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Naari suraksha: smart street lighting with women safety alert system

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Abstract: *Women's safety in public spaces and efficient street-light operation are important concerns in modern urban environments. Conventional surveillance systems often require continuous human monitoring, while street lights operating at fixed brightness may result in unnecessary energy consumption. This paper presents Naari Suraksha: Smart Street Lighting with Women Safety Alert System, an integrated prototype designed to support women's safety through computer vision and Internet of Things (IoT) technology. The system uses OpenCV and YOLOv8 for human detection, while MediaPipe pose landmarks and rule-based motion analysis are used to identify potentially suspicious interactions. An ESP32 microcontroller activates a buzzer and supports notifications through the Blynk IoT platform. An HC-SR04 ultrasonic sensor measures proximity, enabling adaptive LED brightness control using pulse-width modulation (PWM). Five completed functional tests were reported as passed under the tested conditions; four additional tests remain pending. These results demonstrate limited prototype-level functional operation and do not establish real-world safety effectiveness, detection accuracy, or verified energy savings.*

Keywords: *Naari Suraksha; Women safety; Smart Street lighting; YOLOv8; MediaPipe; ESP32; Blynk; Adaptive lighting.*

I. INTRODUCTION

Women's safety in public spaces remains an important concern, particularly in areas with inadequate surveillance and poor street lighting. Conventional surveillance systems primarily depend on human operators to monitor video feeds, which can lead to delayed responses and difficulties in monitoring multiple locations simultaneously. Street lights may also operate at fixed brightness levels regardless of nearby activity.

Naari Suraksha is an integrated prototype developed to support women's safety and adaptive street lighting. OpenCV and YOLOv8 support human detection, while MediaPipe pose estimation and rule-based motion analysis are used to identify potentially suspicious interactions. An ESP32 activates a buzzer and supports notifications through Blynk. An HC-SR04 ultrasonic sensor measures proximity, and PWM control adjusts LED brightness according to distance.

The objectives are to detect human presence, analyse configured motion patterns, activate local and remote alerts, implement distance-based lighting, and evaluate the prototype through functional testing. The work is limited to prototype-level engineering and does not claim validated real-world public-safety performance.

II. MATERIALS AND METHODS

Study Design

This project used a software and hardware development approach followed by functional testing to develop Naari Suraksha, an integrated prototype for women's safety and adaptive street lighting. The system combines computer vision, artificial intelligence, and Internet of Things (IoT) technologies to detect humans, analyse potentially suspicious interactions, generate alerts, and control street-light brightness. The work focuses on system development and functional behaviour; it was not a prospective observational study or a human-participant study.

Study Location and Duration

The project was carried out in the Department of Information Science and Engineering, Bapuji Institute of Engineering and Technology, Davanagere , Karnataka, India. The project report identifies the academic year as 2026-2027. It does not specify the exact development start and end dates.

Study Population and Sample Size

Human participants were not recruited for the project evaluation described in the journal. Therefore, a participant

sample size and sample-size calculation are not applicable. The evaluation focused on functional test cases designed to verify the operation of the implemented hardware and software components.

System Scope and Selection Criteria

The project scope included video-based human detection, suspicious-activity analysis, alert generation, IoT-based notifications, buzzer activation, and adaptive street-light brightness control. OpenCV and YOLOv8 were used for video processing and human detection, while MediaPipe pose estimation and rule-based motion analysis supported the identification of potentially suspicious interactions. An ESP32 microcontroller controlled the alert mechanism, and an HC-SR04 ultrasonic sensor supported distance-based lighting control through pulse-width modulation (PWM).

The project journal does not define clinical or human-participant inclusion and exclusion criteria. The evaluation was limited to the implemented prototype and its documented functional tests. Large-scale deployment, extensive real-world validation, independently measured detection accuracy, and quantified energy savings were outside the reported evaluation.

Procedure Methodology

The system operates through the integration of computer vision, microcontroller-based control, and adaptive lighting. Video frames are processed using OpenCV, and YOLOv8 supports human detection. MediaPipe estimates human pose landmarks, while rule-based motion analysis is used to identify configured patterns that may indicate suspicious interactions. When the configured conditions are met, the system sends an alert command to the ESP32 microcontroller.

The ESP32 activates a buzzer and supports remote notifications through the Blynk IoT platform. For adaptive lighting, the HC-SR04 ultrasonic sensor measures the distance of a nearby object. The system adjusts LED brightness using PWM, with the documented control rule setting brightness to 100% when the measured distance is below 150 cm and to 20% otherwise.

The system integrates Python, OpenCV, YOLOv8, MediaPipe, ESP32, the HC-SR04 ultrasonic sensor, PWM-based LED control, and Blynk. The journal describes the system architecture and component functions but does not establish that the prototype has been validated in extensive real-world environments.

Functional Testing

Functional verification covered human detection, simulated suspicious-behaviour alert generation, ESP32 buzzer activation, Blynk notification delivery, and HC-SR04-based distance-dependent lighting control. The journal reports that all five completed test cases passed, with Blynk notification delivery reported at 1.8 seconds. Four additional test cases—live video capture, OpenCV frame processing, pose estimation, and normal activity detection—remain pending, according to the reported results.

The evaluation was limited to the documented functional tests. The journal does not report an overall detection-accuracy measurement, a detailed real-world evaluation, or measured energy savings. Therefore, the reported results demonstrate the operation of the tested functions under the documented conditions rather than proving real-world safety effectiveness.

Statistical Analysis

No statistical analysis of human-participant data was reported because the evaluation focused on functional testing of the prototype. Results were presented in terms of completed test cases and their pass status. Inferential statistical tests, significance thresholds, and participant sample-size calculations were not applicable to the reported evaluation. The reported notification time of 1.8 seconds represents a functional test result and should not be interpreted as a comprehensive performance benchmark.

III. RESULTS

The system components documented in the project journal cover human detection, video-frame processing, suspicious-activity analysis, alert generation, buzzer activation, IoT notification delivery, and adaptive street-light control. Together, these components demonstrate the integration of computer vision, microcontroller-based alerts, and distance-based lighting in the Naari Suraksha prototype.

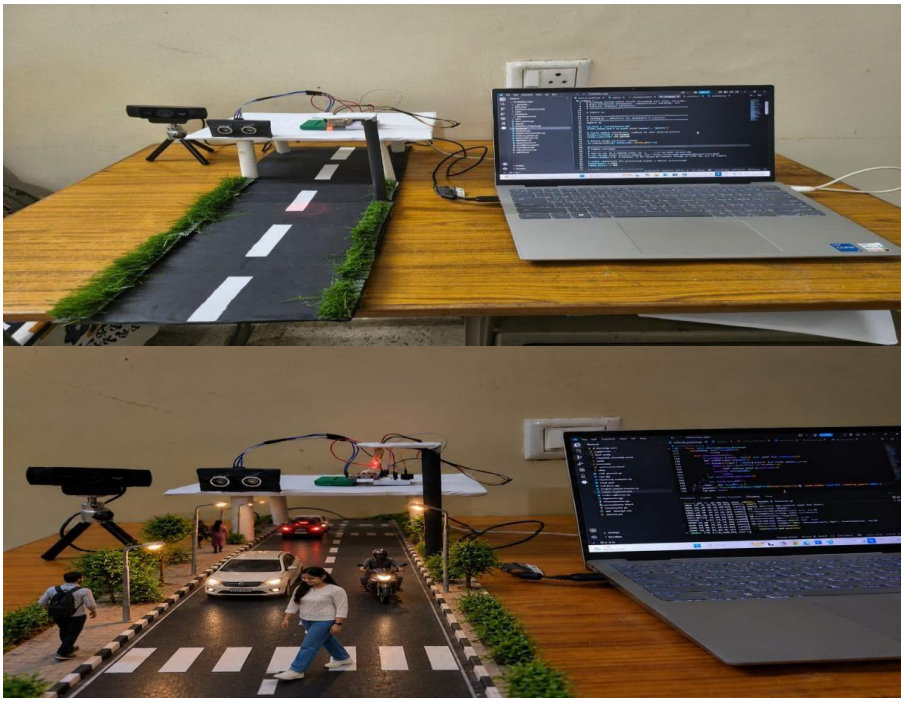
The computer-vision module uses OpenCV and YOLOv8 for video processing and human detection. MediaPipe pose estimation and rule-based motion analysis support the identification of potentially suspicious interactions. When configured conditions are met, the ESP32 activates a buzzer and supports notifications through the Blynk IoT platform. The HC-SR04 ultrasonic sensor measures proximity, and PWM control adjusts LED brightness according to the documented distance rule: 100% brightness below 150 cm and 20% otherwise.

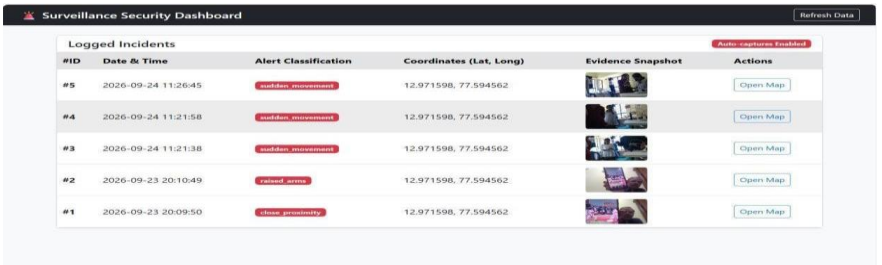
The project journal reports five completed functional test cases covering human detection, simulated suspicious-behaviour alert generation, ESP32 buzzer activation, Blynk notification delivery, and distance-based lighting control. All five completed tests are marked as passed, with Blynk notification delivery reported at 1.8 seconds. Four additional test cases—live video capture, OpenCV frame processing, pose estimation, and normal activity detection—are listed as pending.

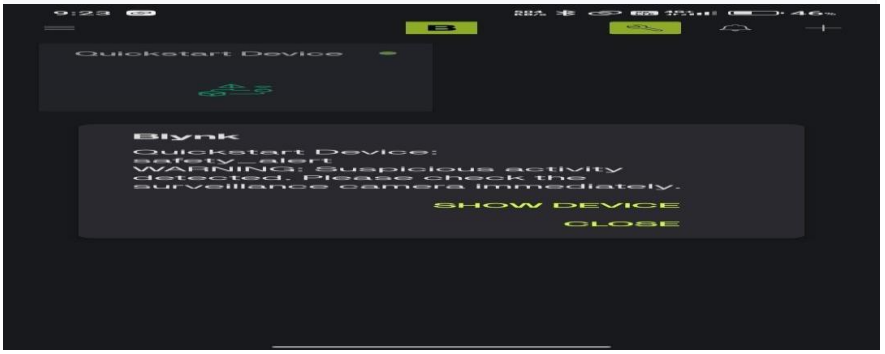
Test ID	Feature tested	Reported expected behavior	Status
TC-1	Human detection	Human presence is detected in the video input	Pass
TC-2	Suspicious-behaviour alert	An alert is generated for simulated suspicious behaviour	Pass
TC-3	ESP32 buzzer activation	Buzzer is activated when an alert command is received	Pass
TC-4	Blynk IoT notification	Notification is delivered through the Blynk IoT platform	Pass
TC-5	Distance-based street lighting	LED brightness changes according to the HC-SR04 distance measurement	Pass
TC-6	Live video capture	Live video is captured for processing	Pending
TC-7	OpenCV frame processing	Video frames are processed using OpenCV	Pending
TC-8	Pose estimation	Human pose landmarks are estimated using MediaPipe	Pending
TC-9	Normal activity detection	Normal activity is identified by the activity-analysis module	Pending

Table II. Functional test cases and reported outcomes.

Snapshots







IV. DISCUSSION

Naari Suraksha integrates computer vision, IoT-based alert mechanisms, and adaptive street lighting within a single prototype designed to support women's safety in public spaces. The system combines human detection, suspicious-activity analysis, local buzzer alerts, remote notifications, and distance-based lighting control. This integrated approach provides a framework for connecting video surveillance with automated alerts and smart-lighting functionality rather than relying solely on conventional fixed-brightness lighting and manual video monitoring.

The functional testing results indicate that the five completed test cases operated as expected under the reported test conditions. These tests covered human detection, simulated suspicious-behaviour alert generation, ESP32 buzzer activation, Blynk IoT notification delivery, and distance-based street-light control. The project journal reports successful outcomes for all five completed tests, with notification delivery through Blynk recorded at 1.8 seconds. Four additional test cases—live video capture, OpenCV frame processing, pose estimation, and normal activity detection—remain pending. Therefore, the results demonstrate the operation of the completed test functions but do not establish the overall performance or effectiveness of the entire system.

The combination of YOLOv8-based human detection and MediaPipe pose estimation provides the computer-vision foundation of the proposed system. OpenCV supports video-frame processing, while rule-based motion analysis is used to identify potentially suspicious interactions. These components are intended to support automated activity monitoring and alert generation. However, potentially suspicious behaviour identified by configured rules should not automatically be interpreted as confirmed threatening activity. The project journal does not report an independently measured detection-accuracy score or a comprehensive evaluation of false-positive and false-negative detections. Consequently, the system should be considered a prototype requiring further validation rather than a proven women's safety solution.

The integration of the ESP32 microcontroller and Blynk IoT platform provides both local and remote alert functionality. When configured alert conditions are met, the ESP32 activates a buzzer and supports notification delivery through Blynk. The reported notification time of 1.8 seconds demonstrates the observed result of the documented test, but additional repeated tests would be required to establish consistent response times under different network and operating conditions. The journal does not provide sufficient measurements to determine the reliability of notifications in real-world environments.

The adaptive street-lighting component uses an HC-SR04 ultrasonic sensor to measure proximity and PWM to control LED brightness. According to the documented rule, brightness is set to 100% when the measured distance is below 150 cm and to 20% otherwise. This approach demonstrates distance-based lighting control within the prototype. However, the project journal does not report comparative power-consumption measurements or quantified energy savings. Further testing would be needed to evaluate lighting consistency, sensor reliability, and the suitability of the configured brightness levels in different environmental conditions. Several technical and evaluation limitations affect the interpretation of the results. Four test cases remain pending, and the journal does not document extensive real-world deployment, a structured evaluation involving representative users, or comprehensive performance measurements. The reliability of the activity-analysis module, camera input, ultrasonic sensor, microcontroller communication, and IoT notifications requires further assessment. In addition, the system should be evaluated under different lighting conditions, distances, movement patterns, and network conditions before conclusions are drawn about its practical effectiveness.

Future development could prioritize completing the pending functional tests and conducting repeated evaluations of human detection, pose estimation, suspicious-activity analysis, and alert delivery. Quantitative measures such as detection precision, recall, false-alarm rate, missed detections, and notification latency could be recorded under clearly defined test conditions. The adaptive lighting component could also be evaluated through measured power consumption and comparisons with fixed-brightness operation. Finally, further work should consider privacy protections for video data, secure communication, responsible handling of alerts, and testing in representative environments. These improvements would provide a stronger basis for assessing the reliability and practical applicability of Naari Suraksha.

V. CONCLUSION

Naari Suraksha combines computer vision, IoT-based alerting and sensor-driven adaptive street lighting. It uses YOLOv8 for human detection, MediaPipe pose landmarks for motion analysis, ESP32 for local control, Blynk for notifications, and an HC-SR04 sensor with PWM for lighting adjustment. Five completed functional tests are reported as passed, including notification delivery in 1.8 seconds.

The results support prototype-level functional feasibility but do not establish real-world safety effectiveness, detection accuracy, or verified energy savings. Future work should complete the pending tests, evaluate varied environmental conditions, quantify detection and false-alert performance, measure power consumption, and assess privacy, security and usability.

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