# AIR DEFENSE MECHANISM USING RADAR SYSTEM

[1]Mrs.T.Sai Priyanka,[2]B.Aashritha,[3]J.Rakshana, [4]K.Kalyani, [5] K.Roopasri

[1] Assitant Professor, CSE(AI&ML), Vignan's Institute of Management Technology for Women, Hyderabad,India

[2,3,4,5]B.Tech 3rdyear Student, CSE (AI&ML), Vignan's Institute of Management and Technology for Women,Hyderabad, India.

[1] saipriyankathotapalli9@gmail.com [2] aashritharao2005@gmail.com
[3]jogurakshana@gmail.com [4]kroopasri219@gmail.com
[5] komaramkalyanikomaramkalyani@gmail.com

## ABSTRACT:

This project focuses on the development of an air-defense mechanism utilizing a radar-based system integrated with an Arduino board. The system works on real-time threat detection by using radar and ultrasonic sensors. Its primary goal is to improve defense by automating threat detection and response mechanisms. For processing, the project uses an Arduino; for radar movement, servo motors; and a display unit to visualize the data in real time. By providing a cheap and scalable solution, this research hopes to advance the field of modern defense technology as a different approach to the expensive methods traditionally employed in air defense. Higher-end sensors, artificial intelligence, and capabilities for remote monitoring related to security could further enhance its functionality.

*Keywords: Air-defense system, Radar, Arduino, Real-time detection, Ultrasonic sensor,*
*Servo motor, automated response, Low-cost solution, Object detection, Embedded systems*

## I. INTRODUCTION:

The development of air technologies, including unmanned aerial vehicles (UAVs), autonomous drones, and guided missile systems, has made it very challenging to defend strategic and national airspace. Traditional air defense systems, though effective, are not agile, scalable, or intelligent enough to deal with the new multi-dimensional air threats. This has created the need to incorporate conventional radar with advanced data processing and communication technologies that adapt to the demands of the contemporary world. The increasing menace of UAVs, missiles, and other contemporary air-based systems has created increasing demand for smart, flexible, and cost-effective air defense systems. While traditional radar-based methods can identify and position targets, they do not possess automatic, distributed real-time response capabilities, which are required for large area surveillance. But the integration of soft Iot technologies into IoT and radars has tremendous potential to overcome these constraints. Here, we suggest an Iot-based air defense system with radar sensors, LED lights and buzzers, wireless communication modules, AI-based threat detection, and pair them with our current air defense algorithms. The system is based on our current algorithms and designs and is intended to autonomously detect and respond to aerial threats using a network of low-cost, low-power and local data processing sensor nodes.

This report discusses system architecture, hardware and software constituents, communication protocols, and results of tests in testing. The suggested solution demonstrates notable enhancement in detection velocity, alert confidence, responsiveness, and system adjustability, and thus merits its adoption as a Next Generation air defense system.

## II. RELATED WORK :

Air defense systems that use radar technology have become quite the focus in both military and civilian sectors. You see, both traditional and modern systems are trying to detect, target, and neutralize various air threats—think aircraft,

missiles, and those unmanned aerial vehicles (UAVs) that seem to be everywhere now. Thanks to some impressive advancement in radar tech, there are now high-performance military products as well as affordable models for those who just want to experiment and learn. Take the USA Patriot Missile System or Russia's S-400 Triumf, for instance. These high-performance systems are equipped with sophisticated radar tracking and interception capabilities, allowing them to detect and engage targets from really far away. They utilize active electronically scanned arrays (AESAs) and come with a computerized command and control setup for effective threat detection and engagement. On the flip side, flip side, we have short-range air systems for defense (SHORAD), such as NASAMS and Israel's Iron Dome. These systems show how radar-guided missiles can intercept threats flying at lower altitudes. They operate in real-time,combining radar with electro-optical sensors and smart algorithms for target classification.

In labs and classrooms, a lot of projects are popping up that use microcontrollers—like the Arduino Uno—and ultrasonic sensors, such as the HC-SR04, to mimic radar features. For example, some open-source radar setups use a servo-mounted ultrasonic sensor to sweep over a field of view, measure distances, and display those results live on a monitor. This kind of system, even without real electromagnetic radar, is a budget-friendly way to play around with radar concepts like detecting objects, tracking angles, and alerting based on proximity. Plus, there's been a shift towards making these systems more autonomous with the help of artificial intelligence (AI) and machine learning (ML) to boost response times and improve target identification. Some designs even incorporate wireless modules for remote monitoring and user-friendly interfaces like LCDs or GUIs.

Projects like the "Arduino Radar Project using Ultrasonic Sensor" and "DIY Object Detection and Tracking System" are great starting points. They help students and researchers understand the basic principles behind radar scanning and response systems. And from there, you can build more advanced systems by adding components like buzzers for alerts, LEDs for status updates, and even cameras for visual identification.

The system we're talking about here takes that research a step further. It integrates ultrasonic radar scanning, servo-controlled direction, and computer responses—like buzzer alarms and LED indicators—to create a simulation that closely resembles a real air defense system.

## III. PROPOSED SYSTEM:

1. Overview of the proposed system

This project is focused on addressing some of the challenges that come with current air defense systems. We're diving into creating a compact and budget-friendly Air Defense Mechanism that operates on an Arduino-based radar system. This setup helps us detect objects in real time within a specific airspace. It continuously rotates and measures distances, allowing the system to build a 2D map of its environment. If it spots any unauthorized aerial objects, it can trigger a simulated defensive response right away. What's cool about this approach is how lightweight and low-maintenance it is compared to traditional systems. It's a more affordable option for local security needs—thinks small facilities, military bases, or even urban areas. We'll set up certain parameters for detecting objects, like size and distance. So, when it identifies a potential threat, it can activate visual alerts or even mechanical responses, like alarms or simulated countermeasures. On top of that, this prototype is just the beginning! It opens the door for future upgrades using advanced technologies like Artificial Intelligence (AI) and Machine Learning (ML). This means we can improve how it recognizes objects, classifies threats, and even anticipates possible interceptions. In the end, we aim

to create a defense mechanism that's not only scalable and adaptable but also bridges the gap between sophisticated

national defense systems and the real-world security needs we see on the ground
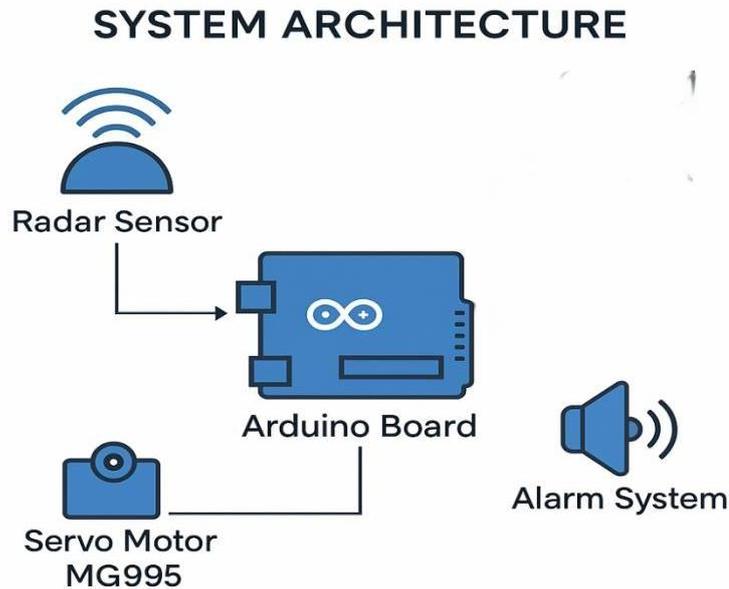
## IV. SYSTEM ARCHITECTURE:



Fig.1: System Architecture

## IMPLEMENTATION DETAILS:

creating an air defense system that uses radar technology is all about building a prototype that can spot and react to aerial threats like drones or other flying objects usually youd put this together with an arduino microcontroller an ultrasonic sensor like the hc-sr04 and a servo motor to mimic how radar works so here's how it goes the ultrasonic sensor is attached to the servo motor this setup allows it to rotate and scan a semicircular area going from 0 to 180 at each angle the sensor sends out ultrasonic waves and then waits to hear the echo bounce back by timing how long that takes it can figure out how far away any object is now if the sensor picks up something within a certain range it flags that as a potential threat that's when the alert system kicks in think buzzers and blinking led pretty neat right if you want to take it a step further you could add an lcd screen to show the angle and distance of whatever its detected or you could connect it to software like processing to create a

real-time visualization of the radar in a nutshell this prototype gives a basic idea of how real-world air defense systems function providing early warnings and automated responses to anything that might intrude on protected airspace it's a cool way to get a glimpse into the tech behind keeping the skies safe.

## V. ALGORITHM:

**Step 1: Get Everything Up and Running**
- First off, make sure that all your modules—radar, microcontroller, buzzer, LED, and communication—are linked up properly.
- You'll want to set up your calculations based on your detection criteria, like minimum distance and speed.

**Step 2: Grab Those Radar Signals**
- Next, check in with the radar regularly to pull data.
- From there, calculate the parameters for the objects you're monitoring, like distance, speed, and direction if you can swing it.

**Step 3: Clean Up the Data**

- You'll need to filter out any unnecessary fluctuations, maybe using something like a moving average or a Kalman filter.
- The goal here is to smooth the data so it's ready for analysis without any hiccups.

**Step 4: Spotting Potential Threats**
- Now, here's where it gets serious: check if the distance is less than your threshold distance and the speed is above your threshold speed.
- If both those conditions are met, then boom! You've got a potential threat on your hands.

**Step 5: Set Off the Alarm**
- Time to activate your alert system—turn on that LED and get the buzzer going.
- And if you've got a display handy, make sure to show the object parameters like distance and speed.

**Step 6: Send Out Wireless Alerts**

- Don't forget to send that threat information to your stealth monitoring system using Wi-Fior LoRa.
- Keep a record of the event too, complete with time and date stamps, plus the threat values.

**Step 7: Visualization**
- You'll want to loop back to Step 2, resetting for continuous monitoring.
- For ease of use and flexibility, you can program this whole setup on an Arduino, ESP32, or Raspberry Pi.

**VII. RESULTS:**

The entire assembly of the air defense radar system was crafted and tested using Arduino Uno, ultrasonic sensors, servo motors, LEDs, buzzer, and LCD displays. The system scanned the surroundings with ultrasonic sensor mounted on a servo motor which provided radar-like sweeping action. The range of object detection was reliable within these parameters and successful up to about 2 meters.
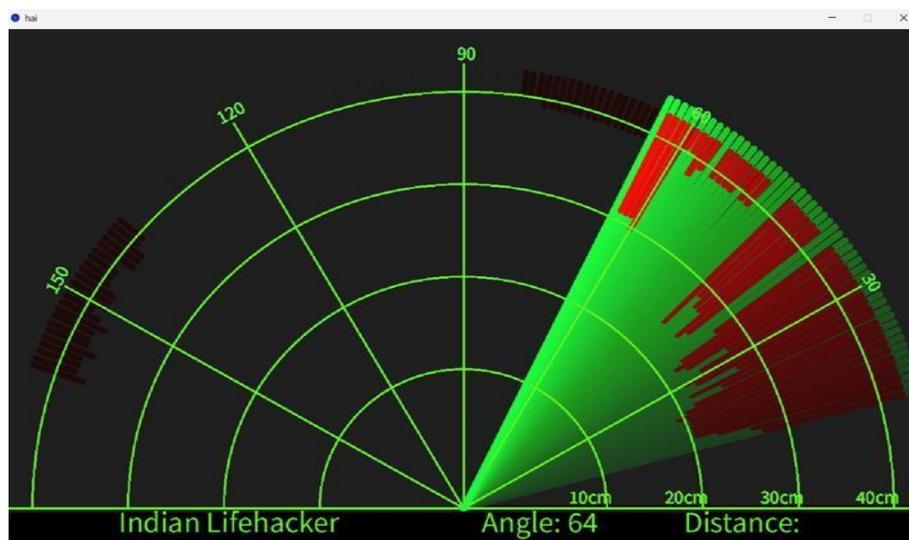


Fig .1.1

1) Current Angle: 64    2) Frequency: Medium(Some Scattered Detections)
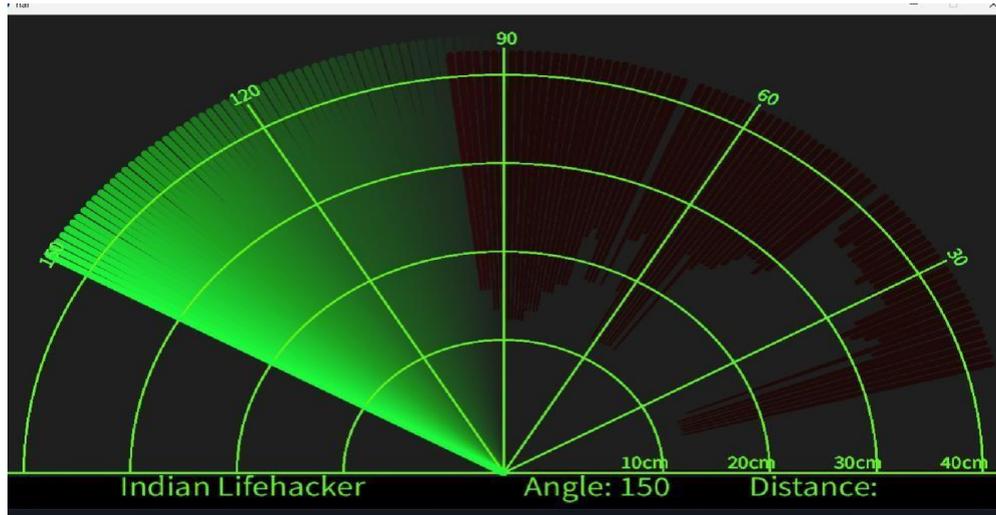3) Distance:25cm    4) Maximum Range:40cm

Fig 1.2
1) Current Angle: 150   2) Frequency: Less Frequency(Fewer Detections)
3) Distance: 15cm  4) Maximum Range:40cm

When any predefined danger zone is breached, the system triggered visual via LED and audible via buzzer warning signals. The LCD display updated in real-time to show the object's distance while the system displayed the object's position on the radar interface of a connected laptop. Thus, hardware and software seamlessly combined to monitor the objects in real-time. The prototype has validated that the model is capable of real-time environmental monitoring, obstacle detection, and providing local alerts instantly. The prototype demonstrates the feasibility of constructing affordable real-time object detection and alerting system that replicates sophisticated air defense systems and integrating AI-based threat classification can enhance the system further and alerting system that replicates sophisticated air defense systems and integrating AI-based threat classification can enhance the system further.

## VIII.CONCLUSION:

In conclusion this prototype showcases an economical air defense mechanism employing radar detection, threat tracking as well as classification with the use of an Arduino UNO interfaced with the IoT alert system. While this approach attempts to improve automation and situational awareness, it is hindered by limited detection ranges, interferences from surrounding environmental conditions, ghost alerts, overly high power drain, and delayed responses. Even with all these challenges, the project gives significant impetus for more advanced air defense system designs. It sheds light on enhancing future iterations.

**REFERENCES:**

1. Zaloga, S. J. (2007). The Kremlin's Nuclear Sword: The Rise and Fall of Russia's Strategic Nuclear Forces, 1945–2000. Smithsonian Institution Press. https://www.smithsonianbooks.com/store/aviation-military-history/the-kremlins-nuclearsword-the-rise-and-fall-of-russias-strategic-nuclear-forces-1945-2000/

2. Skolnik, M. I. (2008). Radar Handbook (3rd ed.). McGraw-Hill Education.

   https://books.google.com/books/about/Radar_Handbook_Third_Edition.html?

3. https://books.google.com/books/about/Radar_Handbook_Third_Edition.html?id=76uF2Xeb m-gC

4. Mahafza, B. R. (2017). Radar Systems Analysis and Design Using MATLAB (3rd ed.). CRC Press.

5. https://www.taylorfrancis.com/books/mono/10.1201/b14904/radar-systems-analysis-designusing-matlab-bassem-mahafza

6. Blake, L. V., & Long, S. A. (2012). Radar Range-Performance Analysis. Artech House. https://uk.artechhouse.com/Radar-Range-Performance-Analysis-P249.aspx

7. Li, X., Liu, Y., & Chen, G. (2019). "Agent-Based Decision-Making in Integrated Air Defence Systems," IEEE Transactions on Systems, Man, and Cybernetics: Systems. https://arxiv.org/abs/1905.01358

8. D Shanthi, Smart Healthcare for Pregnant Women in Rural Areas, Medical Imaging and Health Informatics, Wiley Publishers,ch-17, pg.no:317-334, 2022, https://doi.org/10.1002/9781119819165.ch17

9. Shanthi, R. K. Mohanty and G. Narsimha, "Application of machine learning reliability data sets", Proc. 2nd Int. Conf. Intell. Comput. Control Syst. (ICICCS), pp. 1472-1474, 2018.

10. D Shanthi, N Swapna, Ajmeera Kiran and A Anoosha, "Ensemble Approach Of GPACOTPSOAnd SNN For Predicting Software Reliability", International Journal Of Engineering Systems Modelling And Simulation, 2022.

11. Shanthi, "Ensemble Approach of ACOT and PSO for Predicting Software Reliability", 2021 Sixth International Conference on Image Information Processing (ICIIP), pp. 202-207, 2021.

12. D Shanthi, CH Sankeerthana and R Usha Rani, "Spiking Neural Networks for Predicting Software Reliability", ICICNIS 2020, January 2021, [online] Available: https://ssrn.com/abstract=3769088.

13. Shanthi, D. (2023). Smart Water Bottle with Smart Technology. In Handbook of Artificial Intelligence (pp. 204-219). Bentham Science Publishers.

14. Shanthi, P. Kuncha, M. S. M. Dhar, A. Jamshed, H. Pallathadka and A. L. K. J E, "The Blue Brain Technology using Machine Learning," 2021 6th International Conference on Communication and Electronics Systems (ICCES), Coimbatre, India, 2021, pp. 1370-1375, doi: 10.1109/ICCES51350.2021.9489075.

15. Shanthi, D., Aryan, S. R., Harshitha, K., & Malgireddy, S. (2023, December). Smart Helmet. In International Conference on Advances in Computational Intelligence (pp. 1-17). Cham: Springer Nature Switzerland.

16. Babu, Mr. Suryavamshi Sandeep, S.V. Suryanarayana, M. Sruthi, P. Bhagya Lakshmi, T. Sravanthi, and M. Spandana. 2025. "Enhancing Sentiment Analysis With Emotion And Sarcasm Detection: A Transformer-Based Approach". Metallurgical and Materials Engineering, May, 794-803. https://metall-mater-eng.com/index.php/home/article/view/1634.

17. Narmada, J., Dr.A.C.Priya Ranjani, K. Sruthi, P. Harshitha, D. Suchitha, and D.Veera Reddy. 2025. "Ai-Powered Chacha Chaudhary Mascot For Ganga Conservation Awareness". Metallurgical and Materials Engineering, May, 761-66. https://metall-mater-eng.com/index.php/home/article/view/1631.

18. Geetha, Mrs. D., Mrs.G. Haritha, B. Pavani, Ch. Srivalli, P. Chervitha, and Syed. Ishrath. 2025. "Eco Earn: E-Waste Facility Locator". Metallurgical and Materials Engineering, May, 767-73. https://metall-mater-eng.com/index.php/home/article/view/1632.

19. P. Shilpasri PS, C.Mounika C, Akella P, N.Shreya N, Nandini M, Yadav PK. Rescuenet: An Integrated Emergency Coordination And Alert System. J Neonatal Surg [Internet]. 2025May13 [cited 2025May17];14(23S):286-91. Available from: https://www.jneonatalsurg.com/index.php/jns/article/view/5738

20. D. Shanthi DS, G. Ashok GA, Vennela B, Reddy KH, P. Deekshitha PD, Nandini UBSB. Web-Based Video Analysis and Visualization of Magnetic Resonance Imaging Reports for Enhanced Patient Understanding. J Neonatal Surg [Internet]. 2025May13 [cited 2025May17];14(23S):280-5. Available from: https://www.jneonatalsurg.com/index.php/jns/article/view/5733

21. Srilatha, Mrs. A., R. Usha Rani, Reethu Yadav, Ruchitha Reddy, Laxmi Sathwika, and N. Bhargav Krishna. 2025. "Learn Rights: A Gamified Ai-Powered Platform For Legal Literacy And Children's Rights Awareness In India". Metallurgical and Materials Engineering, May, 592-98. https://metall-mater-eng.com/index.php/home/article/view/1611.

22. Shanthi, Dr. D., G. Ashok, Chitrika Biswal, Sangem Udharika, Sri Varshini, and Gopireddi Sindhu. 2025. "Ai-Driven

Adaptive It Training: A Personalized Learning Framework For Enhanced Knowledge Retention And Engagement". Metallurgical and Materials Engineering, May, 136-45. https://metall-mater-eng.com/index.php/home/article/view/1567.

23. P. K. Bolisetty and Midhunchakkaravarthy, "Comparative Analysis of Software Reliability Prediction and Optimization using Machine Learning Algorithms," 2025 International Conference on Intelligent Systems and Computational Networks (ICISCN), Bidar, India, 2025, pp. 1-4, doi: 10.1109/ICISCN64258.2025.10934209.

24. Priyanka, Mrs. T. Sai, Kotari Sridevi, A. Sruthi, S. Laxmi Prasanna, B. Sahithi, and P. Jyothsna. 2025. "Domain Detector - An Efficient Approach of Machine Learning for Detecting Malicious Websites". Metallurgical and Materials Engineering, May, 903-11.

25. Thejovathi, Dr. M., K. Jayasri, K. Munni, B. Pooja, B. Madhuri, and S. Meghana Priya. 2025. "Skinguard-Ai FOR Preliminary Diagnosis OF Dermatological Manifestations". Metallurgical and Materials Engineering, May, 912-16.

26. Jayanna, SP., S. Venkateswarlu, B. Ishwarya Bharathi, CH. Mahitha, P. Praharshitha, and K. Nikhitha. 2025. "Fake Social Media Profile Detection and Reporting". Metallurgical and Materials Engineering, May, 965-71.

27. D Shanthi, "Early-stage breast cancer detection using ensemble approach of random forest classifier algorithm", Onkologia i Radioterapia 16 (4:1-6), 1-6, 2022.

28. D Shanthi, "The Effects of a Spiking Neural Network on Indian Classical Music", International Journal of Emerging Technologies and Innovative Research (www.jetir.org | UGC and issn Approved), ISSN:2349-5162, Vol.9, Issue 3, page no. ppa195-a201, March-2022

29. Parupati K, Reddy Kaithi R. Speech-Driven Academic Records Delivery System. J Neonatal Surg [Internet]. 2025Apr.28 [cited 2025May23];14(19S):292-9. Available from: https://www.jneonatalsurg.com/index.php/jns/article/view/4767

30. Dr.D.Shanthi and Dr.R.Usha Rani, " Network Security Project Management", ADALYA JOURNAL, ISSN NO: 1301-2746, PageNo: 1137 – 1148, Volume 9, Issue 3, March 2020 DOI:16.10089.AJ.2020.V9I3.285311.7101

31. D. Shanthi, R. K. Mohanthy, and G. Narsimha, "Hybridization of ACOT and PSO to predict Software Reliability ", *International Journal Pure and Applied Mathematics*, Vol. 119, No. 12, pp. 13089 - 13104, 2018.

32. D. Shanthi, R.K. Mohanthy, and G. Narsimha, "Application of swarm Intelligence to predict Software Reliability ", *International Journal Pure and Applied Mathematics*, Vol. 119, No. 14, pp. 109 - 115, 2018.

33. Srilatha, Mrs. A., R. Usha Rani, Reethu Yadav, Ruchitha Reddy, Laxmi Sathwika, and N. Bhargav Krishna. 2025. "Learn Rights: A Gamified Ai-Powered Platform For Legal Literacy And Children's Rights Awareness In India". Metallurgical and Materials Engineering, May, 592-98.