fully automated, real-time surveillance system that enhances security, reduces human effort, and provides reliable monitoring. The system is suitable for applications such as border security, smart surveillance, and intrusion detection systems.

## II. LITERATURE SURVEY

### 1. Moving Target Indication Techniques for Modern Radar Systems

The Moving Target Indication (MTI) methods utilized in radar systems, both traditional and contemporary, are thoroughly examined in this work. It covers adaptive filtering techniques, Doppler processing, and delay-line cancellers that aid in differentiating moving items from stationary background clutter. The authors stress the drawbacks of analog MTI while highlighting the benefits of digital processing, such as better clutter suppression and increased target identification accuracy in noisy or low-visibility settings.

## 2. Digital Signal Processing Approaches for Clutter Reduction in MTI Radar

In order to improve clutter reduction, the authors investigate digital signal processing (DSP) techniques applied to MTI radar. We look at methods including digital notch filters, adaptive thresholding, and FFT-based Doppler estimates. When compared to conventional analog MTI systems, experimental results show that DSP-based MTI delivers superior performance against ground clutter and greatly enhances the identification of slow-moving objects.

## 3. Performance Evaluation of Pulse-Doppler Radar for Moving Target Detection

The performance of pulse-Doppler radar as a substitute for traditional MTI systems is examined in this article. Their relative efficacy in identifying moving objects in various clutter scenarios is compared in this research. According to the report, pulse-Doppler radar is an excellent option for next-generation surveillance systems because it offers better velocity measurement, increased sensitivity to low-speed targets, and more dependable detection in difficult situations.

## 4. Adaptive MTI Filters for Enhanced Surveillance Applications

In order to dynamically reduce clutter and enhance moving target vision, this work explores adaptive MTI filter designs, such as LMS and Kalman-based algorithms. The authors emphasize that adaptive MTI filters provide improved target-to-clutter ratios and greater detection rates by automatically adapting to changing settings. Their usefulness for real-time military and civilian surveillance applications is demonstrated by the results.

## 5. A Review of MTI Radar Systems and Their Applications in Modern Security

The evolution, operational principles, and application fields of MTI radar systems are all thoroughly reviewed in this study. It highlights their importance in disaster monitoring, car safety, border surveillance, and air traffic management. The study comes to the conclusion that MTI radar is still a vital technology since it can consistently identify moving objects even in bad weather and cluttered areas.

## III. EXISTING SYSTEM

CCTV cameras and human observation are the main methods used for monitoring in current surveillance systems. These systems capture video constantly without intelligently analyzing movement, and they are primarily static. The method is time-consuming and inefficient since human operators must watch the video. Furthermore, conventional systems are unable to distinguish between fixed and dynamic targets or automatically identify moving objects.

The majority of current methods perform poorly in crowded surroundings where it is challenging to differentiate motion because they do not use Moving Target Indication (MTI). Furthermore, these systems are unable to monitor the location of identified items in real time since GPS integration is typically lacking. Image capture is not initiated in response to particular occurrences, and alerts are either delayed or not automated.

All things considered, the current systems are less successful in contemporary security applications due to their low automation, lack of real-time reaction, lack of location awareness, and heavy reliance on human interaction.

## IV. PROPOSED SYSTEM

The proposed system is an intelligent and automated radar surveillance solution that integrates Moving Target Indication (MTI) principles with GPS and embedded technologies for real-time object detection and tracking. A Raspberry Pi is used as the central processing unit to control and coordinate all system components efficiently.

In this system, an ultrasonic sensor combined with a servo motor continuously scans the surrounding environment to detect moving objects. When a change in distance is identified, indicating motion, the system triggers a USB camera to capture real-time images of the detected object. Simultaneously, the GPS module retrieves accurate location coordinates (latitude and longitude) of the detection point.

The Raspberry Pi processes all collected data and activates a buzzer to provide an immediate alert. Additionally, the system sends an automated email notification containing the captured image and GPS location details to the concerned authority for quick action. All data can also be stored for future analysis.

This proposed approach ensures real-time monitoring, automatic detection, precise location tracking, and instant alert generation. It reduces human intervention, improves accuracy, and provides a cost-effective and portable surveillance solution suitable for applications such as security monitoring, border surveillance, and smart environments.

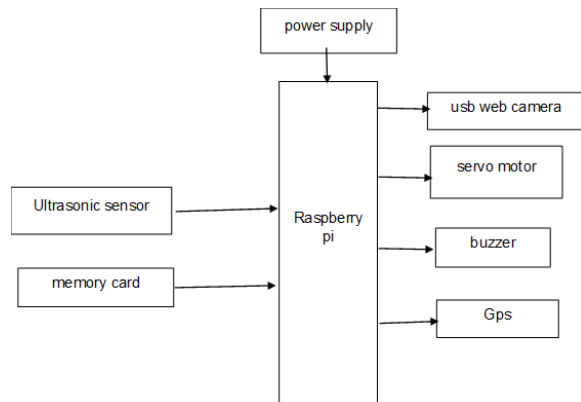


Fig.1. Block Diagram

## V. COMPONENTS USED AND DESCRIPTION

### 1. GPS

The Global Positioning System (GPS) is a satellite-based system that measures and calculates its position on Earth using satellites and ground stations.

Navigation System with Time and Ranging (NAVSTAR) GPS is another name for GPS.

For accuracy, a GPS receiver must receive data from a minimum of four satellites. The satellites receive no information from the GPS receiver.

Numerous applications, including fleet management, taxis, and cellphones, employ this GPS receiver.



Fig. 3: GPS

### 2. Power supply

A component that supplies electricity and at least one electrical charge is called a power supply. It usually transforms one kind of electrical power into another, but it may also transform other forms of electrical energy, such as chemical, mechanical, or solar.

Components receive electrical power from a power supply. Devices integrated within the powered component are typically referred to by this phrase. For instance, computer power supplies, which are often found at the rear of the computer case with at least one fan, transform AC electricity into DC current.



Fig. 4: Power supply component

### 3. USB Web camera

A webcam is a type of video camera that broadcasts or feeds real-time images or videos to a computer network, such the Internet. Typically, webcams are tiny cameras that are integrated into hardware, mounted on a desk,

or attached to a user's monitor. When two or more individuals participate in a video chat session, webcams can be utilized to provide live audio and video communications.



Fig. 5: USB Web camera

#### 4. Raspberry pi

The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512 MB. It utilizes an SD card for booting and permanent storage instead of an integrated hard drive or solid-state drive; the Model B+ uses a MicroSD. Debian and Arch Linux ARM distributions are available for download from the Foundation. Python is the primary programming language supported by tools, along with C, Java, Perl, and BBC BASIC (via the RISC OS image or the Brandy Basic clone for Linux).



Fig. 6: Raspberry pi

#### 5. Buzzer

An electrical gadget that produces a constant or sporadic sound or tone is called a buzzer. It is frequently utilized to offer aural feedback or alarms in electrical circuits and devices. Although buzzer components come in a variety of sizes, styles, and working principles, electromagnetic and piezoelectric buzzers are the most popular varieties.



Fig. 7: Buzzer

#### 6. Ultrasonic Sensor

An ultrasonic sensor is a device that uses ultrasonic sound waves to determine an object's distance. A transducer is used by an ultrasonic sensor to transmit and receive ultrasonic pulses that provide information about the proximity of an item. Different echo patterns are created when barriers reflect high-frequency sound waves.

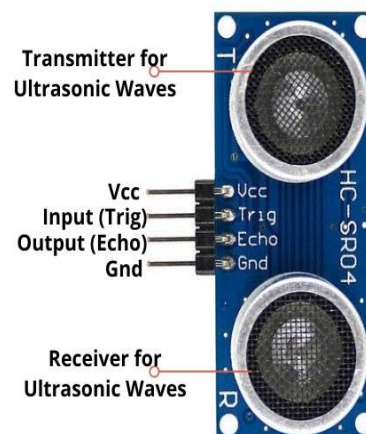


Fig. 8: Ultrasonic Sensor

## 7. Servo motor

One kind of motor that can rotate extremely precisely is a servo motor. This kind of motor often comprises of a control circuit that gives feedback on the motor shaft's present position; this feedback enables the servo motors to rotate extremely precisely. A servo motor is used to rotate an item at a particular angle or distance. It consists just of a basic motor that operates using a servo mechanism. A DC servo motor is one that is powered by a DC power source; an AC servo motor is one that is powered by an AC power source. Based on the kind of gear arrangement and operating characteristics, there are several more types of servo motors in addition to these main categories. A servo motor often has a gear configuration that enables us to obtain a very high torque servo motor in compact, lightweight designs.



Fig. 9: Servo motor

## 8. Raspbian

A Debian-based operating system designed especially for the Raspberry Pi device is called Raspbian. Raspbian, created by the Raspberry Pi Foundation, offers an intuitive environment with a desktop interface and a collection of pre-installed programs designed for learning and development. It is appropriate for a variety of applications, from simple computing to intricate automation jobs, because it has necessary software including web browsers, programming tools, and utilities. Raspbian continues to be a stable and dependable platform for Raspberry Pi users thanks to frequent upgrades and community involvement, which also improves compatibility and performance.

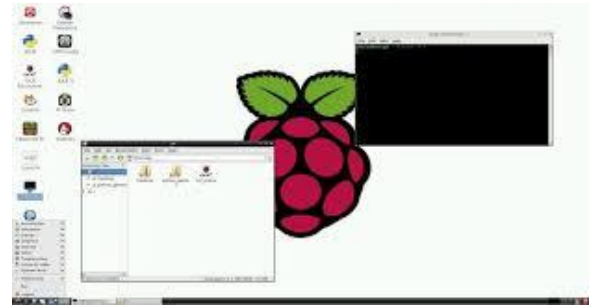


Fig. 10: Raspbian

## VI. WORKING

### 1. Environment Scanning Stage

The system continuously monitors the surroundings using an ultrasonic sensor mounted on a servo motor. The servo rotates at predefined angles (e.g.,  $0^\circ$  to  $180^\circ$ ), allowing the sensor to scan a wide area. Ultrasonic waves are transmitted and reflected back from objects, enabling distance measurement in real time. This scanning ensures full coverage of the surveillance zone.

### 2. Object Detection Stage

The system analyzes the distance values obtained from the ultrasonic sensor. By comparing consecutive readings, it detects variations in object position. A sudden change in distance indicates movement, implementing a basic Moving Target Indication (MTI) concept. This helps differentiate moving objects from static background elements.

### 3. Data Processing Stage

All sensor data is processed by the Raspberry Pi, which acts as the central controller. It applies decision logic to verify whether the detected change corresponds to a valid object movement. The Raspberry Pi also coordinates communication between modules such as camera, GPS, and alert system.

### 4. Image Capture Stage

When movement is confirmed, the Raspberry Pi activates the USB web camera. The camera captures real-time images of the detected object or area. These images serve as visual evidence and help in identifying the nature of the detected object, improving surveillance reliability.

#### 5. GPS Tracking Stage

At the same time, the GPS module retrieves the exact location coordinates, including latitude and longitude. The system ensures accurate positioning by receiving signals from multiple satellites. This location data is essential for tracking and enables authorities to quickly identify where the event occurred.

#### 6. Alert Generation Stage

Once detection is confirmed, a buzzer is triggered to provide an immediate local alert. This helps notify nearby individuals about potential intrusion or suspicious activity. The alert mechanism ensures quick awareness even without internet connectivity.

#### 7. Notification Stage

The Raspberry Pi sends an automated email notification to predefined users or authorities. The email includes captured images and GPS coordinates, providing complete information about the detected event. This enables remote monitoring and quick decision-making.

#### 8. Data Storage Stage

All captured images and related information are stored in the memory card connected to the Raspberry Pi. This stored data can be used later for analysis, verification, or evidence in case of security incidents.

### VII. RESULTS

The suggested radar surveillance system was successfully put into practice and tested in various environmental settings. The system was able to effectively identify moving objects within the ultrasonic sensor's designated range while continually scanning the environment. Effective area coverage was made possible by the servo motor's integration, guaranteeing that there were no blind spots when scanning.

The system consistently detected motion throughout testing by identifying changes in distance data. When the object was detected, the GPS module gave precise position coordinates and the USB camera successfully took real-time pictures of it. The pre-designated user received the recorded photos and latitude and longitude information via email with little to no wait.

When motion was detected, the buzzer alarm system promptly sent out a local notice. During continuous operation, the system showed consistent performance, minimum processing delays, and acceptable reaction times.

Overall, the findings show that the suggested system is appropriate for real-world surveillance applications as it accomplishes efficient real-time monitoring, precise object recognition, trustworthy position tracking, and prompt warning production.

### VIII. CONCLUSION

An effective and automated method for real-time object recognition and tracking is offered by the suggested radar surveillance system that makes use of MTI and GPS. The system effectively detects moving objects, takes pictures, and pinpoints their precise location by combining an ultrasonic sensor, servo motor, camera, and GPS module with a Raspberry Pi. The solution eliminates the need for ongoing human monitoring by ensuring prompt reaction through email notifications and buzzer alarms. It is appropriate for real-world applications like security surveillance and monitoring systems because of its dependable performance, high precision, and affordable price.

By integrating automation, real-time processing, and location awareness into a small, portable architecture, the suggested solution improves safety and surveillance effectiveness overall.

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