Proceedings of the International Conference on Augmented Intelligence and Sustainable Systems (ICAISS-2022)
IEEE Xplore Part Number: CFP22CB2-ART; ISBN: 978-1-6654-8962-1

Versatile Surveillance Bot: for Remote Monitoring in Hazardous Places

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2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS) | 978-1-6654-8962-1/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICAISS55157.2022.10011049

***Abstract* — Wireless sensor technology is the most important technology in the field of Electronics. This technology plays a supreme part in this surveillance act. In recent times, Surveillance plays a major role in privacy and security of each and every individual. A multi-purpose surveillance bot is proposed which can be used to live stream the video of an area under significance and it can be monitored by the user at the receiver end. The objective of this bot is to monitor the areas that are inaccessible by the human beings. Apart from the surveillance act, this bot is capable of detecting temperature and humidity of the atmosphere, the amount of toxic gases present in the environment, which allows to take necessary precautions before any disaster occurs. It is a highly effective and cost-efficient robot that reduces manpower in surveillance act, also it has the ability to avoid the obstacles which provides freedom to explore and rescue in all type of environment.**

Keywords— Field Monitoring, LoRa, Rescue System, Robot, Surveillance, Video Streaming.

I. INTRODUCTION

Human surveillance is achieved by deploying humans in order to consistently monitor for suspicious behaviours and actions in the area under significance. But humans aren't fully capable of surviving in hazardous environments without any additional aids. Here hazardous environments may include radiation, high temperature, flammables which will risk the life of humans and their safety is not guaranteed if they are directly involved in such places. With recent advancements in privacy and security, it is possible to remotely monitor the areas of significance by replacing our surveillance bot in place of humans.

Presently, most of the areas are often monitored with the help of CCTV cameras equipped with infrared sensors. CCTV uses static camera with a restricted viewing angle, in static camera it is difficult to transmit the image of site effectively.

Our motivation is to provide an effective and affordable alternative to CCTV Cameras. So, we designed a versatile surveillance bot which is developed with arduino microcontroller, IP camera and various sensors like ultrasonic sensor, Gas detection sensor, temperature and humidity sensor, metal detectors. This robot consists of larger wheels with heavy treading which helps in locomotion over bad terrains. Using the IP Camera, this bot livestreams the video to the user at the receiving station. Data from the sensors are transmitted to the help of LoRa (Long Range) Communication module. At the receiving station, all the received information can be viewed in a PC and the movement of bot is also controlled by using the PC. This whole aggregate leads to a real time, energy-efficient, affordable and user pleasant surveillance system.

II. RELATED WORKS

Hsing-Cheng Chang, et.al developed an autonomous surveillance system to ensure indoor security. This system contains an autonomous surveillance vehicle (ASV), an algorithm for fire detection, an interface for man - machine interaction along with remote server. Once an event occurs, this system finds the source of the event using ASV and transmits the sensor data to the man-machine interface and user-friendly websites over Wi-Fi and the Internet.[1]

'Smart Fire Detection and Surveillance System Using IoT 'is proposed in [2]. This system is intended to keep away individuals from the fire by sending warning messages to the user via telegram. The telegram bot is developed based on ESP32 with the integration of Passive Infra-Red sensors. The fire sensor helps in providing a real-time temperature sensing and camera captures the necessary images which can be viewed in telegram.

In [3], for effective surveillance in a hazardous environment robotic vehicle acts as substitute for humans. This robot is manually operated by connecting to Wi-Fi and it also has sensors to avoid collisions. Another sensor like the gas sensor which detects for any toxic gas spreaded out in its environment and a webcam for image capturing.

V. Ratna Kumari, et.al proposed a manually operated robot equipped [4] with camera and ultrasonic sensors for detecting objects in a high risky environment such as cave

investigation, mining and army surveillance. This system provides a productive mechanical framework customized as a substitute for humans in hazardous environments. The robot is remotely controlled by arrow keys which allows the user to change the direction of the bot and the camera livestreams the video in real-time to user on receiving end. All this is done with the help of Wi-Fi module using IP address.[5]

Diksha Singh, et.al developed a mini bot that transmits live monochrome video and save images at a specific frequency. It is equipped with multiple sensors for monitoring, obstacle avoidance, temperature sensing and smoke detection. Data transmission in this bot is done using Wi-fi server with help of pc/mobile. The robot can be controlled by Blynk and the NodeMCU ESP module is used to integrate the internet connectivity of this robot.[6]

The outcomes of the literature survey serve as a solid platform for getting started with the design phase of our versatile surveillance bot. Some of the highlighting parameters that are noted in literature survey are,

- The literature survey reveals the need for providing low-cost and user-friendly mobile surveillance system. The existing products are costly and non-reliable.
- Existing systems use robots that have a limited communication range as they are based on RF, Zigbee, and Bluetooth technology

A. Proposed Surveillance System

After analyzing the shortcomings of the various existing systems, we have proposed a miniature versatile surveillance bot that overcomes the limitations of the existing system. The features of our proposed system are as follows;

- The robot uses an ultrasonic sensor mounted on a servo to watch around for any obstacles.
- The robot incorporates LoRa modules for wireless data transmission control and thus communication with the robot occurs in a more secure manner.
- The mobile robot is equipped with an IP camera that transmits live video data to a locally connected PC.
- Smoke sensors are used to alert the base station with the respective information about gas leakage.

III. PROPOSED SYSTEM ARCHITECHTURE

Functional block diagram with its peripheral interfaces of the proposed system is shown in Figure 1.

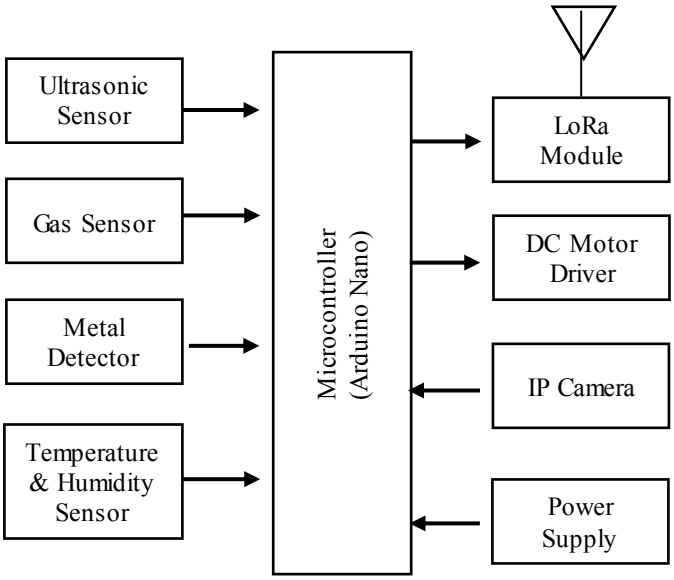

Figure 1. Block Diagram of the Proposed System

This entire robot can be divided into three modules namely,

- Processor module
- Sensor module
- Transmission module

A. Processor Module

1. Microcontroller Unit

Arduino nano is a microcontroller board based on the ATmega328 processor. It has 14 digital inputs/outputs (6 of which can be used as PWM outputs) and 8 analog inputs. It has 2 KB and 32 KB flash EEPROM inbuilt memory [7]. ATmega328 operates with a clock frequency of 16MHz. The hardware interfaces used in this microcontroller are UART, SPI, and I2C. Programming Arduino can be done through Arduino Integrated Development Environment (IDE). Due to very small in size, it is preferred in our system.

B. Sensor Module

1. Ultrasonic Sensor

An ultrasonic sensor uses sound waves to measure the distance between an obstacle and the robot. The distance is measured by sending out sound waves with a certain frequency, after hitting the obstacle the sound waves are reflected back to the sensor. Using the time taken for generation of acoustic wave and rebound of sound wave, it's attainable to calculate distance between the detector and object. If the distance calculated is less than 30 cm, the Buzzer gets ON. Which helps us to prevent robot from collision with obstacle. [8].

2. Gas Sensor

The MQ-2 gas sensor is an analog output sensor used for smoke and gas detection. MQ-2 sensor is highly reactive to LPG, propane, hydrogen, methane and different flammable vapors. [9]. For normal atmospheric temperature, sensor value is 100. If any harmful gases present its value gets increases. It is capable of detecting gases in the range of 400 to 850ppm.

3. Metal Detector

Metal detectors are electronic devices specially designed to detect metals buried underground, such as golden treasures, archaeological treasures from ancient civilizations and various types of precious base metals.[10].

4. Temperature and Humidity Sensor

The DHT-11 is very affordable, entry-level digital sensor for measuring the temperature and humidity level in the atmosphere [11]. It has a capacitor-based humidity sensor and a thermistor to measure the condition of the ambient air. Here, the output produced is in digital form.[12].

C. Transmission Module

1. LoRa Module

In order to enable wireless data transmission with minimum power and for long- distance LoRa (Long Range Radio) module is used. It communicates with the host microcontroller via UART and can be programmed via the UART port [13].

The most important feature of LoRa is that a LoRa gateway can occupy thousands of nodes for data transmission and works in 915MHz frequency band.

2. IP Camera

The ESP32-CAM is a development board that includes an ESP32-S chip, an OV2640 camera, a microSD card slot, and multiple GPIOs for connecting to peripherals. Also allows you to set up a live streaming web server, a surveillance camera to take photos and face recognition [14].

It is a Wi-Fi and Bluetooth integrated board with two high-performance LX6 32-bit CPU and based on seven-Stage pipeline architecture. Operating frequency may vary from 80MHz to 240MHz. [15].

IV. SYSTEM METHODOLOGY

This surveillance bot contains a couple of sensing devices, output devices, and a microcontroller with internet connection for constantly tracking the area under significance [16]. The microcontroller unit receives the output from various sensors like ultrasonic sensor, gas sensor, metal sensor, and temperature and humidity sensor. For providing necessary stimulus to actuators such as buzzer and also sent to the receiver by using LoRa wireless access technology.

The buzzer is actuated when the distance "D" measured by ultrasonic sensor is less than 30 cm and continues to do so until the distance is out of range. The metal sensor works on the principle of Colpitts oscillator [17]. The initial value of the metal sensor is set as 0, Based on the output of metal sensor buzzer gets activated. When it detects any gas in the atmosphere, the value increases. Similarly, the temperature and humidity sensors outputs are also obtained. All these values are sent in real-time using LoRa and can be viewed on PC using arduino serial monitor at the receiving end. The flow diagram of the proposed system is shown in Figure 2.

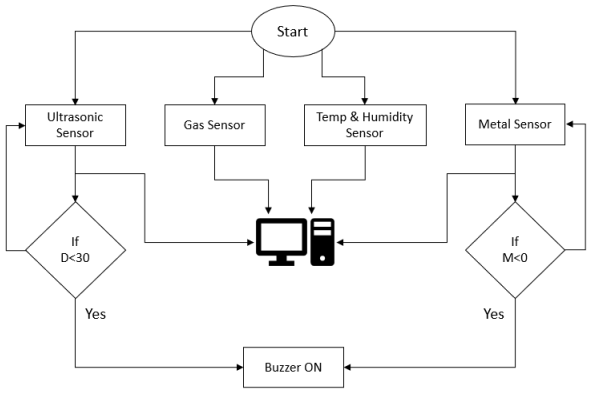

Figure 2. Flow Diagram of the Proposed System

This surveillance system contains another module called as IP camera with Wi-Fi for real-time video streaming [18]. It is also responsible for controlling the movement of robot. Robot control and video monitoring can be done using PC with IP address of the camera.

V. RESULTS AND DISCUSSIONS

The physical appearance of the robot is shown in Figure 3.

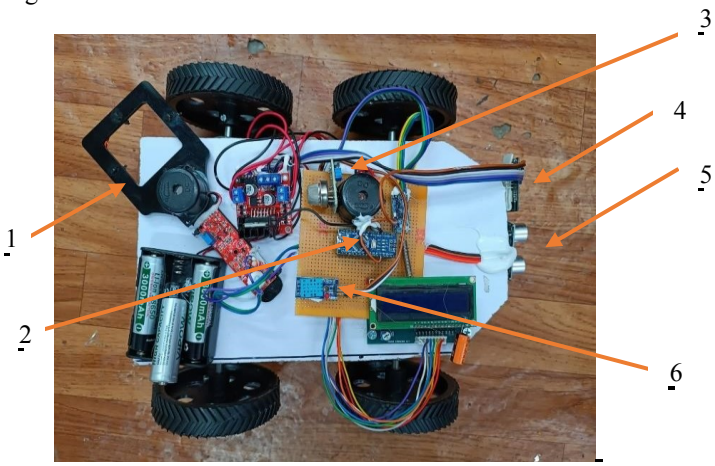

Figure 3. Prototype of the Proposed Model

Description of each component marked in the prototype is mentioned in the Table 1.

Comp. No.	Name of the Component	Specification
1.	Metal Detector	EC -1173
2.	Microcontroller	Arduino nano
3.	Gas Sensor	MQ - 2
4.	IP Camera	ESP 32 - CAM
5.	Ultrasonic Sensor	LV - MaxSonar
6.	Temperature and Humidity	DHT 11

Table. 1 Component Specification

Figure 4. shows the robot control interface. The robot is controlled using Wi-Fi incorporated with IP Camera.

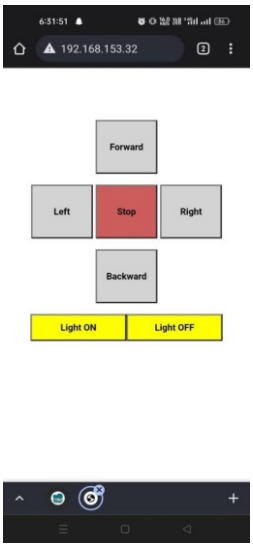

Figure 4. Robot Control

This surveillance robot has various abilities to detect and send signals to the authorized user from different environments. Depending on the data from the robot's sensor, it provides the user with the necessary information to move the robot correctly in the desired direction [19].

The robot transmits real-time data to the monitoring station and it can be viewed via serial monitor of Arduino IDE as shown in Figure 5. The proposed system It is very beneficial and practical for places where human access is impossible and potentially deadly.

```
T: 33, H: 63, G: 390, D: 21, M: 0
T: 33, H: 63, G: 401, D: 22, M: 0
T: 33, H: 63, G: 382, D: 145, M: 0
T: 33, H: 63, G: 378, D: 9, M: 0
T: 33, H: 63, G: 382, D: 10, M: 0
T: 33, H: 63, G: 377, D: 11, M: 0
T: 33, H: 63, G: 369, D: 6, M: 0
T: 33, H: 63, G: 354, D: 3, M: 0
T: 33, H: 63, G: 349, D: 6, M: 0
T: 33, H: 63, G: 338, D: 4, M: 0
T: 33, H: 63, G: 319, D: 145, M: 0
T: 33, H: 63, G: 314, D: 18, M: 0
T: 33, H: 63, G: 285, D: 12, M: 0
T: 33, H: 63, G: 269, D: 24, M: 0
T: 33, H: 63, G: 254, D: 146, M: 0
T: 33, H: 63, G: 253, D: 4, M: 0
T: 33, H: 63, G: 246, D: 6, M: 0
T: 33, H: 63, G: 230, D: 6, M: 0
T: 33, H: 63, G: 221, D: 9, M: 0
T: 33, H: 63, G: 210, D: 5, M: 1
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Figure 5. Serial Monitor Output

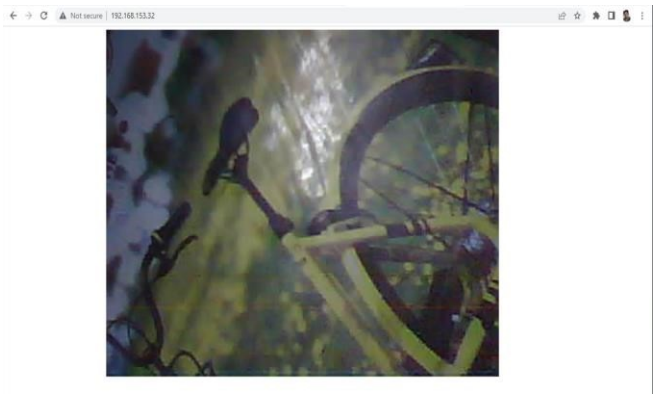

Figure 6. Video Live Streaming

VI. CONCLUSION AND FUTURE SCOPE

The proposed surveillance robot helps in expanding the potential and capacity of conventional surveillance systems. Based on the results of various tests, this system functionalities are validated and the test results agrees that this solution is capable of providing cost effective surveillance in various applications. This robot helps in reducing manpower in surveillance act and has various flexibilities to explore and rescue in all type of environment. The functionalities of this surveillance bot can be enhanced by adding the following features,

- Power consumption can be reduced by using an efficient power optimization technique.
- The location of the robot can be identified by incorporating real-time GPS tracking systems.
- Wide angle camera (360 degrees) can be used for wider view of the area.

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