Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 10s (2025)

Women Safety Night Patrolling Robot in IoT

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Article History:

Received: 12-01-2025

Revised: 15-02-2025

Accepted: 01-03-2025

Abstract:

This document outlines the design, implementation, and usage of the "IoT-Based Women Safety Night Patrolling Robot", which, in various ways, successfully displays a new development in deployment and safety for women alone at night. The concerning issue to society's level of violence against women is unprecedented. This project employe \"Internet of Things\" (IoT) with the ESP32-CAM microcontroller, an adaptive navigation algorithm, and real-time video stream. All of these items combined make an autonomous robotic system patrol an established area and surveils and alerts to possible threats, sending video and other information back to the control center for intervention. The robot is programmed parametrically in speed and light display. It reacts to its external environment entirely, making the device complex for robotic patrol in public. The system also includes an obstacle avoidance capability and can navigate dynamically through its environment autonomously. This robotic, IoT-enabled system is intended to allow peace of mind in safety for women, while building independence in public. Future development involves an AI-enabled threat detection capacity, as well as increasing the patrolling capacity of the system. Ultimately, the Women Safety Night Patrolling Robot is a significant step forward in addressing the societal challenge of women's safety, empowering women to navigate public spaces with greater confidence and ensuring timely, proactive security measures in urban and rural areas.

Keywords: Women safety, Night patrolling robot, Internet of Things (IoT), Autonomous surveillance, Raspberry Pi, Real-time monitoring, Sound detection, Emergency response, Threat detection, Artificial intelligence (AI), Public safety.

1. INTRODUCTION

Currently, women's safety remains an issue, particularly at night or at time that represents an increased risk for harassment, attack, and violence. Safety creates a situation where many women cannot be alone outdoors, restricting their independence and freedom of mobility. Violence against women will continue, regardless of the existence of laws and campaigns aimed at society being aware of protection and equality against gender [1]. By introducing technology such as the Internet of Things (IoT), there are new ways to address these problems. The Women Safety Night Patrolling Robot is proposed in this paper to help reduce threats and provide public space surveillance in real-time. This mobile robotic solution incorporates IoT-enabled mobile components to detect suspicious behavior, alert authorities,

and provide women a sense of safety in outdoor public spaces. By including an innovative array of sensors, artificial intelligence (AI), and proactive communication strategies, the robotic system can help fill the safety gaps that exist, lend women assurance of their safety, and encourage public engagement during evening hours. The safety of women is central in ensuring a public and civic structure that accepts early interventions as a standard practice of 'normal' policing. It is through a cooperative reinforcement of new technologies within public safety oversight that we can contribute to an idea of sustainability that protects women [2].

Although technological advances have progressed rapidly, crimes against women are still a considerable issue on a global scale. Numerous reported cases demonstrate that public spaces are frequently unsafe zones for women, and as a result, they will shy away from public or private engagements, including social, economic, etc. The root of the issue is to address the public safety and public security component of systems, specifically the lack of real-time monitoring and proactive security measures to intervene cases of emergencies [3]. Despite human patrolling to serve this public safety, there are limits to human resources, response times, and geographical location. The Women Safety Night Patrolling Robot serves a technical approach to increased security, with the robot responsible for autonomously patrolling the area, surveillance for unusual behaviors, and live alerts [4]. Other IoT integrated systems would include GPS tracking, night vision cameras, motion sensors, real-time AI based threat assessments, etc. The potential future of the robot is to be one of the types of surveillance systems responsible for monitoring public and private spaces, and acting as a timely guardian of public safety for use by law enforcement. More innovation in the field contributes to the goals of smart cities, where technology informs and minimally enhances public safety and security conditions. Technology will play a growing role in ensuring public safety, especially for vulnerable populations.

Women often experience multiple forms of insecurity, not only in public but also in the so-called safe space of their own home [5]. Some of the risks women face include domestic violence, work-related sexual harassment, and stalking - which continue to impact their sense of safety and feeling of freedom. While the law should provide justice, the law's way to provide justice often comes with long delays and is not safe to use as a preventive measure. With this in mind, there is a need for pre-emptive safety measures that can provide security against threats rather than a traditional response after an incident has occurred. Introducing the Women Safety Night Patrol Robot (WSNPR), an IoT-enabled response robot for women who experience heightened risk [6]. Equipped with autonomous patrolling, live-streaming, a distress message service, and integration with law enforcement databases, the WSNPR is intended to protect and serve as a device to monitor communal spaces. This approach has harnessed artificial intelligence and machine learning to learn behaviors related to suspicious activity and predict threatening behaviors or person's actions to respond accordingly. From a protective standpoint, the WSNPR should increase safety for women and deter criminals or potential perpetrators from committing a crime in identified monitored areas. Ultimately, these advancements will result in security solutions that could also be implemented in cities and areas identified as high-risk areas.

Change within society is a slow process. However, technology can provide immediate answers to existing security gaps. The introduction of an IoT-enabled robot specifically designed for night-time patrolling is a step towards maintaining an inclusive and safe society wherein women can have access

to their rights without feeling insecure. The combination of smart surveillance, fast communication systems, and AI-enabled analysis creates a powerful crime prevention system [7]. Additionally, this robot can be deployed in many different urban and rural contexts, and access to it could also become widespread throughout different societies, benefiting many locations and people. By using technology to innovate in the area of women's safety, society is on its way to achieving gender equality and facilitating an inertia where women truly feel empowered, as opposed to constrained and unsafe. This academic paper will explore the technical issues and aspects related to the practical deployment and societal benefits of the Women Safety Night Patrolling Robot. In the end, it will show how technology can be used or adapted to create a world where women feel safer as other technological (or suggested technological) solutions to women's safety arise in societies across the globe.

2. RELATED WORK

Women's safety has become a rising concern internationally, warranting significant advancements in robotics and IoT (Internet of Things) associated monitoring systems. Several researchers have tested different autonomous robots for night patrols and emergency response.

Patel et al. (2018) developed a smart surveillance robot that could detect suspicious activity using infrared sensors and send real-time alerts to law enforcement with the help of Internet of Things (IoT) integration [8]. In the same way, Ali et al. (2024) designed a mobile-based security bot that incorporated GPS tracking and voice recognition to increase emergency response capabilities [9]. In another study, Sharma and associates employed machine learning algorithms on an IoTea-embedded robot to identify human behavior patterns for interventions in distress situations[10]. Singh and colleagues created a patrol robot equipped with artificial intelligence (AI) that used ultrasonic sensors with GSM communication for alerting police and emergency services automatically [11]. The study conducted by Kumar et al. (2022) focused on the edge-computing approach aiming to minimize response time in emergencies by accessing real-time data within the device instead of performing computations in the cloud [12]. The most recent research by Malik et al. (2025) points to the use of a hybrid system integrating LiDAR-based navigation and artificial intelligence-based threat assessment to optimize patrol effectiveness in remote areas [13].

The latest developments in night patrol robots have utilized artificial intelligence (AI), computer vision, and networks connected through the Internet of Things (IoT) to improve the safety of women in public areas. Reddy and others (2024) introduced a smart wearable device that utilizes IoT, GPS, and messaging to improve the safety of women and children with automated emergency alerts [14]. The integrated model presented by Dubey et.al (2025) uses a combination of AI, IoT, and cloud computing technologies to enhance women's safety through real-time threat detection, enhanced monitoring, and improved data processing, which will inform ongoing security initiatives [15]. A recent study by Narayan et al. (2024) explored the use of blockchain technology in IoT-based patrolling robots to ensure tamper-proof data storage, improving transparency in security interventions [5]. This evolution in security robotics showcases how AI, IoT, and real-time communication systems can create a safer environment for women, especially during night-time hours.

Overall, these findings demonstrate the expanding role of technology in increasing women's safety, and they show how IoT-enabled robotic patrolling systems are becoming smarter and increasing efficiency of security use.

3. MATERIALS AND METHODS

The Women Safety Night Patrolling Robot uses cutting-edge technologies based on the Internet of Things (IoT) for enhancing security and monitoring and ensuring better safety. The system is based on the ESP32-CAM microcontroller, which is capable of Wi-Fi communication and streaming video at the present time. The robot itself is controlled remotely by the user with a web-based interface, through a web browser to send commands. The ESP32 Web Server serves as the center hub, processing commands via WebSocket to link the user, the ESP32-CAM and facilitate video to be transferred to the web browser. When the robot needs to move autonomously, the L298N motor driver controls two DC motors to drive its left and right wheels. The robot's direction and speed are controlled with a precise pulse-width modulated (PWM) control scheme for precise robot movement. The ESP32-CAM captures the video and streams MJPEG video through Wi-Fi so that it can be continually monitored and watched in the web browser. The robot implements an Adaptive Obstacle-Aware Navigation Algorithm (AOANA) that dynamically detects and avoids obstacles as it patrols.

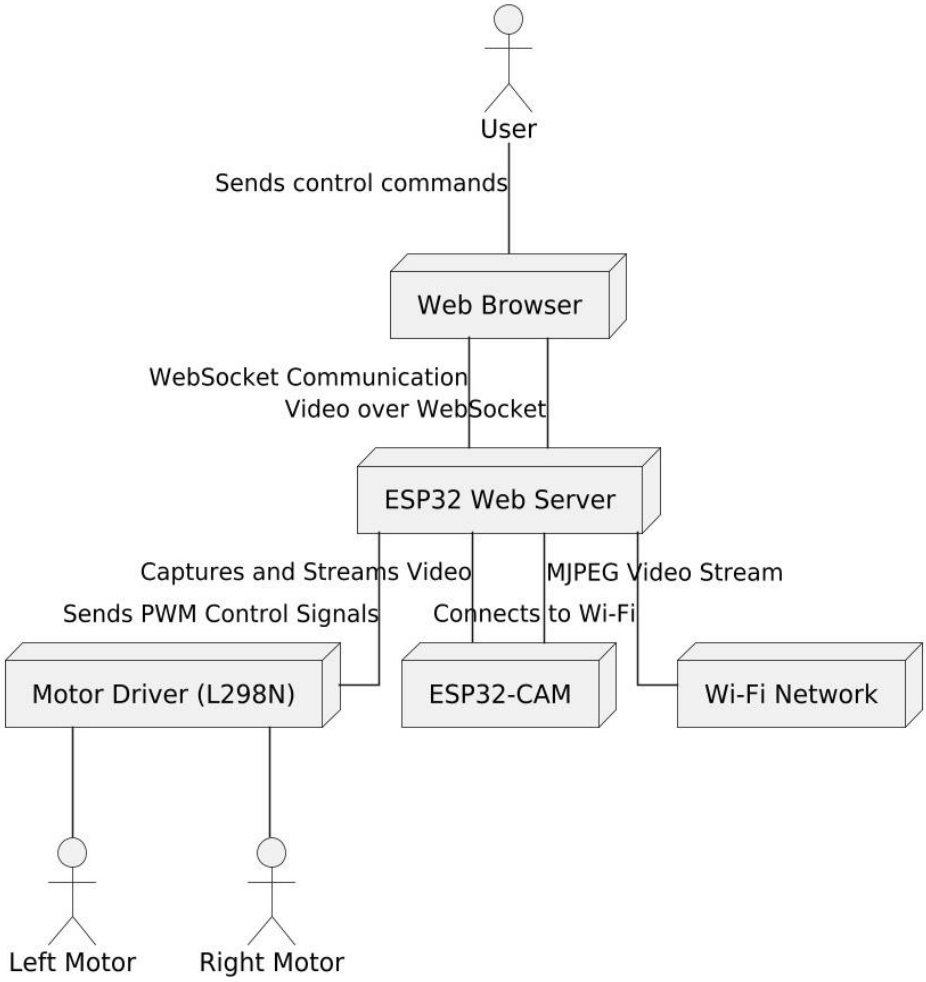


Fig. 1. ESP32-CAM IoT-Based Robot Architecture

The robot runs on a power source consisting of three 18650 Li-ion batteries which are electronically regulated by a voltage regulator to maintain power to the robot at all times. This permits the robot to perform constant patrols during the night while maintaining sustained patrols. The Women Safety Night Patrolling Robot employs an IoT system based on WebSocket communicating along with live video detecting, providing a reliable and efficient form of night-time safety for uncontrolled areas as well as in inner city patrols. Future iterations incorporated artificial intelligence which could detect threats, along with GPS-hat for even more security monitoring.

3.1. Microcontroller

Central to the Women Safety Night Patrolling Robot is the ESP32-CAM microcontroller. This versatile and compact module serves as the main/intelligent controller receiving commands via Wi-Fi and live streaming video. The ESP32-CAM module was chosen for the project as a powerful module for IoT applications due to the low-power consumption, camera, and Wi-Fi options the ESP32-CAM develops. It also allows remote monitoring where the live video feed is sent to a web interface or mobile application, allowing for a real-time view to assess and take action (if needed).

3.2. Motor Driver & Motors

The robot is capable of autonomous movement through a L298N motor driver that controls two DC motors. The motor driver receives commands from the ESP32-CAM and makes adjustments to the motors' speed and direction of motion based on the commands. The DC motors are connected to two wheels (one wheel on each side) which can turn and rotate forward and backward in addition to motion. Either a front or rear mounted caster wheel maintains stability while crossing over uneven surfaces. This mobility will allow the robot to patrol with autonomy areas that were previously captured and avoid obstacles in its path.

3.3. Power Supply

The power source of the robotic system is made up of three (18650) Lithium-ion batteries, which are known for their energy density and ability to recharge. The batteries are placed in a battery holder for safety and ease of use. Since a different voltage is needed for each of the components, the voltage is decreased to a desired voltage with a voltage regulator (AMS1117 3.3V or 5V). This voltage regulates the entire power-delivering process through the ESP32-CAM, and motor driver. Managing power is important during operation to extend time of power consumption, while also operating surveillance.

3.4. Camera

The ESP32-CAM camera houses the primary vision system of the robot, facilitating live video streaming. The camera captures video of the environment surrounding the robot, then transmits that video over Wi-Fi to an associated device for staff to watch the area the robot was patrolling and determine if a security breach occurred. The camera includes night vision capabilities, which are essential for monitoring the surveillance area in low-light conditions.

3.5. Communication & Connectivity

One essential aspect of the Women Safety Night Patrolling Robot is its communication connectivity between the robot and the operator interface. The robot can engage in wireless communications

through the ESP32-CAM which has a built-in Wi-Fi module, that allows the operator to see live video and communicate to the robot remotely. Furthermore, the ESP32-CAM itself has an on-board web server allowing the operator to control the robot to communicate using a mobile application or web interface. The connectivity gives the ability for monitoring and patrol of the robot to have real-time communication with the robot. Therefore, this makes presenting the robot if a real solution for patrolling and responding to a possible risky situation at night.

3.6. Adaptive Obstacle-Aware Navigation Algorithm (AOANA)

To enhance autonomous navigation, the robot employs the Adaptive Obstacle-Aware Navigation Algorithm (AOANA). This algorithm enables the robot to detect and avoid obstacles dynamically, ensuring smooth movement across various terrains. The AOANA operates by analyzing real-time data from sensors and adjusting the robot's path accordingly. The algorithm consists of the following key steps:

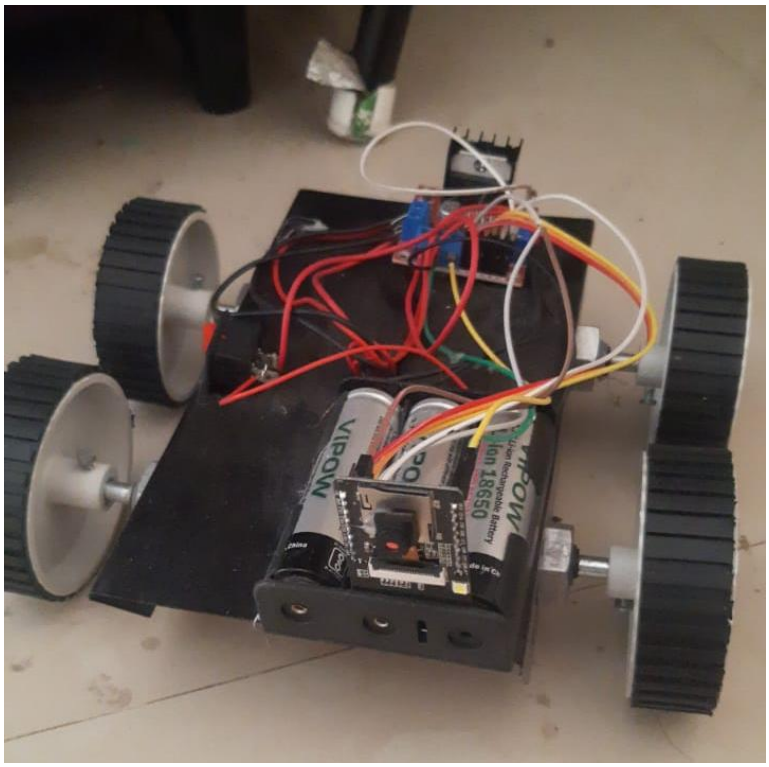
- Obstacle Detection: The robot continuously scans its surroundings using input from the ESP32-CAM and integrated motion sensors.
- Path Analysis: Based on the detected obstacles, the algorithm calculates an optimal path to navigate safely.
- Real-Time Adjustment: The motor driver adjusts the speed and direction of the motors to follow the computed path while avoiding obstacles.
- Emergency Stop Mechanism: If a sudden obstruction is detected, the algorithm triggers an immediate stop and sends an alert to the monitoring system.

The AOANA ensures that the robot can navigate autonomously in unpredictable environments, enhancing its efficiency as a patrolling device.

3.7. System Implementation

The development of the Women Safety Night Patrolling Robot involves multiple stages, from hardware assembly to software integration and testing. The implementation process includes:

- Hardware Setup: The ESP32-CAM, motor driver, DC motors, battery module, and camera are assembled into a compact chassis.
- Software Development: A firmware program is developed using Arduino IDE, integrating motor control logic, Wi-Fi communication, and live-streaming functionalities.
- Testing & Calibration: The robot undergoes multiple test runs in simulated environments to fine-tune obstacle detection, navigation algorithms, and power efficiency.
- Deployment: The final prototype is deployed in real-world conditions to evaluate its effectiveness in night-time patrolling and women's safety applications.



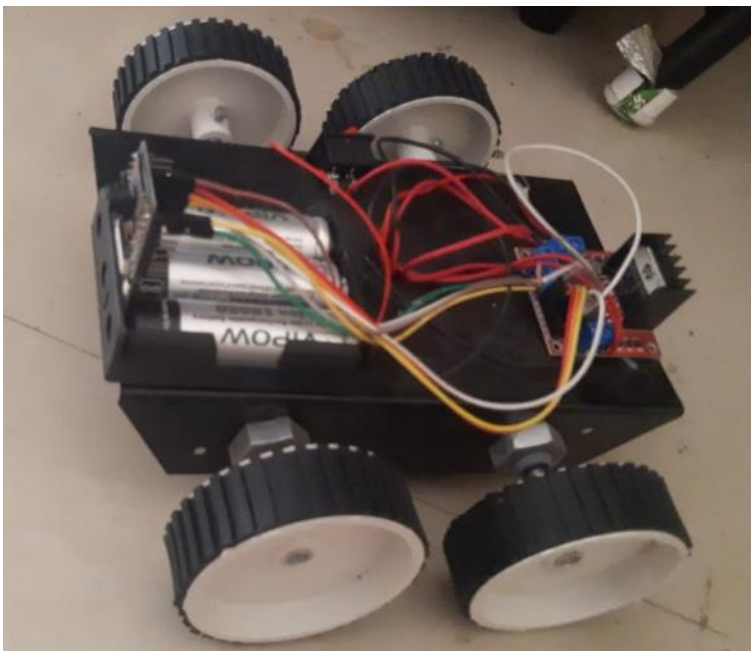


Fig. 2. Model Design and Setup

The described materials and methods provide a strong foundation for the Women Safety Night Patrolling Robot that creates an autonomous navigation system that utilizes both IOT and AI-driven technologies to facilitate real-time surveillance. The combination of an ESP32-CAM, motor driver, adaptive navigation algorithm, and web-based control interface is an effective and multi-functional robotic system. Future enhancements could include additional AI-based threat detection, improved camera resolution or added connectivity options to improve overall security.

4. RESULTS AND DISCUSSION

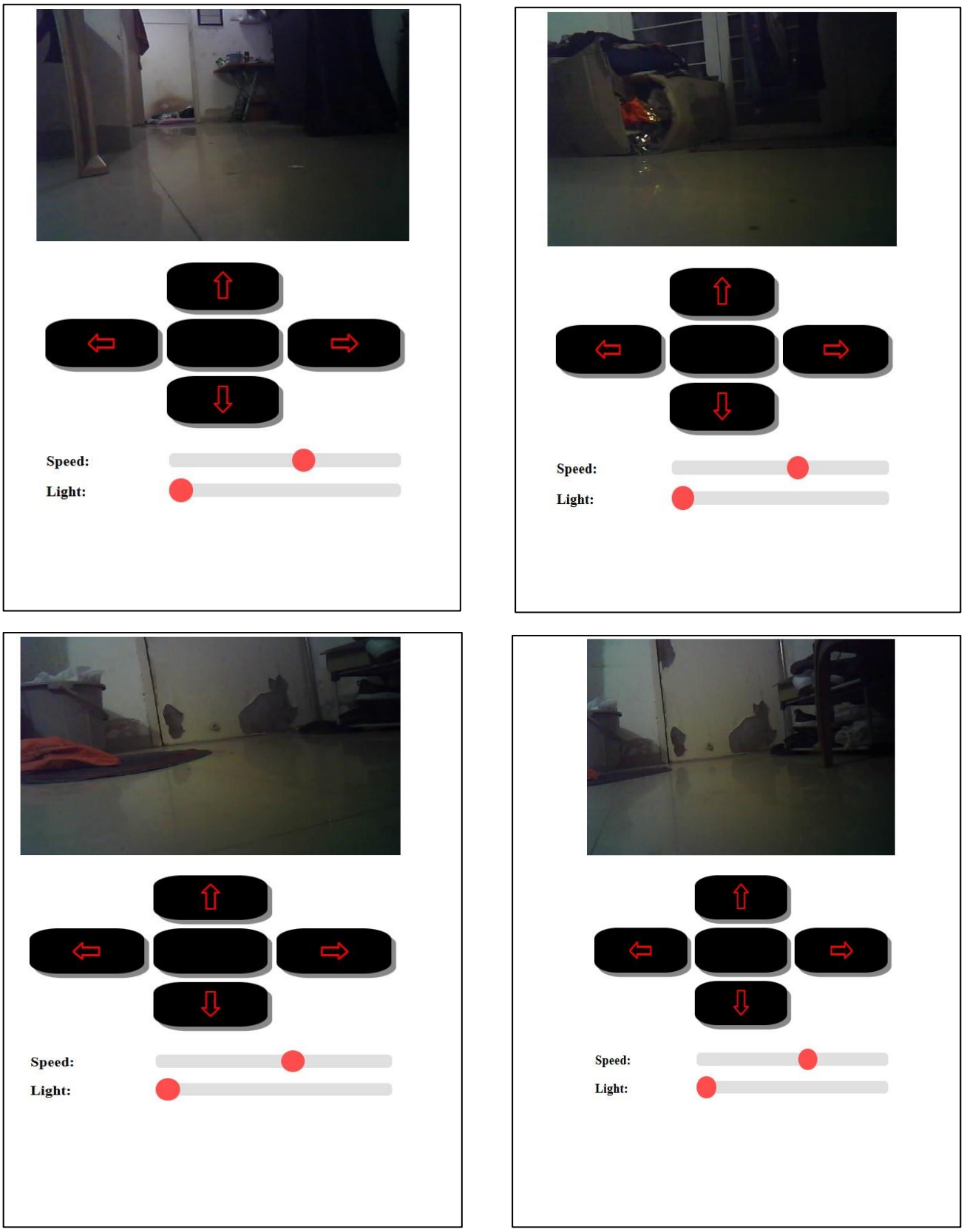


Fig 3: Control Interface for the Women Safety Night Patrolling Robot

As shown in the image above, this is the control interface of the Women Safety Night Patrolling Robot via IoT. The image shows a full view of the control panel, and these options shown are for directional movements (up, down, left and right), and to control the robot's speed and light intensity. The options for each allows the user to adjust how the robot operates based on circumstances, such as in darker areas, in a crowd or to slow or speed up the pace of the patrol based on the circumstances of the patrol.

The system is planned to allow the operator to control and monitor the robot's actions in real-time. With speed and light adjustable features, the robot is flexible enough to respond to a range of situation requirements autonomously while it is patrolling. It is essential that the robot has the ability to work in dynamic circumstances to achieve its primary mission of women safety, especially during the night.

Also, incorporating the directional controls (arrows) and adjustable speed and light enhances its interactivity, making it responsive and capable of traversing public spaces depending on instructions in the moment. Connections to the real-time video feed and the control system supply an overall view for surveillance. The data is comprised of user control coupled with autonomous functionality, that will contribute to enhancing safety capability in urban and rural situations.

5. CONCLUSION

The Women Safety Night Patrolling Robot is intended to be an inventive way to meet the men's safety issue that face women, particularly at night. This exciting design employs both IoT technology, such as an ESP32-CAM microcontroller, adaptive navigation algorithms, and live streaming video, to accomplish intelligent patrol and monitoring capabilities. To provide a higher level of safety for urban and rural dwelling women, the robot requires continuous oversight via video streaming, so any unknown threats can be monitored and responded to quickly. There will be an emergency alert system using a semi-autonomous robot to aid with obstacle avoidance while in a semi-dynamic and unpredictable environment.

The controllability of factors such as speed and light intensity affords some flexibility and an easy way to adjust to the context. The robot can patrol public venues, collecting information related to threats and facilitating actions for a monitoring control center on site. Future upgrades, such as AI-based threat detection capability and better camera resolution will further improve its functionality. The robotic platform is a significant shift towards increasing women's safety by incorporating safety and their comfort to engage in public spaces in order to do so. This project is establishing the groundwork for advancement in safety technology for the public in general and satisfies the larger goal of safety for women in environments.

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