Women Safety Night Patrolling Robot Using Raspberry Pi and IoT - A Review

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Abstract

Streets, campus roads and parking areas become risky for women after dark, yet fixed cameras cannot follow a person and round-the-clock guards are costly. Small robots built on single-board computers and Internet of Things (IoT) links offer a cheaper, mobile alternative. This paper first reviews six recent studies on women-safety technology, covering sound-triggered patrol robots, camera-based spy rovers and wearable alert devices, and then presents the design of a Women Safety Night Patrolling Robot. The proposed robot uses a Raspberry Pi as its main controller, with a camera for live video, a microphone for audio monitoring, an ultrasonic sensor for obstacle detection, an L298N driver with two DC gear motors for movement, LED/IR lamps for night illumination and a 12 V battery. A Wi-Fi link lets an operator drive the robot, and watch and listen through a mobile phone or laptop. The review shows that earlier patrol robots depend on one or two sensing modes, present their outcomes as screenshots rather than measurements and rely on Bluetooth or messaging applications, while wearable devices need the victim to act first. The paper also explains the architecture, the working sequence, the planned evaluation and the limitations of the proposed design.

Keywords: Women safety, night patrolling robot, Raspberry Pi, Internet of Things, live surveillance, obstacle detection, IR night vision

I. INTRODUCTION

Personal safety after dark remains a daily concern for many women. Deserted lanes, dimly lit campus roads, bus stops and parking areas are the places where help is farthest away at the moment it is needed. Official figures explain the worry: the authors of [1] recall that about 30% of women worldwide have experienced violence and that recorded crime against women in India rose by 15.3% in 2021 compared with 2020, and the authors of [2] point to an international poll that placed India fourth on a list of the most dangerous countries for women.

The usual countermeasures have clear limits. A closed-circuit camera watches one spot only and cannot move toward a disturbance [3]. Human patrols need staff, and a person in distress may be unable to press a button or open an application. Remote-controlled patrol vehicles ease the staffing problem, yet some of them still have to be driven by a person who watches the area continuously [2].

Low-cost single-board computers, camera modules, ultrasonic ranging and Wi-Fi now make it practical to build a mobile watch-keeper. A Raspberry Pi can capture and stream video, read sensors and drive motors at the same time, and an IoT link lets a remote operator see and hear what the robot sees and hears. Researchers have used this combination for patrol robots that react to sound [2], [4], [5], for spy rovers [3] and, in a different form, for wearable alarms [1], [6].

Most published work, however, describes a single prototype with a narrow sensor set and shows its output as screenshots or photographs. This paper therefore does two things. It reviews six recent studies [1]–[6] and

notes what each leaves unaddressed, and it then presents a Women Safety Night Patrolling Robot that combines live video, audio monitoring, obstacle detection, infrared night illumination and remote driving on one low-cost Raspberry Pi platform.

The remainder of the paper is arranged as follows. Section II reviews the related studies and their limitations, Section III describes the proposed design, Section IV sets out the evaluation plan and the expected outcomes, and Section V concludes the paper.

II. LITERATURE REVIEW

Work on IoT-based safety technology for women falls into a handful of families. This section groups the six studies examined for this paper into five themes and then summarises the gaps that remain.

A. Sound-Triggered Patrol Robots

Babu et al. [2] built a night patrol robot around a Raspberry Pi with a USB camera, four infrared sensors, a sound sensor, an L293D motor driver and an ESP8266 Wi-Fi module. The robot follows a fixed line, pauses at chosen points to listen and, when a noise is picked up, uses its infrared sensors to lead itself along a line toward the source, photographs the scene and sends the pictures to a control room before resuming its round. Shubhangi and Hashmi [4] swapped the Pi for an Arduino Uno and an ESP32-CAM. Their robot carries four microphones aimed in separate directions to estimate where a sound originates, an ultrasonic sensor for obstacles and a GPS module, and it reports its position and a photograph through the Telegram messaging application, with a Bluetooth link to a phone used to follow the robot. Pratyusha et al. [5] returned to the Raspberry Pi and added a Pi camera, an ultrasonic sensor, a USB microphone, an L298N driver, GPS and built-in Wi-Fi. Their robot has an autonomous mode that heads toward unusual sounds and a manual mode for remote driving, and it posts an image, an audio clip and the coordinates to a Telegram group.

These three studies show that sound can serve as the trigger for a patrol response. Their limits are equally visible. The robot in [2] can travel only along a pre-set line, and although its abstract mentions machine-learning methods, the detection it describes is threshold-based. The system in [4] depends on Bluetooth for tracking, a short-range link, and its microcontroller is far less capable than a Raspberry Pi. In [5] the authors themselves list night-vision hardware, artificial intelligence and facial recognition as future work, so the robot cannot yet judge what a sound means. None of the three reports numerical results such as detection accuracy, response time or battery life.

B. Camera-Based Surveillance and Spy Robots

Chavan et al. [3] present a spy robot in which a Raspberry Pi running Raspbian reads a PIR motion sensor and infrared obstacle sensors, streams video from a night-vision Pi camera to a web page and lets the user steer the vehicle with on-screen wheel buttons; OpenCV handles the video stream and an L293D driver moves the motors. Their literature table summarises four earlier robots: a Pi-based spy robot that reports intruders through a web interface but is held back by its wheels on rough ground; an Android-controlled night robot with remote audio and video that is limited by Bluetooth range; a LoRa-based military robot built on an ESP32 with gas and metal sensors that gains range but loses data rate; and a face-recognising household robot that works only indoors and depends on internet speed [3].

This family is the closest to the proposed design, because it adds live video and remote steering to a mobile base. Its weaknesses are that [3] leaves its modelling-and-analysis section empty, so no performance figure is reported; that detection rests on a PIR sensor for living bodies rather than on sound; and that the video page can be seen by anyone on the same network unless it is protected, a risk the authors acknowledge.

C. Wearable and Hand-Held Safety Devices

Anisha et al. [6] designed a wearable unit with a Raspberry Pi 3, a push button, GPS, GSM and a camera. When the wearer presses the button, coordinates go to trusted contacts by SMS, a picture and a ten-second clip are e-mailed and uploaded to cloud storage, and a FaceNet-based recognition step tries to match the attacker against a database; a companion Android application, SEGURO, manages the contacts. Kane et al. [1] remove the button: pulse, temperature and ambient-light sensors feed a logistic-regression classifier on a Raspberry Pi that decides whether the wearer is in danger and then triggers a buzzer, an electric-shock circuit and an SMS carrying the location. Their related-work section lists about a dozen further designs, such as bands, necklaces, garments and pepper-spray devices, and observes that many of them need the user to switch them on [1].

A wearable protects only the person who carries it, and the device in [6] depends on that person acting at the right moment. Neither can inspect an empty street in advance. The automatic trigger in [1] answers part of the problem, but it relies on body signals, includes a shock mechanism whose acceptable use would need legal and safety review, and, like [6], cannot patrol.

D. Communication and Alert Channels

Across the six studies the link between machine and human takes five forms. Telegram messages carry images, audio and coordinates in [4] and [5]; Bluetooth connects a phone to the robot in [4]; Wi-Fi modules and a web server serve the operator in [2] and [3]; SMS through a GSM modem delivers alerts in [1] and [6]; and e-mail with cloud storage preserves visual evidence in [6]. Messaging applications are convenient because the phone needs no custom software, but they depend on internet coverage, and [5] notes that some earlier systems lose reliability where the network is weak. Bluetooth and GSM sit at opposite ends: the first has a short range and the second carries only brief text.

E. Intelligence in Existing Systems

Intelligent processing is rare and narrow. Face recognition appears only in [6], where it works on frames captured after a button press, and machine learning for emergency detection appears only in [1], where it classifies body signals. The patrol robots rely on thresholds from a sound sensor or on motion detection, and [5] points out that earlier robots seldom tell a distress sound from ordinary noise. No reviewed study analyses live audio or video on board to recognise a distress event, so in practice a human operator remains the decision maker.

F. Summary of Gaps

Table I sets the six studies beside the proposed robot; a “No” means that the feature is not reported in the cited work, and “Part” means that it is mentioned but only partly described. Three patterns emerge. First, no single study combines live video, audio, obstacle avoidance, night illumination and remote driving. Second, GPS and alert messaging are well covered by the earlier work, which marks them as the natural next step for the proposed robot. Third, none of the six reports measured performance, so claims of reliability cannot be compared.

TABLE I

COMPARISON OF REVIEWED STUDIES WITH THE PROPOSED ROBOT

Feature	[1]	[2]	[3]	[4]	[5]	[6]	Proposed
Raspberry Pi controller	Yes	Yes	Yes	No	Yes	Yes	Yes
Mobile patrol platform	No	Yes	Yes	Yes	Yes	No	Yes
Live video	No	Part	Yes	Yes	Part	No	Yes
Audio sensing	Part	Yes	No	Yes	Yes	No	Yes
Obstacle detection	No	Yes	Yes	Yes	Yes	No	Yes
Night illumination	No	Part	Yes	Yes	No	No	Yes
Remote driving	No	No	Yes	Yes	Yes	No	Yes
GPS location	Yes	No	No	Yes	Yes	Yes	Future
Measured results	No	No	No	No	No	No	Planned

III. PROPOSED METHODOLOGY

The proposed robot is a battery-powered, Wi-Fi-connected patrol vehicle controlled by a Raspberry Pi. Fig. 1 shows the block diagram: three input units (camera, microphone and ultrasonic sensor) feed the controller, which drives two motors through a motor driver, switches the LED/IR lamps and exchanges data with a mobile phone or laptop over Wi-Fi. Fig. 2 presents the operating sequence as a flowchart.

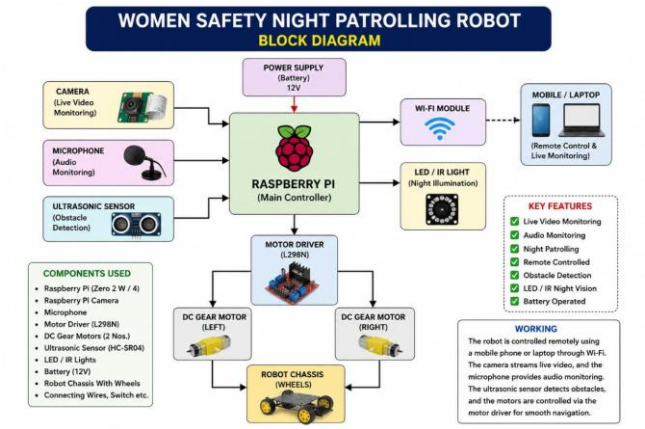


Fig. 1. Block diagram of the proposed Women Safety Night Patrolling Robot.

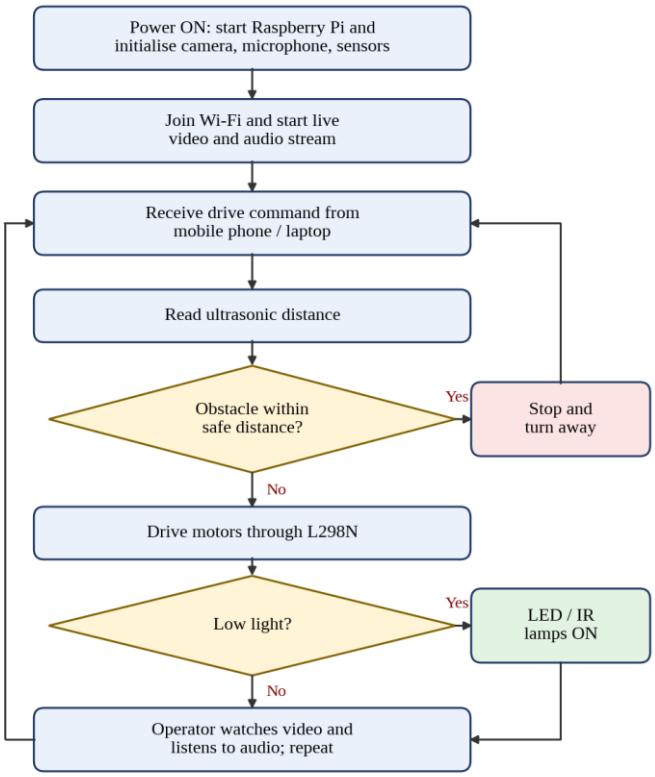


Fig. 2. Operating flowchart of the proposed robot.

A. Sensing and Input Units

Three input devices give the controller its view of the surroundings. A Raspberry Pi camera supplies the live video that the operator watches; with the infrared lamps switched on it can also serve in darkness, as night-vision cameras do in [3] and [4]. For the infrared light to be useful, the camera module should be of the type without an infrared-cut filter. A microphone brings in ambient sound, so that shouting, footsteps or vehicles can be heard without being present, a role played by sound sensors in [2], [4] and [5]. An HC-SR04 ultrasonic sensor measures the distance to objects ahead by timing an echo, and the controller uses the reading to avoid collisions, as in [4] and [5].

B. Central Controller

The Raspberry Pi, either a Zero 2 W for a compact build or a Pi 4 where more processing is wanted, is the only controller. It reads the ultrasonic distance, captures video and audio, serves them to the operator, receives commands and sets the motor-driver pins. Using one board for all of these tasks avoids the extra microcontroller and the separate camera board found in designs that split the work [4]. The software is written in Python on Raspberry Pi OS, with OpenCV or a streaming server handling the video, in the manner of [3].

C. Drive and Navigation

An L298N dual H-bridge driver turns the controller's logic signals into the current that two DC gear motors need, one for each side of a four-wheel chassis. Running the two sides at different speeds turns the robot, and pulse-width modulation sets the speed. The earlier robots used the lighter L293D driver [2], [3]; the L298N copes with the larger motor current drawn from a 12 V supply. When the ultrasonic reading falls below a software-set threshold, the controller halts forward motion and turns the robot away from the object before driving on.

D. Night Illumination and Wireless Link

An LED/IR lamp ring beside the camera lights the scene. White light also helps any bystander, whereas infrared light lets the robot watch without drawing attention. The Wi-Fi interface of the Raspberry Pi joins a router or hotspot, and a web page or application on the phone or laptop shows the video, plays the audio and carries the drive commands. Wi-Fi reaches farther than the Bluetooth link used in [4], although it remains bound to the coverage of the access point. The connection should be protected by a password and encryption, since [3] observes that an unprotected camera stream is open to anyone on the network.

E. Power Supply and Components

A 12 V battery supplies the motors through the driver and the controller through a voltage regulator that lowers the supply to the 5 V the Raspberry Pi requires; this regulator is an addition to the block diagram. A main switch isolates the battery. The parts used are listed in Table II.

TABLE II

COMPONENTS OF THE PROPOSED ROBOT

Component	Function
Raspberry Pi (Zero 2 W / 4)	Main controller, streaming, Wi-Fi
Raspberry Pi camera	Live video monitoring
Microphone	Audio monitoring
Ultrasonic sensor (HC-SR04)	Obstacle detection
Motor driver (L298N)	Drives the two motors
DC gear motors (2)	Left and right wheel drive
LED / IR lights	Night illumination
Battery (12 V) and switch	Portable power
Chassis, wheels, wires	Frame and connections

F. Working Sequence

When the switch is turned on, the Raspberry Pi boots, starts the video and audio streams, joins the Wi-Fi network and waits for the operator. The operator opens the interface on a phone or laptop and drives the robot along the planned route. Before and during every movement the ultrasonic sensor is read; if an object lies inside the safe distance, the robot stops, turns and carries on. In dim light the LED/IR lamps are switched on. Anything unusual that is seen or heard is handled by the operator, who can steer the robot closer or call for help, and the cycle repeats until the robot is switched off.

IV. RESULTS AND DISCUSSION

The paper covers the design and the evaluation plan; numerical results from the finished prototype are not reported here. The section therefore describes the outcomes the design is expected to deliver and the yardsticks that will be used to judge them. It is worth noting that none of the six reviewed studies [1]–[6] gives figures for detection accuracy, response time, operating range or battery life, and the planned tests are intended to close that gap.

The first expected outcome is a usable live feed. The delay between an event and its appearance on the operator’s screen will be timed, and the audio will be checked for intelligible speech at stated distances. The second is dependable obstacle handling: objects of different size and surface, including soft cloth that reflects ultrasound poorly, will be placed in the robot’s path at several speeds to see whether it always stops or turns in time. The third is night performance: a person standing in an unlit area will be observed with and without the infrared lamps to find the distance at which the person can be recognised.

The fourth outcome concerns endurance and range. The patrol time on one battery charge and the distance over which the Wi-Fi link keeps the commands and the video stable will be recorded indoors and outdoors.

The measures and their planned criteria are given in Table III. The criteria are engineering targets chosen for a campus-scale patrol, not measured results.

TABLE III

PLANNED TESTS AND CRITERIA

Test	What it checks	Criterion
Video delay	Time from event to on-screen display	Under 1 s
Obstacle stop	Robot halts or turns before contact	No contact in 20 trials
Night visibility	Person recognisable in the dark with IR lamps	At 5 m
Audio monitoring	Normal speech audible through the interface	At 3 m
Wi-Fi control range	Distance with stable video and commands	At least 30 m
Battery run time	Patrol time on one charge	At least 1 h

Set against the reviewed work, the proposed robot adds live video and audio monitoring together with remote driving, which [2], [4] and [5] provide only in part. Compared with the spy robot of [3], it adds audio monitoring and a dedicated LED/IR lighting unit. Compared with the wearable devices of [1] and [6], it patrols ahead of an incident rather than reacting after the wearer is already in trouble. It does not yet match [4], [5] and [6] in GPS tracking and automatic alert messages.

Five limitations deserve a plain statement. First, the robot depends on Wi-Fi coverage, so dead zones will break control and streaming. Second, it has no on-board detection of distress, so its value rests on an alert operator. Third, it has no GPS, which makes its position hard to share when it leaves sight. Fourth, a wheeled chassis and a small battery restrict it to smooth ground and limited hours. Fifth, recording audio and video in public places raises privacy questions, so local rules must be followed and the recordings stored securely. The robot is meant to deter, record and summon help; it cannot intervene physically.

V. CONCLUSION

This work reviewed six studies on IoT-based women-safety technology and used them to shape the design of a Women Safety Night Patrolling Robot. The review found that sound-triggered robots [2], [4], [5] prove the idea, that spy rovers [3] add live video and steering, that wearable devices [1], [6] add alerts and evidence but act only once the wearer is in trouble, and that almost all of these works report screenshots instead of measurements. The proposed robot gathers live video, audio monitoring, ultrasonic obstacle avoidance, LED/IR night illumination and Wi-Fi remote driving on one Raspberry Pi. Future work will add GPS and Telegram or SMS alerts as in [4]–[6], sound classification to recognise screams, person detection with privacy safeguards, a thermal camera and solar charging as suggested in [5], coordinated multiple robots and cloud storage of recordings, and will carry out the tests of Table III on the built prototype.

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