IoT Based Autonomous Multi-Purpose Surveillance and Rescue Robot

Ansh Dudeja[1], Anshul Yadav[2], Anveshak Parashar[3], Arnay Kabtiyal[4], Shaveta Arora[5*]

[1,2,3,4] UG Students, Department of Computer Science and Engineering,
The NorthCap University, Gurugram, India
[5]Associate Professor, Department of Computer Science and Engineering,
The NorthCap University, Gurugram, India
*shavetaarora@ncuindia.edu

Abstract

This paper aims to develop a multi-purpose surveillance robot to perform surveillance activities in industrial areas, militarized war zones or radioactive field areas with the objective of analyzing, governing and protecting the areas from unwanted threats. The use of robots and their role in our day to day life has been rapidly increasing since the day they were introduced to the world, further reducing the errors and life risk to humans. The objective is to design and develop an Internet of Things (IoT) based autonomous multi-purpose surveillance robot at a low cost that will roam around freely and give live updates about their surroundings by broadcasting video and information through the sensors installed. The sensors collect the data from the surroundings and send it to the arduinomicrocontroller which can be seen by the user any time. This technology is controlled by the user remotely through any device such as mobile phone, tablet or laptop with the help of IoT based services. The entire project is built and monitored by wireless platform to minimalize the use of wire and help it work smoothly in remote places. Further improvements and advancements in this project can help in reducing life risk of valuable soldiers or identification of any hostage in unknown places.

Keywords: Arduino, IoT, Autonomous, Surveillance, ESP32 Module, Thingspeak.

1. Introduction

In 1954, humans were introduced to the world's first fully functioning industrial robot "The Unimate" and after that, scientists and engineers have come together to create dynamic and diverse changes in the field of automation and roboticsto make the daily humane tasks easier and faster. The use of robots in development and automation fields is increasing day by day and there is no doubt about the future being largely controlled by robots and artificial intelligence (AI) [1].

The Surveillance System closely observes and analyzes the surrounding and get instant information about the conditions. It is mainly required in areas of high risk, borders, public places, and prison or in industries which is mainly used for monitoring behavior and activities of a group or any individual. The need of surveillance robots arises when the life risk is too high and the user wants the information to be highly accurate.
Robots are nothing but fully automated electronic and internet controlled devices that are capable of performing various tasks that a normal human might not be able to do. Thus, use of robots for surveillance is one of the greatest advancements in the field of automation [2]. These multifunctional robots are able to perform tasks in dangerous situations like collapsing buildings or radioactive zones. One of its best uses is in the protection and rescue works after unexpected tragedy or unwanted invasions like Ukraine-Russia Cold war or tragedies like Chernobyl/Bhopal Gas Plant [3]. There are many obstacles faced by the rescue forces during inspection of such sudden and unexpected events like narrow spacing, collapsing of damaged structures. It becomes difficult for an ordinary human to deal with such risky tasks to enter areas without knowing the present information. These robots being autonomous in nature are designed to perform efficiently without human interference and have high mobility.

Back in 1999, Kevin Ashton introduced the term 'Internet of Things' to the world in one of his presentations. IoT connected people with everything on the internet from anywhere around the world and since then the definition of IoT has evolved and growth has rapidly increased. Nowadays, we can see the wide use of IoT in various fields to connect the world virtually and physically. The number of devices connected via IoT as of 2021 are close to 30 billion and expected to react 75 billion in the year 2025 enumerated by Statista [4].

This IoT Based Autonomous multi-purpose surveillance and rescue robot is built on mainly two systems as shown in Fig.1.First, the motorized working of the robot with all the connections and second, the communication of the device with the user and smooth data transfer from the sensors to the cloud platform. These systems help in carrying out task properly. The main aim of this project is to combine the two different systems into one machine that would make them work simultaneously and perform the required tasks. To achieve this aim, an IoT based monitoring system is also included with the robot which can be used to monitor by the user through their device [5]. The main applications include:

1. Record video visuals and broadcast it to the user
2. Send data from sensors to the IoT channel
3. Can explore areas that are dangerous for human
4. Used for the inspection of border areas

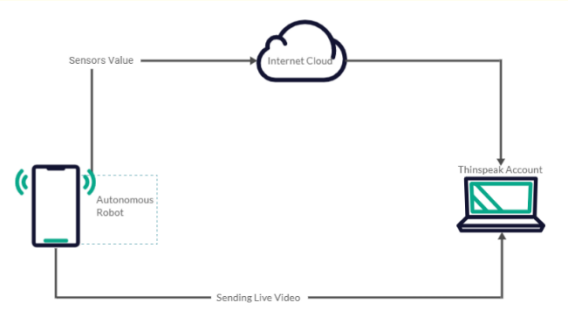

Figure 1. Block Diagram for Communication with Surveillance and Rescue Robot

2. Literature Review

Table 1. Literature Review of IoT Based Surveillance and Rescue Robot using various existing solutions

Year	Title	Proposed Technique	Limitations
2016 [6]	Design and Implementation of IoT-based Intelligent Surveillance Robot	- SMART-I a mobile robot and moved on fixed line tracing - Real time Video Transmission - Smartphone App	Limited Battery Backup and No Night Vision Camera
2017 [7]	Military Robot for Reconnaissance and Surveillance using Image Processing	- Robot for detecting land mines and can move on any terrain - Face recognition as per the database - Updates a new person after taking 20 pictures - Gas leak , Radiation, Heat Detection	No Battery Backup, Connected to Vulnerable Cloud
2017 [8]	Autonomous Surveillance Robots	- Robots for human assistance - gesture sensing like waving the camera for assistance	Decision making and the robot can't cover large areas Irregular sensor data
2018 [9]	IOT-Based Wi-Fi Surveillance Robot with Real-Time Audio and Video Streaming	-Smartphone app with easy UI - PIR sensors along with gas sensors, night vision camera instead of IP cam	Using third party app may create hindrance with the security concerns like IP cam breach
2018 [10]	Smart Surveillance Robot for Real-Time Monitoring and Control System Monitoring and Control System	-Smartphone app -PIR/IR and Night Vision for patrolling	Only related to data collection about environmental aspects

2020 [11]	IoT Based Smart Multi Application Surveillance Robot	Instead of cayenne use cloud platform self-made UI to customize other feature also	Limited data storage up to 64gb Laser gun to be replaced with much more powerful weapon

3. Problem Statement

The limitations of the earlier models motivated us to build a monitoring robot that allows for active and inactive monitoring, in use independent monitoring mode and manual mode that notifies the user when movement is detected. The robot will record the video and stream it to the Android device via Wi-Fi. A lot of the disadvantages of robots that are currently on the market: too expensive, ranging from thousands of dollars; they need a large domain to communicate with a robot, and they have some gaps in the model such as poor battery backup, limited storage, using 3rd party applications.

Our robot will have fewer benefits than the ones already unlocked in the market such as detection sensors, solar panels for better battery, thermal imaging.

A. Existing System: There are many already existing systems that tackle different problems.

- Some developed for only monitoring activity
- Systems have a few sensors for detection
- Already existing systems have limited range for communication with short ranged cameras [12].

B. Proposed System

- Aim is to design a robot to replace humans in dangerous areas
- Robot that consists of sensors like Gas Detector, Motion Detector, Thermal Sensors, PIR Sensor, Fire Sensor,Alarm System and Buzzer
- Long range and night vision camera for clear night monitoring
- Using WIFI module with Arduino to make better connection

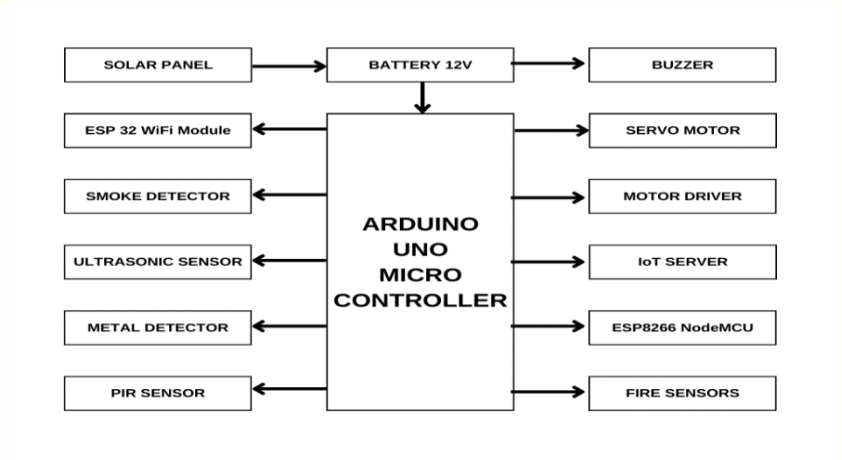

Figure 2. Block Diagram for IoT Based Surveillance and Rescue Robot

4. System Design

The system consists of two major sections – one is the user control section and the other one is the mobility section. The robot has an arduinounomicrocontroller which acts as the brain of system as it is used for controlling the motors and movement of the robot. In the user section, with the help of a mobile or a laptop user control is much better as compared to the old versions where a big control instructed panel was required to make the robot move and perform tasks. The communication from the user end to the robotic mobile section can be performed in various ways, using a Zigbee device or any Bluetooth controlled technology, but in these the range of communication is limited. So in order to make the robot remotely controlled from a far distance, user Section can be connected with the internet using the IoT technology. For connecting the user with the robot from far distance, ThingSpeak,an IoT based technology is used[13].

For receiving the live video visuals and the data from the sensors, ThingSpeak channel plays a vital role. The sensors and ESP32 Camera Wi-Fi Module is connected to the Arduino Board that further provides the Wi-Fi facility to the Robot. After the full connection, the robot can send the data collected from the sensors using the Wi-Fi modules and the IoT platform to the users.

In mobility part, the robot consists of wheels, motors, battery, ESP32 Wi-Fi Module and various different sensors. The arduino board is placed on the body of robot which gives input supplies to the DC Motors and the motors are further connected to the wheels which move according to the user instructions. The arduino microcontroller is coded through its IDE software where the code is defined for appropriate movement. Parallel to the movement of the robot, various sensors such as Gas sensor, Ultrasonic sensor, PIR sensor are also mounted on the robot interfaced with the microcontroller. The circuit diagram is shown in fig.3.

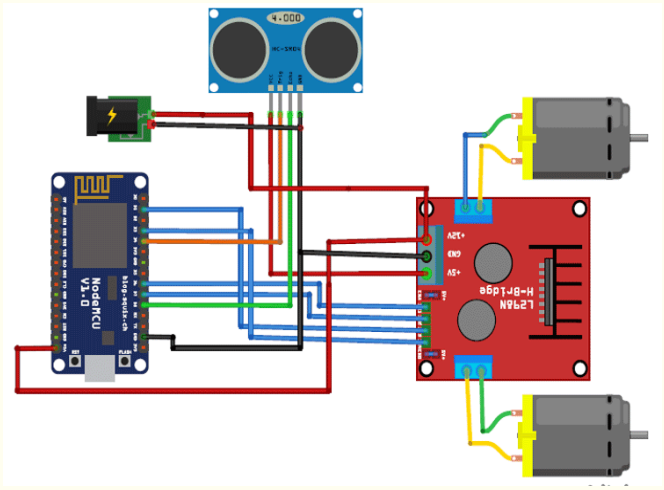

Figure3. Circuit Diagram of IoT BasedSurveillance and Rescue Robot

5. Hardware Used

For the robot to be autonomous it requires a large amount of hardware components for better efficiency and functionality. The major components required for the making of this robot are as follows:

5.1 Arduino UNO

Arduino Uno is a microcontroller board based on easy to use hardware and software. The microcontroller is used for connecting sensors and motors and the board is able to read inputs and turn them into an output.

5.2 DC Motors

DC Motors are used for the movement of robot that operate with the help of 12V power supply. These are also known as rotary electrical machines because they convert the electrical supply to kinetic energy.

5.3 LITHIUM ION Battery

Li-ion batteries are used in this robot acts as the source of voltage for the device and Arduino Microcontroller.

5.4 Gas Sensor

It is a device used to detect the presence of gases in the surrounding environments. These sensors are operated through batteries and send the data to the user via Wi-Fi modules.

5.5 Ultrasonic Sensor

This robot device consists of Ultrasonic sensors to measure the distance of the objects in front of the device regardless of the shape or surface. These sensors can also provide data of any object approaching towards the robot.

5.6 Buzzer

Electronic Buzzer i.e. also known as a beeper acts as an audio device and works as per the user requirements or can be triggered remotely as a signal.

5.7 Jumper Wires

Electric wire that consists of a connector/pin at both ends and is normally used to connect electronic components via breadboard.

5.8 ESP32 CAMERA WIFI MODULE

The ESP32 Wi-Fi cam is a tiny module based on ESP32 chip. This module is mounted on the robot to provide live video from the camera and broadcast it to the user's device through the Wi-Fi module. It is widely used in IoT devices such as home security devices, industrial monitoring devices.

5.9 L298N Dual Motor Controller

The L298N motor driver is used to control 4 DC Motors or 2 DC direction controlled motors further it acts as an interface between the motors and the circuits.

5.10 PIR Sensors

Passive Infrared Sensors are electronic sensor used to measure light radiation from an object. It is a combination of two different sensors that come together to make a PIR sensor. It helps to provide the motion detection information happening in its view.

6. Software Used

6.1 Arduino Software (IDE)

The Arduino IDE is a softwareused to write codes, comments and upload the code to the board and execute them to test their working.

6.2 Thingspeak

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. You can send data to

ThingSpeak from your devices, create instant visualization of live data, and send alerts. It provides instant visualizations of data posted by your devices to ThingSpeak [14].

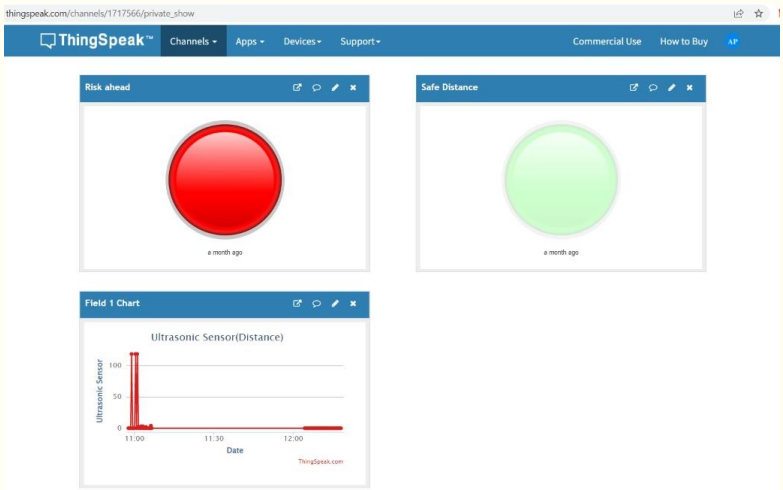

Figure 4.Thingspeakinterface

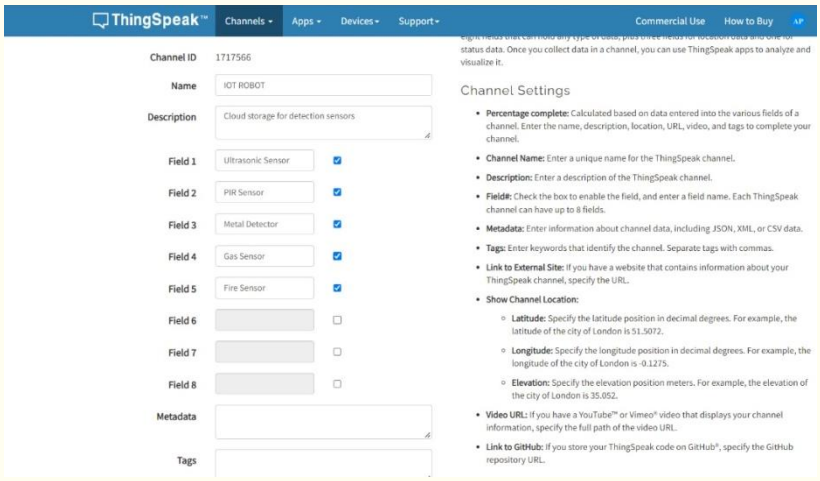

Figure5.Thingspeak Channels for IoT Based Surveillance and Rescue Robot

The Thingspeak channels are used to gather all the information collected by the various sensors, i.e. PIR Sensor, Ultrasonic Sensor, Metal Detector and Gas, Fire Sensor. These details help the user to understand the surrounding environment of the robot and to monitor the situation.Separate channels are made for each sensor and have their own interface to monitor or gather live data from these sensors as shown in figure 4 and 5.

7. Cost of Making

The total cost required to make one Multi-purpose surveillance and rescue robot is INR 4800 only, including all the above mentioned hardware and software components. Moreover, this robot has been made at a very cheaper cost as compared to other available options in the market with same technologies.

8. Application Interface

Figure 6 shows the user Interface that will help the user to control the multi-purpose surveillance robot to move in all the four directions. The user will also be able to control the speed of the multi-purpose surveillance robot and the light attached on the ESP-32 camera for better visuals.

Figure 6. User Interface for IoT Based Surveillance and Rescue Robot

On the top there is a video display that will be streaming the live video footage through the ESP-32 Camera module attached on the multi-purpose surveillance robot and can be monitored for different purposes.

9. Conclusions

In this paper, an IoT-based autonomous multi-purpose surveillance and rescue robot is proposed which can solved the problems regarding inspection of difficult areas and unexpected situations. This autonomous robot is fully capable of replacing humans and providing extremely accurate data to the user. It overcomes the problem of short ranged communication with the help of ThingspeakIoT platform and broadcasts the live videos to the user. The robot is small in size and is capable of maneuvering hard terrains, also it rotate in all directions. There are many applications to this robot such as surveillance while being steady or in motion, analyzing the surrounding areas, displaying land mines, spying and other militarized operations.

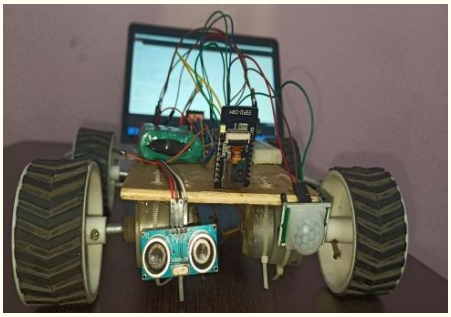

Figure7. Prototype of IoT Based Surveillance and Rescue Robot with sensors

10. Conflict of Interest

There is no conflict of interest in this work.

11. Future Scope

New technologies can be implemented to make the robot more efficient. Instead of using the ESP32 WIFI module, a proper HD camera can be used and a separate network can be made for fast and accurate transfer of data. Instead of using the Thingspeak platform an API can be built for fetching data. The design of the robot can be upgrades as per the needs and an arm can be attached to the robot, which will have new functionalities and a few more sensors.Instead of using battery, a proper solar powered battery might be planted the working of robot. Further, thermal imaging or face/identity detection systems can be installed on the robot that will help in identifying people and thermal imaging can be used to get information regarding any hostage or people in restricted areas.

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