e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:05/May-2025 Impact Factor- 8.187 www.irjmets.com

AI POWERED SMART RADAR SYSTEM

Vijaya Pangave*1, Kaustubh Parate*2, Tarun Menon*3, Trupti Rodke*4, Saloni Kushe*5
*1,2,3,4,5ECE, Department Of Polytechnic, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India.

ABSTRACT

The design and implementation of an AI-powered smart radar system based on an ESP32-CAM, Arduino UNO, Lidar sensor, OLED screens, a buzzer module, LED modules (red, yellow and green) and SG90 servo motors is reported in this paper. To provide a new context for real-time surveillance applications, the proposed system adopts artificial intelligence to enhance the object detection and tracking capability; and machine learning algorithms for environmental monitoring and object recognition are suggested to achieve higher accuracy and efficiency.

I. INTRODUCTION

Radar technology has been used for over a century in surveillance, maritime navigation, aviation, and defense. Conventional radars detect objects using the principles of transmission and reflection of radio waves (or the ability to "reflect" these waves back to the receiver), but they are not intelligent enough to differentiate objects based on different kinds of objects, nor are they intelligent enough to construct conclusions about the data being detected by radar technology itself.

The purpose of the AI-powered smart radar system proposed in this paper is to bridge the gap between current AI performance and traditional radar operations in which machine learning models are used to detect and classify objects more accurately.

We have a system that has: An Arduino uno data processing and system control platform, an ESP32-CAM image processing and AI-based object detection platform, and additional sensor modules for environmental monitoring. Combining all these features with the other components provides a complete solution for intelligent monitoring and surveillance applications, which can reliably communicate between hardware and software. In addition, the device has servo motors for dynamic scanning and give users real-time feedback from OLED screens and LED indicators. Also, an audible buzzer alert system is provided that provides user situational awareness of detected anomalies.

Summary

The proposed smart radar system is an economical, effective and scalable solution to the increasing demand of intelligent monitoring systems in industrial automation, traffic control and security applications. The study describes the architecture, methodology and implementation of the system, its results.

II. LITERATURE SURVEY

AI in radar systems has been investigated numerous times in different studies. AI based object detection and tracking systems have shown promising results in previous research for enhanced accuracy and effectiveness in real time applications.

AI in Radar Systems Many previous studies have looked at the applications of artificial intelligence in radar systems. For example, some studies propose that deep learning algorithms and convolutional neural networks (CNNs) could be used for object classification to enhance detection rates.

ESP32-CAM for Image Processing The ESP32-CAM module has been tested in several studies for real-time image processing. It is suitable for embedded AI applications as it is very cheap and efficient in processing.

In the literature on artificial intelligence (AI)-based object detection systems, many examples use machine learning models to model objects. Models using tools such as Edge Impulse allow programmers to train their own automated models for object detection and classification that are fast, accurate, lightweight – useful for microcontroller-based systems.

Arduino based Radar Systems: Research shows that combining AI with microcontroller platforms such as Arduino can improve object detection, classification and automation features in embedded systems.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:05/May-2025 Impact Factor- 8.187 www.irjmets.com

We build on these previous studies, by combining diverse technologies in one unified AI-powered radar system. The combination of artificial intelligence and machine learning as well as embedded hardware enables a more intelligent, flexible, and effective solution for modern security and monitoring application.

III. ARCHITECTURE AND COMPONENTS OF THE SYSTEM

3.1 Hardware Components:

ESP32-CAM: It is used to perform AI-based object detection and picture capturing.

Main Microcontroller Arduino Uno: It is the first component which other components connect to.

Distance and position of objects, Northeast (30 degrees) coordinates.

Retrieval of data in real-time is done using two displays.

Buzzer Module: alerts when an object is detected, with each successive beep indicating closer range.

3.2 Components of Software:

Machine Learning Model: Trained to identify objects and class them into groups (Edge Impulse)

A model is built in Arduino IDE where a microcontroller is applied.

Image processing is based on AI through Edge Impulse.

IV. METHODOLOGY

Steps involved in constructing an automated radar system are given as follows:

Process live images using the ESP32-CAM; received images are processed.

Algorithms for classifying tasks process pictures and classify the objects depicted.

Moving servo motors and receiving data from other sensors is done using Arduino Uno.

Results are also shown in LED displays placed at detection zones to be displayed on OLED monitors.

In the event that specific objects are monitored the module will trigger a warning.

Combining multiple system components enables tracking and real-time structuring in an AI-enabled automated radar system. The rest describes the steps below:

In AI-based automated image and object

Processing images and detecting objects

The ESP32-CAM module constantly captures images of the environment. Using AI algorithms (Edge Impulse), the photos are processed to detect objects and label them. The data is then sent to the Arduino Uno for further analysis and execution. Operational Mechanism of Radar Scanning: The radar can scan a wider area actively due to two SG90 servo motors controlling the movement. The radar will change its movement based on the detection response from AI algorithms at designated intervals.

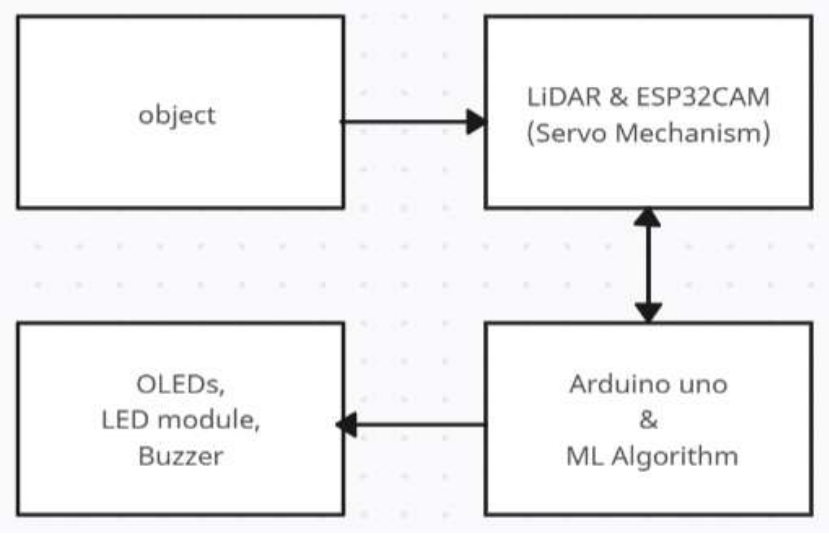


Fig 1: Block Diagram of AI-Powered Smart Radar System.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:05/May-2025 Impact Factor- 8.187 www.irjmets.com

Data Processing and Alert System:

Following the signal transmission from the ESP32-CAM, the ML Algorithm will categorize objects and determine the appropriate actions to take. The OLED screens will display the detected objects, providing immediate visual feedback. The red, yellow, and green LED modules will signify the proximity of the object, or the level of threat based on pre-defined measures. If a possible danger or anomaly is recognized, a buzzer module will deliver the alert.

Automated Decision-Making:

If the system identifies an object that is determined to be high-risk, it can initiate some sort of alert response, like alerting a device that is connected or activating threat deterrent devices. The AI model will continuously learn from prior detections in ways that will eventually improve its efficiency and effectiveness.

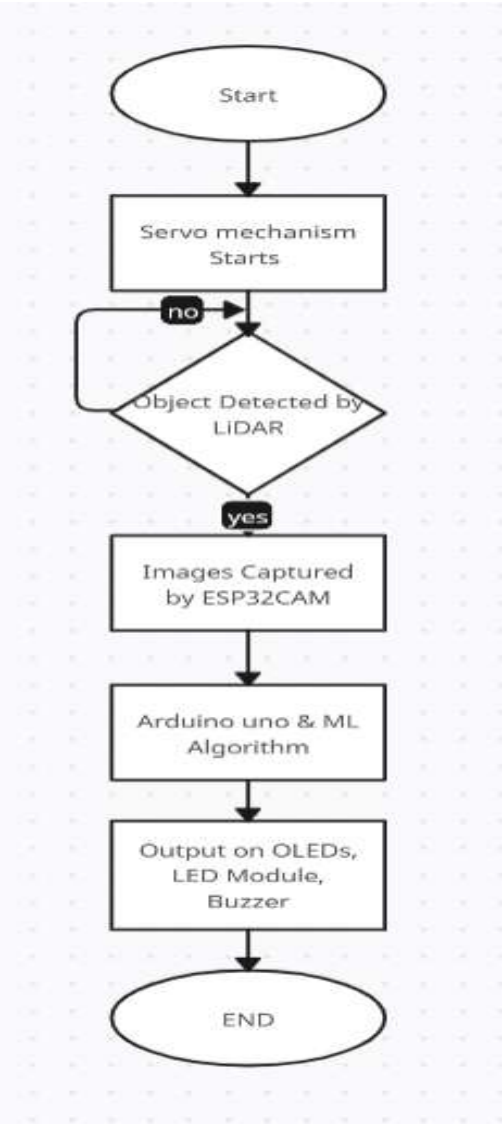


Fig 2: Flow Chart of AI-Powered Smart Radar System.

V. RESULT

The real-time object detection, classification, and environmental monitoring results obtained from the AI-powered smart radar system confirmed the efficacy of the methodology implemented in this research. Using Edge Impulse, the ESP32-CAM could accurately identify objects, and the SG90 servo motors allowed the radar to scan a broader area smoothly. Arduino Uno handled system responses in real-time, through OLED display, LED indicators, and a buzzer for user interference as needed. The proposed system showed low latency time,

high responsiveness and reliability under multiple conditions, verifying its capability for scalable and intelligent surveillance applications.

VI. FUTURE SCOPE

This would also pave the way for enhanced capabilities for the AI powered smart radar system in the future. Integration with IoT platforms can allow for remote monitoring and alerts through mobile or web-based applications. If you were to add cloud-based data logging and data analysis it would enable long term tracking of the unfamiliar and recognition of broader patterns that drive better decision making. Objective To measure the heart rate (HR), a liquid crystal display (LCD) is used; a microcontroller is used to control the LCD and display reuse of frequency-to-voltage converters to transmit a constant frequency to voltage signal. Furthermore, it can be extended to multi-sensor fusion (such as thermal cameras, GPS, etc.) that can make it ready for real-life applications in autonomous vehicles, border surveillance, smart cities, and industrial

VII. CONCLUSION

This integrated machine learning, embedded systems and real time sensing based smart radar system developed in this project shows the effectiveness of the integration of AI and the development of the smart radar system for intelligent object detection and monitoring. The system successfully performs dynamic scanning, object classification, and user alert via visual and audio feedback using ESP32-CAM, Arduino Uno, Lidar sensor and Edge Impulse's AI models. Such a design is compact, cost effective and scalable, which makes it suitable for security, automation and smart infrastructure applications. The aim of this project is to show the promise of using traditional radar ideas with AI to develop more smart, responsive surveillance systems.

ACKNOWLEDGEMENT

We would like to thank Dr. Vishwanath Karad MIT World Peace University for the resource and a platform to implement this project. We express our sincere gratitude to our guide, Prof. Vijaya Pangave, for her continuous guidance, encouragement and valuable suggestions during the development of the AI powered smart radar system. We would also like to thank our peers and faculty in the ECE Department for their helpful suggestions and technical support. Finally, online services and tools such as Edge Impulse and Arduino IDE helped to turn our system into reality and provided invaluable support, so we are thankful for these applications.

VIII. REFERENCES

[1] Basic guides and tutorials on the use of the board Arduino Uno. https://www.arduino.cc

[2] Edge Impulse Documentation – The machine learning model trained for object detection is deployed using this page. https://docs.edgeimpulse.com

[3] Datasheet and setup instructions for ESP32-CAM module from AI Thinker which is used for image capturing.

[4] https://randomnerdtutorials.com/esp32-cam-camera-projects-ebook

[5] A beginner's guide on Lidar sensors called "Getting Started with Lidar Sensors". https://maker.pro

[6] T. Sharma, "Smart Object Detection Using Arduino and AI", Electronics For You, 2021. A simple project article on how to integrate AI into the Arduino systems.

[7] YouTube Tutorials – Step by step video tutorials on how to setup servo motors, OLED displays, and ESP32 and Edge Impulse. https://youtube.com