International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

Iot-Enabled Autonomous Night Patrolling Robot For Enhanced Women's Safety In Urban Environments

[1]Dr.M.V. Sruthi,[2]Gose Meghana,[3]Kunduru Charitha,[4]Bandi Kumari,[5]Kummetha Bhavya Sree

[1]Professor, Department of Electronics and Communication Engineering, Dr. K.V. Subba Reddy Institute of Technology

[2,3,4,5]B. Tech Student, Department of Electronics and Communication Engineering, Dr. K.V. Subba Reddy Institute of Technology

ABSTRACT

Women's safety remains one of the most pressing concerns in modern society, especially during nighttime in isolated or poorly monitored areas. Traditional security systems rely heavily on human patrol officers, CCTV surveillance, and emergency helplines, all of which suffer from limitations such as delayed response, limited coverage, and lack of real-time intervention. To address these challenges, this research proposes an IoT-enabled autonomous night patrolling robot designed specifically to enhance women's safety through intelligent surveillance, threat detection, and instant communication features. The robot is equipped with sensors such as PIR motion detectors, GPS, ultrasonic sensors, and a camera module capable of real-time video streaming. The system leverages IoT connectivity for remote monitoring and emergency alerts, ensuring that suspicious activities are immediately detected and reported. Using machine learning–based facial recognition and audio anomaly detection, the robot can identify potential threats and trigger automated responses. The robot navigates autonomously using path-planning algorithms while avoiding obstacles, enabling continuous monitoring of dark or restricted pathways. The proposed system is cost-effective, scalable, and suitable for deployment in campuses, residential societies, public parks, and urban streets. By integrating surveillance, communication, and automation, the robot strengthens prevention and rapid response capabilities, contributing to a safer environment for women at night.

Keywords: Internet of Things (IoT), Women's Safety, Autonomous Patrolling Robot, Night Surveillance, Motion Detection, GPS Tracking, Facial Recognition, Audio Anomaly Detection, Obstacle Avoidance, Smart Security Systems.

Received: 19-02-2026 | Accepted: 24-03-2026 | Published: 31-03-2026

I. INTRODUCTION

Ensuring women's safety in public spaces remains a global concern, especially in areas where manual surveillance is minimal or ineffective. Crimes such as harassment, stalking, kidnapping, and assault often occur in poorly lit and isolated regions, where victims lack access to immediate support. Traditional security measures—including CCTV cameras and human patrol teams—offer limited situational awareness and delayed reactions. With the rapid development of robotics, artificial intelligence, and Internet of Things (IoT) technology, there is a significant opportunity to create autonomous systems capable of continuous monitoring and active threat response. An IoT-enabled night patrolling robot presents a promising solution by combining mobility, intelligent sensing, and connectivity. Such a robot can independently navigate through assigned zones, detect anomalies, record evidence, and communicate with authorities in real time. The integration of cloud platforms and mobile applications allows remote users or command centers to access alerts and live surveillance feeds instantly. This system not only enhances safety but also helps deter crime through its continuous presence. The research explores the design, functionality, and potential impact of implementing an autonomous patrol robot tailored for women's safety.

II. Related Words

Women's safety has become an important research area where modern technologies such as the Internet of Things (IoT), wearable devices, and intelligent monitoring systems are being applied to provide faster response and improved protection mechanisms. Several studies have explored IoT-based safety solutions that enable real-time monitoring and emergency communication. For instance, Jatti *et al.* developed an IoT-based wearable device designed to ensure the safety of women and children by integrating GPS and communication modules that allow immediate alerts during emergency situations [1]. Similarly, Sogi *et al.* proposed SMARISA, a Raspberry Pi–based smart ring that enables quick distress signaling and location tracking through IoT connectivity, demonstrating how wearable technology can enhance personal security [2]. Another study by Sunehra *et al.* introduced a Raspberry Pi–based wearable safety device that uses GPS and GSM technologies to transmit the user's location to predefined contacts, enabling rapid assistance during emergencies [3].

Mobile applications have also been widely explored as tools for improving women's safety. Khandoker *et al.* developed the Lifecraft Android application, which allows users to send emergency alerts and location information to nearby contacts or authorities in case of danger [4]. In addition, Farooq *et al.* conducted a systematic literature review highlighting the growing role of IoT technologies in improving women's safety by enabling real-time monitoring, sensor integration, and automated alert systems [5]. These technologies have opened opportunities for creating smart security systems capable of detecting threats and responding quickly.

Robotic surveillance systems are emerging as an innovative approach to enhance safety in public spaces. Umapathy *et al.* proposed a night surveillance robot that uses sensors and cameras to monitor surroundings and assist in security patrol tasks, demonstrating how autonomous robots can support law enforcement in maintaining safety during nighttime [6]. Similarly, Raganna *et al.* developed an IoT-based night patrolling robot capable of monitoring suspicious activities and transmitting real-time alerts to control centers, highlighting the effectiveness of robotic systems for continuous surveillance [10]. Bhatia further explored the integration of artificial intelligence with IoT in safety robots, enabling intelligent threat detection and automated response mechanisms [11].

Several other studies have examined IoT-based safety frameworks and wearable solutions designed to improve emergency communication and situational awareness. Islam *et al.* developed a wearable device specifically aimed at improving women's safety by enabling quick alerts and location tracking through connected systems [7]. Ramachandiran *et al.* conducted a survey on IoT-based women safety devices and emphasized the importance of integrating sensors, communication networks, and real-time monitoring systems to build effective safety solutions [8]. Sathyasri *et al.* proposed an IoT-based safety system that integrates sensors and communication modules to provide automated alerts and tracking features, ensuring timely assistance in emergency situations [12].

Beyond individual safety devices, broader IoT frameworks and intelligent systems have been investigated to enhance safety and security in smart environments. Broens *et al.* discussed context-aware IoT applications capable of adapting to real-time environmental conditions, which can be applied in safety monitoring systems [9]. Wagh *et al.* evaluated IoT-based smart safety systems and highlighted their potential to improve urban security through automated monitoring and rapid communication networks [13]. Additionally, research on IoT architectures and applications demonstrates how interconnected devices can support socially relevant applications such as public safety and surveillance [14]. Studies on human–robot interaction have also emphasized the importance of designing robots that improve perceived safety and trust among users when deployed in public environments [15].

Overall, these studies demonstrate significant progress in developing IoT-enabled safety devices, mobile applications, and robotic surveillance systems. However, many existing solutions focus primarily on wearable devices or alert systems and lack integrated autonomous monitoring capabilities. Therefore, the proposed IoT-enabled autonomous night patrolling robot aims to combine intelligent surveillance, real-time communication, and autonomous navigation to provide a more comprehensive and proactive solution for enhancing women's safety in urban environments.

III. PROPOSED MODEL

The proposed system introduces an IoT-enabled autonomous night patrolling robot designed to improve women's safety in urban environments through intelligent monitoring, real-time communication, and automated threat detection. The system integrates sensors, embedded controllers, communication modules, and machine learning techniques to provide continuous surveillance in areas that are poorly monitored during nighttime. The robot operates autonomously and patrols predefined paths such as streets, campuses, parks, or residential communities. By combining robotics with IoT technology, the system enables remote monitoring and immediate response to suspicious activities, thereby enhancing the overall security infrastructure.

The robot is built around a microcontroller-based control unit, which coordinates all hardware components and manages the communication between sensors and IoT platforms. Sensors such as Passive Infrared (PIR) motion sensors, ultrasonic sensors, and a camera module are used to detect

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

human presence, monitor surrounding activities, and avoid obstacles during navigation. The PIR sensor detects movement in the robot's vicinity, while the ultrasonic sensor helps measure distances to nearby objects, enabling safe navigation and collision avoidance. The camera module captures images or streams video to a remote monitoring station, allowing security personnel to observe the environment in real time.

To ensure accurate location tracking, the robot is equipped with a Global Positioning System (GPS) module that continuously provides geographic coordinates of the robot's position. These coordinates are transmitted through the IoT network to a cloud platform where authorized users or security personnel can monitor the robot's movement remotely. If suspicious activity is detected, the system automatically sends alerts and location details to predefined contacts or monitoring centers. This real-time communication capability significantly reduces response time during emergency situations.

The proposed model also integrates machine learning–based facial recognition and audio anomaly detection to identify potential threats. The facial recognition system compares captured images with stored datasets to detect unknown or suspicious individuals. Similarly, the audio detection module analyzes environmental sounds such as screams or distress signals that may indicate emergency situations. When such anomalies are detected, the system automatically triggers alerts, activates a buzzer, and transmits notifications to the monitoring system through IoT connectivity.

Autonomous navigation is another key feature of the proposed model. The robot follows a predefined patrol route using path-planning algorithms while continuously scanning the environment for obstacles and suspicious activities. If an obstacle is detected, the system automatically adjusts the robot's movement to avoid collisions while maintaining the patrol path. This autonomous capability ensures continuous monitoring without requiring constant human intervention.

Overall, the proposed model provides an integrated safety solution that combines IoT communication, robotic mobility, intelligent surveillance, and automated alert mechanisms. The system is designed to be cost-effective, scalable, and suitable for deployment in urban areas, including campuses, residential societies, and public spaces. By enabling proactive monitoring and rapid response, the proposed autonomous night patrolling robot significantly enhances women's safety and contributes to the development of smarter and safer urban environments.

IV. PROPOSED SYSTEM

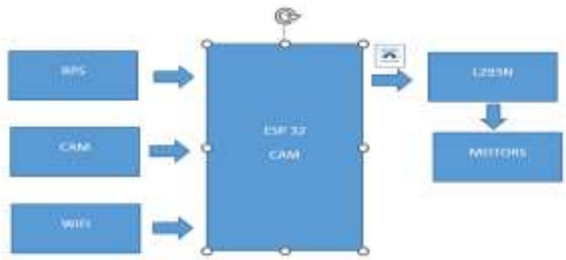

Fig.1.Block diagram

The diagram represents the system architecture of the IoT-Enabled Autonomous Night Patrolling Robot. In this architecture, the ESP32-CAM module acts as the central processing unit that controls and coordinates all components of the robot. On the input side, the PIR sensor (RPS) detects human motion or suspicious activity in the surrounding environment, while the camera module (CAM) captures images or streams live video for monitoring purposes. The Wi-Fi module, integrated within the ESP32, enables IoT connectivity, allowing the robot to transmit real-time data, alerts, and video feeds to a remote monitoring system or cloud

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

platform. Based on the sensor inputs and programmed logic, the ESP32 processes the information and sends control signals to the L293N motor driver, which acts as an interface between the microcontroller and the DC motors. The motor driver amplifies the control signals and drives the motors to move the robot forward, backward, or change direction during patrolling. This integrated architecture enables autonomous navigation, real-time surveillance, and remote monitoring, thereby improving safety and security during nighttime patrol operations.

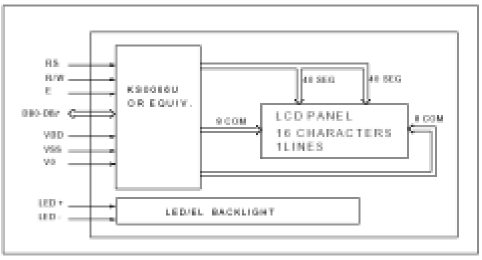

Fig.2. Electrical Block Diagram

V. RESULTS AND DESCUSSIONS

The proposed IoT-Enabled Autonomous Night Patrolling Robot for Enhanced Women's Safety in Urban Environments improves public safety by integrating IoT communication, embedded processing, and autonomous robotic surveillance. The system continuously monitors urban environments during nighttime using sensors, a camera module, and wireless communication technologies connected to the ESP32-CAM controller. The robot patrols predefined paths and collects environmental data through its sensors while streaming live video through the camera module. When suspicious motion or unusual activity is detected, the system immediately sends alerts to the monitoring station through Wi-Fi connectivity. This intelligent surveillance mechanism enables real-time monitoring and rapid response, which significantly improves safety in isolated or poorly monitored areas.

The specifications of the components used in the proposed system are presented in Table 1. The ESP32-CAM module acts as the central controller responsible for processing sensor inputs, handling camera operations, and enabling IoT connectivity. The PIR motion sensor detects human presence or suspicious movement in the robot's surrounding area. The camera module captures real-time images and video streams that can be accessed remotely through the IoT network. The Wi-Fi module, integrated within the ESP32, allows wireless communication between the robot and the remote monitoring platform. The L293N motor driver controls the movement of the DC motors by receiving control signals from the ESP32 controller. Finally, the DC motors enable the robot to move in different directions during its patrol operations.

TABLE 1: SENSOR AND COMPONENT SPECIFICATION

SI.NO	Components	Specifications
1	ESP32-CAM	Operating Voltage: 3.3–5V, Built-in WiFi, Integrated Camera Interface
2	PIR Motion Sensor	Operating Voltage: 5V, Detection Range: 3–7 m
3	Camera Module	Real-time image and video capture for surveillance
4	WiFi Module	Wireless communication for IoT monitoring
5	L293N Motor Driver	Dual H-Bridge Motor Driver, Operating Voltage: 5–12V
6	DC Motors	Provide movement and direction control for robot
7	Power Supply	Battery-based power source for robot operation

Received: 19-02-2026 | Accepted: 24-03-2026 | Published: 31-03-2026

International Journal of
AI Electronics and Nexus Energy
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0515 www.zesterapublications.com Original Research Paper

The hardware implementation integrates all sensing and control components with the ESP32-CAM microcontroller to create an intelligent patrolling system. During operation, the robot moves along its predefined path while continuously monitoring the surrounding environment. The PIR motion sensor detects human movement and sends signals to the ESP32 controller whenever motion is identified. Simultaneously, the camera module captures live images or video frames of the area being monitored. These images are transmitted to the remote monitoring system through Wi-Fi connectivity, allowing security personnel to observe real-time conditions.

The L293N motor driver receives control signals from the ESP32 and regulates the movement of the robot by controlling the speed and direction of the DC motors. This allows the robot to navigate autonomously through streets, campuses, or residential areas. If an obstacle or unusual movement is detected, the system can stop or change direction accordingly to continue patrolling without interruption. The integration of sensors and motor control ensures that the robot operates safely and efficiently during its surveillance tasks.

The experimental results demonstrate that the proposed system effectively performs autonomous monitoring and threat detection during nighttime patrol operations. The PIR sensor accurately detects motion within its detection range, enabling the robot to identify potential human presence in low-visibility environments. The camera module successfully streams real-time video, which allows remote users to monitor the patrolling area continuously. The IoT communication system reliably transmits alerts and monitoring data to the remote platform, ensuring timely responses in case of suspicious activities.

Overall, the implementation of the proposed system contributes to improved urban safety by providing continuous surveillance, automated motion detection, and real-time communication. The integration of IoT connectivity with robotic mobility enables proactive monitoring of vulnerable locations, which can help prevent incidents and improve emergency response time. By combining embedded systems, intelligent sensing, and wireless communication technologies, the proposed night patrolling robot provides a cost-effective, scalable, and efficient solution for enhancing women's safety in urban environments.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion:

Women's safety requires proactive, intelligent, and continuous surveillance solutions capable of functioning effectively during nighttime when the risk of crime is highest. The proposed IoT-enabled night patrolling robot addresses the limitations of human patrols and static CCTV systems by offering autonomous navigation, intelligent sensing, and real-time IoT communication. The literature review reveals the progression from simple sensor-based robots to advanced AI-integrated patrol units capable of detecting threats, recording evidence, and initiating instant alerts. By integrating IoT, robotics, and machine learning, the system significantly enhances situational awareness and response capability. Such a robot can play a vital role in public safety by monitoring high-risk areas, reducing crime attempts, and ensuring a safer environment for women in urban and campus settings. With future enhancements—including energy-efficient hardware, advanced AI models, and swarm-based patrolling—this technology can become a cornerstone of modern safety infrastructure.

Future Scope:

The proposed IoT-Enabled Autonomous Night Patrolling Robot provides an effective

Received: 19-02-2026 | Accepted: 24-03-2026 | Published: 31-03-2026

solution for improving women's safety through automated surveillance and real-time monitoring. However, several enhancements can be implemented in the future to further improve the system's efficiency, intelligence, and scalability. One possible enhancement is the integration of advanced artificial intelligence and deep learning algorithms for more accurate threat detection. By using improved facial recognition models and behavior analysis techniques, the robot can identify suspicious activities, recognize known offenders, and analyze abnormal human behavior more effectively.

Future developments can also include the addition of advanced sensors such as thermal cameras, sound detection modules, and environmental sensors to improve monitoring capabilities in low-visibility or noisy environments. Thermal imaging can help detect human presence even in complete darkness, while sound detection systems can identify distress signals such as screams or unusual noises that may indicate emergency situations.

Another potential improvement is the implementation of autonomous navigation using advanced path-planning and mapping algorithms such as SLAM (Simultaneous Localization and Mapping). This would allow the robot to dynamically explore and patrol large environments without relying solely on predefined routes. Additionally, integrating multiple patrolling robots that communicate through a centralized IoT platform can create a coordinated robotic surveillance network capable of covering larger urban areas.

The system can also be integrated with smart city infrastructure and emergency response systems, allowing real-time communication with nearby police stations, security control rooms, and emergency services. This integration would enable faster response times during critical situations and enhance overall urban security management.

Overall, future improvements in artificial intelligence, robotics, and IoT technologies can transform the proposed system into a fully autonomous smart surveillance platform capable of providing continuous monitoring, predictive threat detection, and coordinated security operations in modern urban environments.

VII. REFERENCES

[1]. A. Jatti, M. Kannan, R. M. Alisha, P. Vijayalakshmi, and S. Sinha, "Design and development of an IoT based wearable device for the safety and security of women and girl children," in *Proc. IEEE Int. Conf. Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, 2016, pp. 1108–1112. doi: 10.1109/RTEICT.2016.7808070.

[2].Kalae, U. K. (2021). Enhancing data analytics and reporting efficiency using Power BI and SQL in cloud computing environments. Journal of Computational Analysis and Applications, 29(6), 2021. https://doi.org/10.48047/jocaaa.2021.29.06.48

[3].Kalae, U. K. (2025). Optimizing cost-effective cloud data pipeline orchestration across multiple cloud providers. Journal of Information Systems Engineering and Management, 10(63s), e726–e741.

[4].Saikumar, B. (2023). Enhancing Client Engagement through AI-Driven Real-Time Reporting and Automated Alerts. International Journal of Enhanced Research in Science, Technology & Engineering, 12(11), 111–117. https://doi.org/10.55948/ijerste.2023.1115

[5].Saikumar, B. (2024). Optimizing Crew

Scheduling and Absence Management using Microservices: Enhancing Reliability and Efficiency in Crew Management Systems. International Journal of Enhanced Research in Management & Computer Applications, 13(11),50–55. https://doi.org/10.55948/ijermca.2024.0116

[6]. O. Vermesan and P. Friess, *Internet of Things – From Research and Innovation to Market Deployment*. River Publishers, 2014. DOI: https://doi.org/10.1007/978-3-319-05029-4

[7]. D. Múnera, V. Diana, J. Aguirre, and N. Gómez, "IoT-based air quality monitoring systems for smart cities: A systematic mapping study," *International Journal of Electrical and Computer Engineering*, vol. 11, no. 4, pp. 3470–3482, 2021. doi: 10.11591/ijece.v11i4.pp3470-3482.

[8]. N. R. Sogi, P. Chatterjee, U. Nethra, and V. Suma, "SMARISA: A Raspberry Pi based smart ring for women safety using IoT," in *Proc. IEEE Int. Conf. Inventive Research in Computing Applications (ICIRCA)*, 2018, pp. 451–454. doi: 10.1109/ICIRCA.2018.8597279.

[9]. D. Sunehra, V. S. Sreshta, V. Shashank, and B. U. Goud, "Raspberry Pi based smart wearable device for women safety using GPS and GSM technology," in *Proc. IEEE Int. Conf. Innovation in Technology (INOCON)*, 2020. doi: 10.1109/INOCON50539.2020.9298257.

[10]. R. R. Khandoker, S. Khondaker, F. N. Nur, and S. Sultana, "Lifecraft: An Android based application system for women safety," in *Proc. IEEE Int. Conf. Sustainable Technologies for Industry 4.0 (STI)*, 2019. doi: 10.1109/STI47673.2019.9068043.

[11]. M. S. Farooq, A. Masooma, U. Omer, R. Tehseen, S. A. Gilani, and Z. Atal, "The role of IoT in women's safety: A systematic literature review," *IEEE Access*, vol. 11, pp. 69807–69825, 2023. doi: 10.1109/ACCESS.2023.3253475.

[12]. K. Umapathy, S. Chandramohan, A. Sathvika, and M. Sivakumar, "Night surveillance robot for women safety," in *Proc. IEEE Int. Conf. Electronics and Sustainable Communication Systems (ICESC)*, 2022. doi: 10.1109/ICESC54411.2022.9885479.

[13]. M. Islam et al., "A wearable device for the safety of women in Bangladesh," in *Proc. Int. Conf. Advances in Mobile Computing and Multimedia*, 2018. doi: 10.1145/3292147.3292160.

[14]. R. Ramachandiran, L. Dhanya, and M. Shalini, "A survey on women safety device using IoT," in *Proc. IEEE Int. Conf. System, Computation, Automation and Networking (ICSCAN)*, 2019. doi: 10.1109/ICSCAN.2019.8878782.

[15]. Todupunuri, A. (2025). Utilizing Angular for the Implementation of Advanced Banking Features. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5283395

[16]. Sushma Babburi. (2025). Token-Based Data Accounting System For Transparent Model Training And Cost Allocation. American Journal of AI Cyber Computing Management, 5(4), 463–474. https://doi.org/10.64751/ajaccm.2025.v5.n4.pp463-474

[17]. Snigdha Gaddam. (2025). SOFTWARE STACK PREPARED FOR AI TRANSITIONING FROM MODULES TO MODELS. American Journal of AI Cyber Computing Management, 5(4), 451–462.

https://doi.org/10.64751/ajaccm.2025.v5.n4.pp451-462

[18]. T. Broens, A. Van Halteren, M. Van Sinderen, and K. Wac, "Towards an application framework for context-aware m-health applications," *Int. J. Internet Protocol Technology*, vol. 2, no. 2, pp. 109–116, 2007. doi: 10.1504/IJIPT.2007.016775.

[19]. A. Raganna, K. Nithesh, B. Neha, O. V. Shrivastav, and P. T. Musaguppi, "IoT based night patrolling robot for women safety," *International Journal of Modern Agriculture*, vol. 10, no. 2, pp. 3886–3894, 2021.

[20]. S. Bhatia, "IoT and AI based women's safety night patrolling robot," *SSRN Electronic Journal*, 2022. doi: 10.2139/ssrn.4158918.

[21]. B. Sathyasri et al., "Design and implementation of women safety system based on IoT," in *Proc. Int. Conf. Smart Systems and Inventive Technology*, 2019. doi: 10.1109/ICSSIT46314.2019.8987814.

[22]. N. R. Wagh et al., "Evaluation of IoT-based smart safety systems for women," *Scientific Reports*, vol. 15, 2025. doi: 10.1038/s41598-025-29146-4.

[23]. S. Anush Lakshman, S. Akash, J. Cynthia, R. Gautam, and D. Ebenezer, "Architecture and applications of IoT devices in socially relevant fields," *arXiv*, 2023. doi: 10.48550/arXiv.2308.09195.

[24]. Gaddam, S. INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING.

[25]. Bajarang Bhagwat, V. (2023). Optimizing Payroll to General Ledger Reconciliation: Identifying Discrepancies and Enhancing Financial Accuracy. JOURNAL OF ADVANCE AND FUTURE RESEARCH, 1(4). https://doi.org/10.56975/jaafr.v1i4.501636

[26]. Suhasnadh Reddy Veluru, Sai Teja Erukude, and Viswa Chaitanya Marella. 2025. Multimodal Detection of Fake Reviews using BERT and ResNet-50. In 2025 4th International Conference on Innovative Mechanisms for Industry Applications (ICIMIA). IEEE, 877–882.

[27]. Doragacharla, V. R. (2026). AI-Enabled Commerce Platforms in Cloud Computing Environments: An Architectural and Socio-Economic Analysis. Journal of Computational Analysis & Applications, 35(1).

[28]. Jay Bharat Mehta. (2025). AUTONOMOUS PATCH VALIDATION FOR ZERO-DAY EXPLOITS IN ENTERPRISE CLOUDS. International Journal of Applied Mathematics, 38(4s), 1270–1285. https://doi.org/10.12732/ijam.v38i4s.685

[29]. Reddy, S. K. (2025). Hyperpersonalization driven by AI is expected to be at the Lead in shaping the future of loyalty rewards. Journal of Emerging Technologies and Innovative Research.

[30]. Reddy, S. K. R. Developing a Modular AI Framework to Enhance Scalability and Personalization in Next-Generation Reward Platforms.

[31]. Poojari, R. (2026). Privacy-Preserving Generative AI in Healthcare Systems Using Federated Learning Approaches. International Journal of Data Science and IoT Management System, 5(1),

78-88.

[32]. N. Akalin, A. Kristoffersson, and A. Loutfi, "Factors influencing perceived safety in human-robot interaction," *arXiv*, 2021. doi: 10.48550/arXiv.2106.05854.