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DESIGN AND IMPLEMENTATION OF SURVEILLANCE AND RESCUE ROBOT USING SMARTPHONE

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Abstract: As technology continues to advance, there is a growing interest among researchers in creating robots that can simplify human lives. One area of focus is security and To enhance surveillance capabilities and determining unauthorized access and to meet these requirements, we have developed a robot capable of conducting surveillance and alerting home owners or industries when an unauthorized individual attempts to enter their premises without proper authorization. This versatile robot operates in two distinct modes: auto-pilot mode and manual mode. Moreover, the robot is furnished with a suitable environmental sensors, including temperature and humidity sensors, pressure sensors, LDR (Light Dependent Resistor), and PIR (Passive Infrared) sensors. These sensors continuously monitor environmental parameters and trigger alert messages if any of the values exceed the predefined normal range. The software tool known as blue dot which is used to control the motion of the surveillance robot in all directions (left, right, forward, backward) which is the android application used. This integrated system offers a robust and comprehensive solution for enhancing security and surveillance, making it an valuable asset for safe guarding homes and industrial facilities.

Keywords: Raspberry pi 3; PIR sensor; Surveillance; Webcam.

I. INTRODUCTION

Basically, surveillance is a crucial process involving the monitoring of people, places, or objects, often with the intent to influence, manage, direct, or protect them. Surveillance plays a important role in various places including national borders, public spaces, government facilities, homes, and industries. However, traditional surveillance methods have their limitations, such as blind spots, restricted coverage areas, and lack of mobility. Human involvement in surveillance also has its constraints, as accessing remote or hazardous locations can be impossible and human lives are inherently valuable. Therefore, relying solely on humans to collect data from distant areas is not always possible. Numerous surveillance systems, such as cameras and CCTV, are currently in use. Nevertheless, these systems have a drawback in that they typically allow individuals present at the location to observe events in real-time, limiting remote access where robots come into play. Robots can be equipped with cameras for surveillance purposes, and the data they collect can be accessed from remote locations. They excel at outdoor surveillance, monitoring critical sites, and can even be deployed to investigate suspicious areas up close. Using robots, close observations can be conducted without exposing humans to risky environments. Moreover, in situations where unauthorized people is detected then alerting message is given to the authorized person and One important hardware component is the Raspberry Pi a compact computer which is installed with cameras can stream live video of their surroundings by controlling with android application known as blue dot which is the software tool to control the motion of the surveillance robot over the internet. Furthermore, these robot possess the capability to monitor environmental conditions such as temperature, pressure, and humidity, notifies users if readings exceed predefined limits.

II. LITERATURE SURVEY

The primary goal of literature review to identify the research problem this includes understanding the current state of knowledge on the topic. Identifying gaps in knowledge and determining the research questions that need to be answered. It involves the different approaches to study the problem and selecting the approach that is most likely to be successful. . This section presents best techniques that are taken from various research publications that are best suited for the proposed design. Damodhar et al proposed a Surveillance robot can work on capturing the image and to store video

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frames in SD (Secure Digital) memory mounted on the robot for further verification. To enhance security to access the robot and data produced by robot, password is used in LAN (Local Area Network) and password with OTP (One Time Password) for WAN (Wide Area Network [1]. Jayasree K R et al developed a Mobile robot that can obtain the knowledge of its location and environment and plan an online trajectory to track the target that's moving. The model of the system and the path planning algorithm including all case studies has been simulated and the required results are obtained [2]. Meghana S et al designed a modern approach for surveillance of outdoor security. This robot has the ability to detect a human whether he/she is authorized or not using RFID tag and also detects metal bombs using metal detector sensor. Two DC motors are interfaced at the receiving end of the microcontroller, which controls the movement of the robotic vehicle[3]. Hetal K et al developed a robot for Tracking people or moving objects across a PTZ camera and maintaining a track within a camera and Then detected object can be classified in various categories such as humans, vehicles, birds, floating clouds, swaying tree and other moving objects [4]. Qifeng Yang et al designed a robot for investigating the problem of monocular vision based ground moving target tracking for a patrol robot and the TLD algorithm integrates tracking, detection and learning modules, which can improve the performance and the robustness of moving target tracking [5]. Hemesh et al implemented a wireless surveillance robotic vehicle which can navigate through obstacles with the help of sensors, embedded system and its programming. It will be able to capture the footage or pictures of area with its camera eye and send them back using wireless transmission technology such as Bluetooth and User Interface is responsible for getting access [6]. Sateesh Reddy Avutu et al designed a Autonomous path navigation for indoor navigation and which proposes a novel design of an autonomous path navigation robot based on the touch screen. The robot has the capability to move from specific location to any other chosen location that can be customized with a fixed path [7]. N Poornima Varma et al proposed a robot for target tracking which is achieved by Goto Goal approach. Here the obstacle avoidance and target tracking is done along with time and path optimization using intelligent Fuzzy Controller and Genetic algorithm. Both the Genetic Algorithm and Fuzzy Controller are compared to find the flexibility and accuracy of the motion control. [8]. Anand Nayyar et al implemented a remote surveillance and monitoring robot for any kind of household. The base controller of the robot is the Raspberry Pi 3 Model B. A webcam is attached to the Pi which monitors the area and sends a notification which will possess the ability to identify the person responsible for the motion triggering. If it is an authorized personnel, the on board voice assistant will start talking with the person[9]. Prof. S A Joshi et al developed a modern approach for surveillance at remote and border areas using multifunctional robot based on current IOT used in defense and military applications. This robotic vehicle has ability to substitute the solider at border area to provide surveillance. The robotic vehicle works both as autonomous and manually controlled vehicle using internet communication medium [10].

III. METHODOLOGY

The Hardware components is basically centred around the Internet of Things (IOT) and utilizes a Raspberry Pi board, a Raspberry Pi camera, and motors mounted on a robot chassis to create a robotic car system. The key feature of this setup is its capability to be controlled and monitored remotely via a web browser over the internet. In the auto-pilot mode, the robot continuously monitors a specified area and streams live video feed. Whenever it detects something suspicious, it notifies the authorized user. If required, the user can switch to manual mode for more direct control. In the manual mode, the robot can be accessed using a web page interface, allowing control from various smart devices accessible via the web browser. The web page is designed in HTML and provides directional controls (left, right, forward, backward) for moving the robot. The webcam captures real-time environmental data, transmitting it over the internet to the user's chosen device. Users can observe this data on their monitor and command the robot through the web page. A notable aspect of this project involves the application of image processing for the identification of known and unknown individuals. When the robot detects movement, it attempts to match the person's identity with information stored in its database. If a match is found, the robot continues its surveillance. In cases where there is no match, it immediately notifies the authorized user, who can then decide on appropriate actions. Additionally, the robot is equipped with temperature and gas sensors, serving to provide alerts if readings exceed predefined thresholds. This feature enhances the robot's capacity for monitoring environmental conditions beyond just visual surveillance as shown in Fig:3.1

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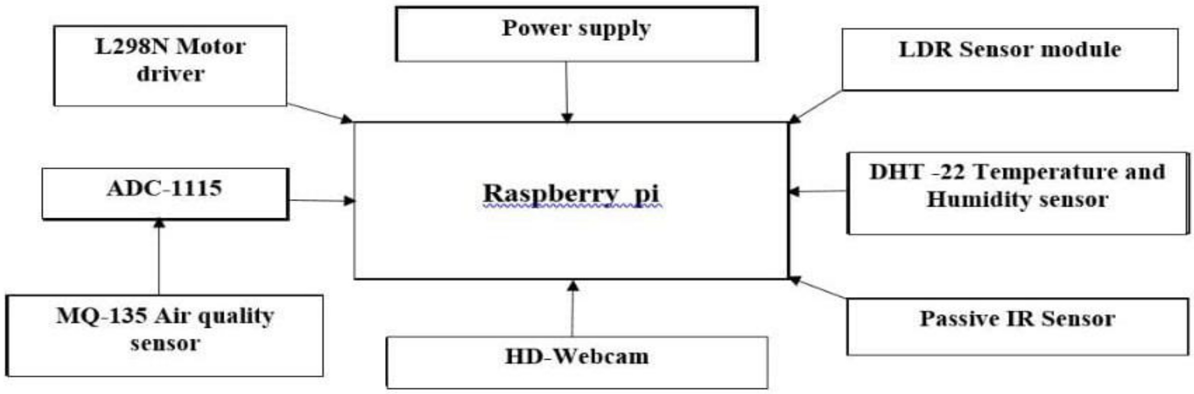

Fig:3.1: Block diagram of surveillance robot

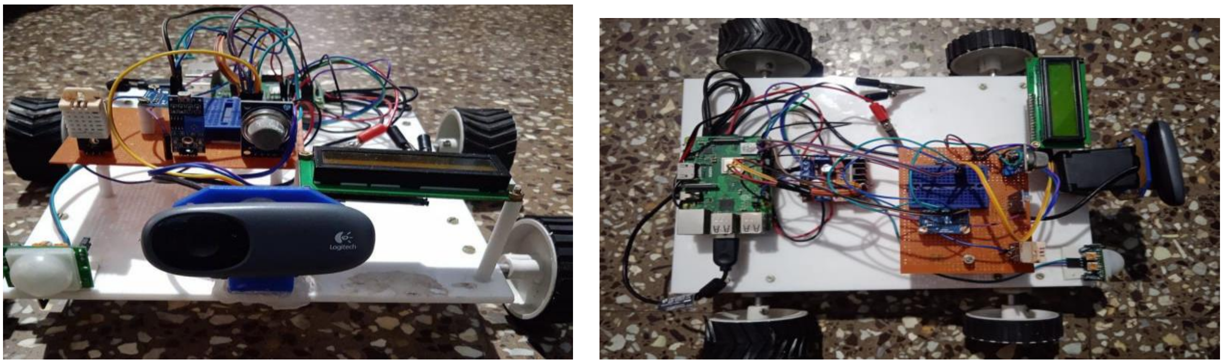

Fig 3.2 (a) (b)

Fig 3.2 (a) : represents the arrangement of the hardware components on the chassis with a front view of the surveillance robot ; (b): shows the interfacing of the raspberry pi with hardware components with a top view of the surveillance robot .

IV. CIRUIT DIAGRAM AND FLOWCHART

The circuit diagram for the Surveillance and Rescue Robot is depicted in Fig 4.1 Raspberry Pi serves as the core component for enabling wireless and web-based functionalities. Raspberry Pi requires a 5-volt supply with a minimum current rating of 700-1000 mA, and it is powered via a micro USB cable. To control one or two DC motors conveniently, the L298N H-bridge module is employed. In cases where two motors are used for a robot or similar application, make sure their polarities match to avoid issues when both motors are set to move forward or backward. Connect the power supply to pin number 4 on the L298N module and the negative/GND to pin number 5 of the L298N module. For this particular project utilizing two DC motors, digital pins 35 (GPIO19), 36 (GPIO16), 37 (GPIO26), and 38 (GPIO20) on the Raspberry Pi are connected to pins IN1, IN2, IN3, and IN4 of the motor driver, respectively. The direction of each DC motor is controlled by sending either a HIGH or LOW signal to the corresponding motor drive inputs. For instance, to make motor one turn in one direction, apply a HIGH signal to IN1 and a LOW signal to IN2. Conversely, a LOW signal to IN1 and a HIGH signal to IN2 will result in the motor moving in the opposite direction. For measuring environmental conditions, the DHT22 sensor is employed, and its connection to the Raspberry Pi is as follows: Place a 10kΩ resistor between Pin 1 and Pin 2 of the DHT22. Wire Pin 1 of the DHT22 to Physical Pin 1 (3v3) on the Pi, and wire Pin 2 of the DHT22 to Physical Pin 7 (GPIO4) on the Pi. Additionally, wire Pin 4 of the DHT22 to Physical Pin 6 (GND) on the Pi. The Light sensor module comprises four wires: VCC, GND, DIGITAL, and ANALOG. As Raspberry Pi lacks analog input pins, only the DIGITAL output is usable. Connect VCC of the Light sensor module to 3.3V (Pin 1), GND to GND (Pin 6), and the Data pin to GPIO 4 (Pin 7).

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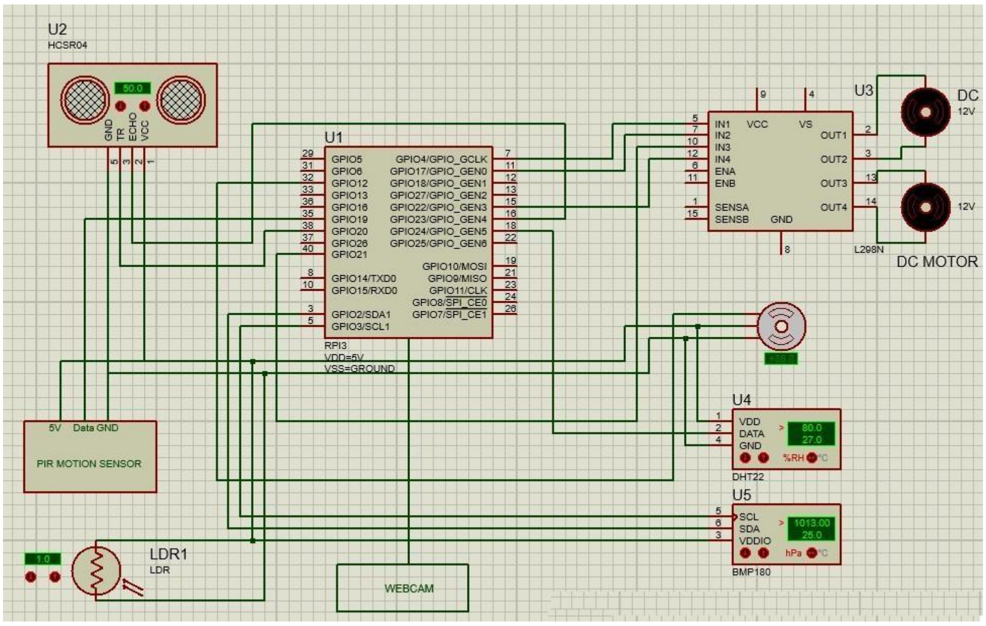

Fig 4.1: Circuit diagram of Surveillance and rescue robot

The algorithm for the proposed Surveillance and Rescue Robot, as depicted in Fig 4.2, outlines the sequential steps involved in its operation. The algorithm begins by initializing all the sensors and the camera, setting up the system for the surveillance process. It gathers and provides the relevant measured values corresponding to the environmental conditions in the designated area. This includes data such as temperature, humidity, gas levels, and pressure. The robot's movement can be controlled through commands sent via a mobile application, specifically a blue dot Android application. This allows for remote navigation of the robot. The algorithm checks whether any person is detected with in the surveillance area using image processing techniques. It identifies and distinguishes between known and unknown individuals. If no person is detected, the robot continues with its monitoring tasks, which may include capturing and transmitting live video feed. It periodically updates the user with relevant data and information for future reference or action.

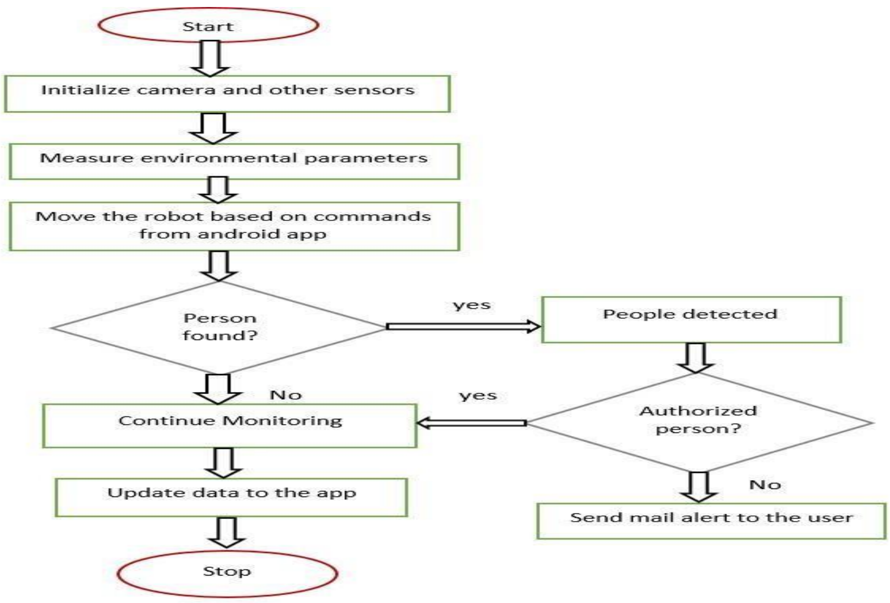

Fig 4.2 Working of surveillance and rescue Robot

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V. HARDWARE DESCRIPTION

The main hardware components used in this work are Raspberry Pi 3, Motor driver L298N, Temperature and Humidity Sensor, PIR Sensor, LDR Sensor, Air Quality Sensor, 12V DC Motor

A. Raspberry Pi 3

The Raspberry Pi 3 is a versatile and compact single-board computer that has garnered widespread popularity for its capabilities and affordability. Powered by a 1.4GHz 64-bit quad-core processor, this ARM-based computer offers improved processing performance compared to its predecessors. It features 1GB of LPDDR2 SDRAM, enabling seamless multitasking and efficient data handling. With built-in wireless LAN capabilities supporting both 2.4GHz and 5GHz frequencies, as well as Bluetooth 4.2 and BLE (Bluetooth Low Energy), the Raspberry Pi 3 facilitates convenient connectivity. Its Gigabit Ethernet over USB 2.0 ensures speedy networking, while the extended 40-pin GPIO header provides extensive options for hardware interfacing and integration. It also helps in implementing the wireless communication for the surveillance robot and also provides the interface for the hardware components as shown in the

Fig 5.1: Raspberry Pi 3

B. MQ-1115 AIR QUALITY SENSOR

The MQ-135 air quality sensor is a versatile gas sensor capable of detecting various gases, including ammonia, carbon monoxide, and benzene. The sensor's operation hinges on its ability to discern alterations in the electrical conductivity of a tin dioxide (SnO_2) sensing material. This conductivity shift occurs when gas molecules adhere to the surface of the material. The sensor generates an analog voltage output, and this voltage is directly proportional to the concentration of the specific gas being detected. Notably, the MQ-135 sensor is known for its affordability, making it an accessible choice for many applications involving air quality assessment. It also helps in measuring the toxic gas from surveillance robot which is present in the surrounding environment as shown in Fig 5.2

Fig 5.2 MQ-1115 AIR QUALITY SENSOR

C. DHT 22 Humidity and Temperature Sensor

The DHT22 is an economical digital sensor designed for measuring both temperature and humidity. It employs a single-wire digital interface, eliminating the need for analog input pins. This sensor utilizes a capacitive humidity sensor and a thermistor to gauge the surrounding air conditions, transmitting a digital signal through its data pin. In the humidity measurement, the sensor relies on a humidity-sensing component equipped with two electrodes separated by a moisture-absorbent substrate. As humidity levels fluctuate, the conductivity of this substrate changes, resulting in alterations in the resistance between the electrodes which is provided as the result in the raspberry pi of the surveillance robot as shown in Fig 5.3

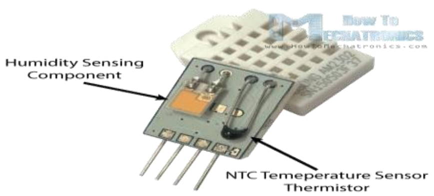

Fig 5.3: DHT 22 Humidity and temperature sensor

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D. LDR SENSOR

The LDR Sensor Module serves the purpose of detecting the presence of light and quantifying its intensity. When exposed to light, the module's output signal goes high, and conversely, it goes low when deprived of light. This module primarily relies on a photosensitive resistor to discern variations in the ambient light's brightness and intensity. When the environmental light conditions or intensity surpass a predefined threshold, the DO (Digital Output) port of the module switches to a high state. Conversely, when the external ambient light intensity falls below the set threshold, the module's D0 output becomes low. The digital output, D0, can be directly interfaced with a microcontroller unit to monitor. It also helps in finding whether it is a day or night for the respective area for the surveillance robot as shown in Fig 5.4

Fig 5.4: LDR SENSOR

E. PIR SENSOR

Passive Infrared Sensors (PIRs) are primarily constructed around pyroelectric sensors capable of detecting varying levels of infrared (IR) radiation. Infrared radiation is emitted by all objects, with higher temperatures resulting in increased radiation emissions. The uniqueness of PIR sensors lies in their ability to sense motion, specifically changes in IR levels, rather than merely average IR levels. This configuration is intentional, aiming to identify motion or changes rather than steady IR levels. The two halves are connected in such a way that they counterbalance each other. If one half detects a variance in IR radiation compared to the other, it leads to a shift in output, either high or low. The PIR sensor itself features two slots, each composed of a specialized material highly sensitive to IR radiation and also it detects the obstacle that are found near the surveillance robot as shown in Fig 5.5

Fig 5.5: PIR SENSOR

VI. SOFTWARE REQUIREMENTS

The software requirements for the system include the use of the Raspberry Pi OS and Integrated Development and Learning Environment (Idle 3), Blue dot.

A. Raspberry Pi OS

Raspberry Pi OS serves as the official operating system tailored for Raspberry Pi single-board computers. Previously recognized as Raspbian, this OS is meticulously designed around the Debian-based Linux distribution, specifically optimized to harmonize with Raspberry Pi hardware. Its primary aim is to offer an accessible interface and an array of software tools, streamlining the setup and utilization of Raspberry Pi devices. IDLE has a very important aspect: the text editor that is we will use it throughout the book to write our programs and modules.

B. Blue Dot Android Application

Embedded within the smartphone's framework is a pre-installed Android application known as "Blue Dot," pivotal for orchestrating the movement of the Surveillance Robot. This application ingeniously employs a virtual joystick, depicted as the "Blue Dot," serving as an intuitive control interface. By interacting with the blue dot, specifically by pressing it in the top, bottom, left, and right positions within the Android application, users can command the robot's motions. The "Blue Dot" application is a versatile tool, functioning both as a Python library and an Android application. Through its seamless integration with the programming language, it empowers diverse functionalities within the robot's operation. Predominantly, it dictates the robot's directional movements—forward, backward, left, and right—corresponding to the

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specific positions touched on the blue dot interface. Additionally, the "Blue Dot" application introduces an element of speed control. By interacting with the blue dot's extremities, users can dictate the robot's speed. Engaging with the outermost regions prompts the robot to move at maximum velocity, while interactions with the inner region induce a slower pace. Crucially, the robot movement comes to a halt upon the release of the "Blue Dot." In essence, the "Blue Dot" application transforms the smartphone into a dynamic control interface, facilitating precise and intuitive manual control of the Surveillance Robot's movements.

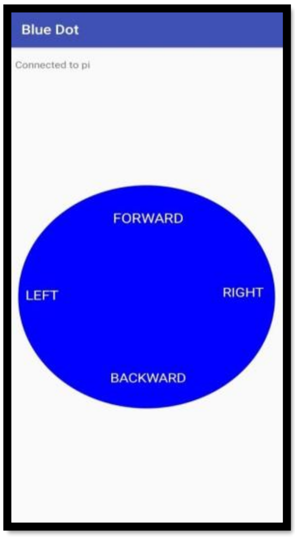

Fig 6.3: Snapshot of Android Application

VII. RESULTS AND DISCUSSION

The robot functionality encompasses responsive movement including Left, Right, Forward, and Backward. These movements are executed in response to user commands issued through the Blue Dot Android application. The robot camera rotation is installed using a servo motor, enabling it to scan its surroundings effectively. The core feature of the robot involves live streaming of the designated surveillance area. Simultaneously, the robot actively conducts person detection within this area. The results of these surveillance activities are presented on an LCD screen.

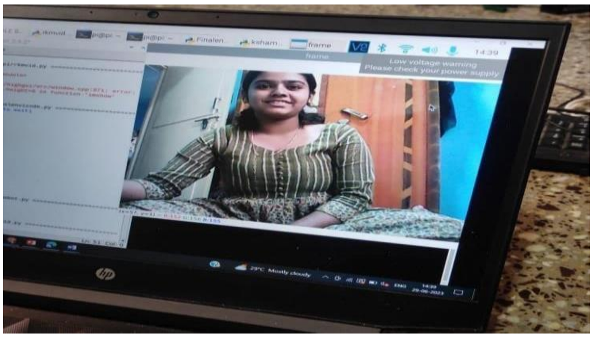

Fig 7.1 (a)

(b)

(c)

(d)

Fig 7.1(a) : Shows the live streaming from surveillance robot;(b): Disclosing whether the people detected or not ; (c) :

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Exhibiting the temperature and humidity of the Corresponding area; (d): Displaying the air quality of the corresponding area. Furthermore, the robot provides real-time data concerning temperature and humidity levels in the monitored environment, Operation of the robot relies on a smartphone equipped with the "Blue Dot" Android application. This application serves as a virtual joystick for controlling the Surveillance Robot. By manipulating the blue dot on the Android application, positioned at the top, bottom, left, or right, users can dictate the robot's movement. "Blue Dot" functions both as a Python library and an Android application. The robot interprets these touch commands to initiate movements such as forward, backward, left, or right. Additionally, users have the ability to adjust the robot's speed using the blue dot. Pressing the extreme ends of the blue dot help the robot to move at maximum speed, while touching the inner regions results in slower movement. The robot halts its motion when the Blue Dot is released.

VIII. CONCLUSION

This project introduces a versatile robot designed to perform surveillance tasks. When the robot detects movement it initiates a process of identifying individuals using a face recognition system. This system is capable of distinguishing between known and unknown individuals. The robot exhibits autonomous mobility, equipped with obstacle avoidance capabilities. Additionally, it can be manually controlled via a Bluetooth-enabled Android application. The robot boasts the ability to detect and notifies users of any alterations in its surrounding environment. A live streaming feature is incorporated into the system, enabling remote monitoring of the surveillance area. Video frames captured by the robot are seamlessly streamed to a web browser interface, granting users the flexibility to view the feed from any location via a web browser.

IX. FUTURE SCOPE

To enhance the accuracy of intruder detection, it is essential to explore alternative feature extraction and classification methods. These methods can significantly contribute to improving the system's overall performance. Additionally, the implementation of rotatable cameras can expand the coverage area, making surveillance more comprehensive and effective. Furthermore, there is a need to design and develop a waterproof robot to ensure the system's robustness in various environmental conditions. A waterproof robot will enable the system to operate seamlessly even in adverse weather conditions or environments with water exposure. This enhancement will contribute to the reliability and durability of the surveillance system, making it a more resilient solution for security and monitoring purposes.

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