DEVALOPMENT OF NIGHT PATROLLING ROBOT

Project Reference No.: *49S_BE_3866*

College : K.L.K Institute of Technology, Hubballi
Branch : Department of Mechanical Engineering
Guide : Dr. S. C. Sajjan
Students : Mr. Sayamdev V. Sakhare
Mr. Prajwal M. Mulagund

Key Words:

Night Surveillance, Wi-Fi Controlled Robot, Live Video Streaming, ESP32-CAM, Embedded Vision System, Web-Based Control Interface, Real-Time Monitoring, Indoor Navigation Differential Drive, Motor Driver (L298N), PWM Speed Control, Mobile Robot Platform, Directional Control, Compact Chassis Design, Gear Motor Actuation

Introduction:

The development of the Manually Controlled Night Patrolling Robot addresses the critical limitations of traditional human-led security, such as fatigue, limited night visibility, and environmental risks. In large indoor environments like academic campuses, warehouses, and residential complexes, maintaining a constant security presence is both labor-intensive and subject to human error. This project introduces a cost-effective, mobile surveillance solution designed to navigate single-floor structures while providing real-time visual feedback to a remote operator. By integrating the ESP32-CAM microcontroller, the robot functions as both the primary logic controller and a localized web server, allowing for seamless wireless communication without the need for external infrastructure.

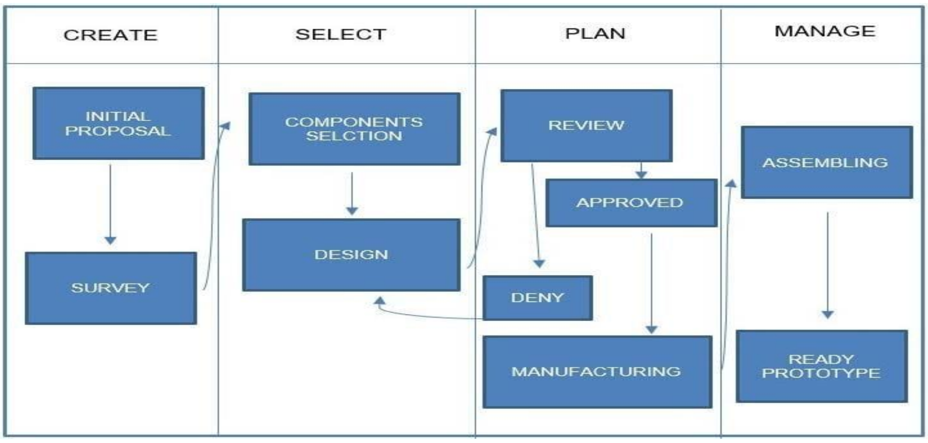
The robot’s architecture is centered on a four-wheel-drive chassis powered by DC geared motors and an L298N motor driver, enabling precise differential steering. To tackle the challenges of low-light environments, the system features an onboard high-brightness LED array with adjustable intensity, ensuring clear image capture during night hours. Users can control the robot’s movement and lighting via a custom-built web interface accessible from any Wi-Fi-enabled device. This eliminates the complexity of specialized mobile applications and ensures cross-platform compatibility. The integration of real-time MJPEG streaming allows the operator to perform perception-based navigation, effectively extending the reach of security personnel into restricted or dimly lit areas. Ultimately, this prototype demonstrates how affordable embedded systems and IoT frameworks can be combined to create a robust, versatile tool for modern indoor security management.

Objectives:

1. Establish Real-Time Visual Surveillance: To implement a high-definition camera system (ESP32-CAM) capable of streaming live video to a remote dashboard for immediate threat assessment.
2. Enable Remote Wireless Navigation: To develop a robust control system using Wi-Fi Access Points and WebSockets, allowing operators to maneuver the robot through complex indoor environments without physical tethering.
3. Optimize Low-Light Performance: To integrate adjustable PWM-controlled LED illumination that ensures clear visibility and image capture during night patrolling or inside dark conduits.
4. Ensure Mechanical Resilience: To design a collision-tolerant chassis or protective drone cage that allows the system to continue its mission after physical contact with obstacles or walls.
5. Reduce Human Risk and Fatigue: To provide a reliable robotic alternative for patrolling hazardous or repetitive environments, such as sewage systems or restricted industrial zones, thereby enhancing personnel safety.

Result And Conclusion:

The robot prototype was successfully manufactured and tested for single-floor indoor night patrol using a compact Wi-Fi-camera control architecture. The Night Patrolling Robot has been successfully designed and implemented as a compact cyber-physical surveillance platform optimized for indoor night patrol on a single floor. The primary design goal—achieving real-time video streaming combined with wireless manual navigation without GPS or dependency on a dedicated mobile application or external router—was fully accomplished using single-board embedded vision compute. The main processing and sensing functions were consolidated into a camera-equipped Wi-Fi microcontroller, enabling the robot to host itself as an independent wireless access point and serve its control dashboard through an intuitive browser interface. This significantly simplified user interaction and deployment logistics, ensuring universal accessibility across devices such as smartphones and laptops without requiring app installation, authentication delays, or persistent client-side software updates.



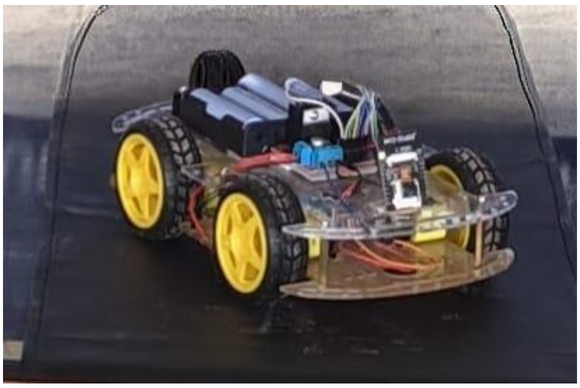
Project Outcome and Industry Relevance:

The project achieves the successful deployment of a remotely operated mobile platform that integrates real-time video streaming with a self-hosted wireless control interface. By utilizing an ESP32-CAM and a high-torque 4WD chassis, the system provides a stable and responsive solution for navigating single-floor indoor environments. A primary outcome is the implementation of PWM-controlled illumination, which allows for clear visual data acquisition in pitch-black conditions without the common issue of lens flare or image washout. Furthermore, the inclusion of a collision-tolerant frame and mechanical gimbal ensures that the sensor payload remains operational even after physical contact with obstacles, providing a level of durability not found in standard consumer electronics.

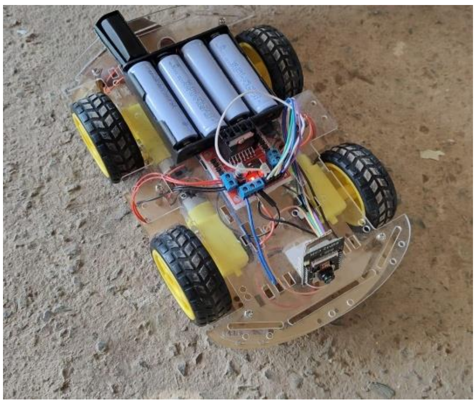
In terms of industry relevance, this technology addresses critical needs within the infrastructure and security sectors. It is particularly valuable for unmanned sewage and pipeline inspection, where hazardous gases and confined spaces pose significant risks to human workers. By replacing manual patrols with resilient robotic units, industries can improve Occupational Health and Safety (HSE) compliance and reduce labor costs. Additionally, the project's reliance on cost-effective components like the L298N driver demonstrates a scalable model for "Frugal Innovation," making advanced surveillance accessible to small-scale warehouses and academic campuses. Ultimately, these systems serve as essential data-gathering tools for Smart City initiatives, where real-time monitoring of underground utilities and indoor public spaces is becoming a standard requirement for modern urban management.

Working Model Vs Simulation/Study:

Simulation Model:



Working Model:



References:

1. O. H. Jimoh et al., "Design of an Indoor Security Patrolling Robot," 2016 ieee conference.
2. A. S. Mohan et al., "Internet of Robotic Things for Real-Time Surveillance," 2018 journal

3. Espressif Systems, "ESP32-CAM Datasheet," 2021.
4. L. Louis et al., "Low-Cost Controlled Robot for Campus Monitoring," 2019 research.
5. R. S. Kodali et al., "Websocket-Based Robot Control Using Embedded Wi-Fi Controllers," 2020 publication.
6. A. Nayyar et al., "IoT Wireless Robots: Trends and Challenges," Handbook of IoT and Robotics, 2019.
7. S. Thulasi et al., "Web-Based Surveillance Robot with Live Video," 2025 arxiv paper.
8. M. B. Alatise et al., "Onboard Video Streaming for Remote Mobile Inspection Robots," 2017 paper.
9. L298N Technical Manual, STMicroelectronics 2000 Series, in motor driver doc.
10. M. S. Couceiro et al., "Differential Drive Robots for Indoor Patrol Kinematics," robot kinematics paper.
11. Arduino IDE User Guide.
12. PlatformIO Documentation.

Future Scope:

1. Add ultrasonic/ToF/IR sensors for basic obstacle awareness
2. Enable automatic patrol scheduling using motion planning logic
3. Integrate audio sensing via microphone or sound sensor module
4. Improve Wi-Fi security by enabling stronger WPA2/WPA3 firmware
5. Add anomaly/face/object detection using lightweight CNN models.