IoT Based Multipurpose Field Surveillance Robot

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Abstract - Mobile robots are gaining popularity day by day because of their versatile usage. They are being used in hospitals, household and military applications. Detecting landmines, sensing poisonous gases and finding movement of the enemy is a difficult task for the military. Achieving those tasks manually are costly and error prone. Electronic surveillance provides effective solutions for the stated problem. Earlier studies demonstrated usage of different sensors for different applications. But there was not much focus on integrating the number of sensors on a mobile robot and operating it by using mobile android applications. This paper discusses design of multi-purpose mobile surveillance robot based on IoT technology to cater to the military needs. The robot used an Arduino UNO microcontroller to collect sensor data. NodeMCUwifi is used to connect the robot with the controller. The robot also uses metal detection, gas and motion detection sensors for corresponding applications. The robot motion is controlled with an android application and sensor data can be visualized on a mobile screen. The robot is successfully designed and motion could be controlled remotely using mobile.

Key Words: Mobile Robot, Surveillance, Metal detection, Integration, Internent of Things

1. INTRODUCTION

Robots are known to work in dull, dirty, dangerous and difficult environments. Especially mobile robots are becoming part of our day to day life. They are being used in hospitals for medicine delivery, remote servivilance for mine detections, warehouses are using them to efficiently move materials from stocking shelves to order fulfillment areas and many more. These robots are also used in industrial and military applications[1].

Landmines are normally infested under the ground to destabilize the enemy from entering territory. These are detonated by pressure when a person or vehicle steps over it. It causes damage due to blast or metal objects present in it. Landmines once used as weapons against intruders became life threatening because of their indiscriminate use. These are causing 15000-20000 deaths worldwide and the majority are young children. The landmines are also causing soil degradation and polluting ground water [2]. The process of removing planted landmines has become a huge burden for security forces. Detecting landmines manually is very difficult and it can't ensure 100% success. There are also instances of poisonous gas leakages, fire accidents, intrusion of unauthorised persons into highly secured areas. IoT technologies provide convenient solutions to these types of problems. Here, a number of devices are connected in a network using controllers to make better decisions [3].

The design of the mobile robot consists of a controller, sensors, actuators and power system. The controller is normally a microprocessor/microcontroller which is used for the computation [4]. The sensors used here detect metal, gases, and objects. The motors are used as actuators in this robot.To power a mobile robot, a DC power supply is used [5].

The rest of the paper is organized as follows, section II will discuss related work related to proposed work. The detailed materials and methods are discussed in section III. The experimental setup, results and discussion are explained in section IV. Finally the paper concludes in section V.

2. Related Work

In this section, similar studies, the methods and working principles are summarized.

Anh, P. Q. et al., [1] developed obstacle avoidance robot which can sense and avoid obstacles using ultrasonic sensor. ,Ashok Kumar M et al., [2] built integrated IoT based multipurpose field surveillance robot for military applications. Phung Quang Ahn et al., made obstacle avoidance mobile controlled robot. Tawfiqur Rakib et al., [3] made a fire fighting robot with multi sensor capability using PID controller. Papoutsidakis M et al.,[4] designed an autonomous robot for area mapping and remote monitoring. S. S. Pujari et al., [5] designed a Robot for working families that could monitor children remotely and communicate with the camera. In this

work, the surveillance is monitored through camera but not suitable for monitoring in war zones. D. Chakraborty et al. [6] designed and developed a robotic car using sensors and Bluetooth technology. They had established communication between the smart device and the robot. The obstacles in the opposite direction were prevented from colliding with the ultrasonic sensor. The recorded images are analysed. S. J. Lee et al. [7] designed an autonomous robotic car using Arduino Uno R3 for the robot's brain. The robot scanning the placed QR codes could move along the road autonomously. It also provided voice communication with the Android device in the Text-to-speech feature. M. R. Mishi et al. [8] designed a robotic car for multi motion detection, measurement of the obstacle and finding the path using Arduino Uno, Raspberry Pi and GPS. The system is not applicable for the detection of the mines. Premkumar et al. [9] designed a robotic arm controlled using Raspberry Pi. The main purpose of this robot was to add the human arm feature to the robot arm. Esra Yilmaz et al., [10] discussed autonomous controlled robot car with real time obstacle detection and avoidance capability. The other related works specified in [11, 12, 13].

The major gaps identified from the above works are inability of robots to work in warlike environments, no single solution for mine detection, gas detection, object detection, and surveillance monitoring. In this work, a real time mobile robot is proposed to fulfill these gaps.

3. Materials & Method

The IoT enabled multi-purpose mobile surveillance robot is designed by combining the electro-mechanical components such as body of the robot, wheels, motors, power backup, arduino uno, esp32, motor driver, camera, metal detection sensor, smell detection sensor, object detection sensor, and motion sensor. The general architecture of the proposed system as shown in figure 1. The mobile robot at remote places moves from place to place and gathers the information like bombs, gases, videos/images, and objects motions. The gathered information is sent to the cloud for storage through the internet. The robot can also be controlled and monitored by the user using the mobile phone/computer.

Figure 2 represents the hardware architecture of the mobile robot. It consists of a Arduino UNO as a controller. To which camera, metal detection, smell detection, object detection and motion sensors are connected. Mobile robot wheels are run by DC motors. The motors are connected to the controller through a motor shield. The motor shield is used to provide speed and direction control for motors. The esp8266 wifi module is used to connect the robot with the controller. A 9V battery is used to power the robot.

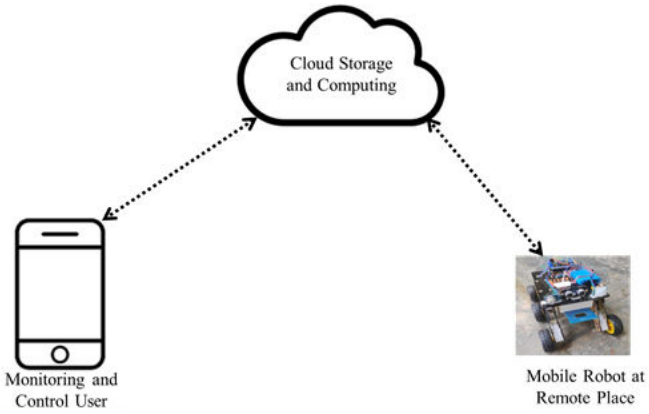

Fig-1: The general architecture of the multi-purpose mobile surveillance robot based on IoT technology.

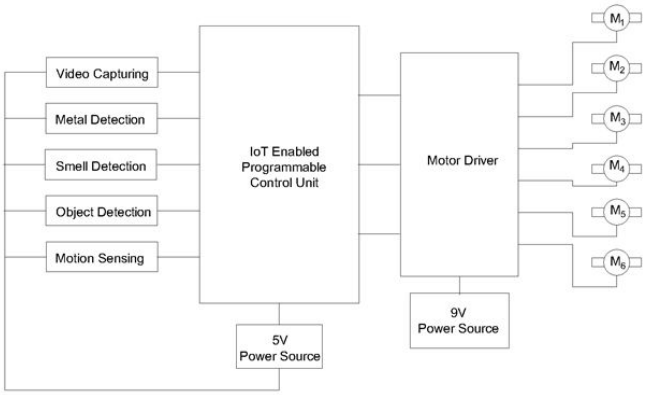

Fig-2: The hardware architecture of the multi-purpose mobile surveillance robot.

The robot is connected to Arduino Uno as an IoT enabled programming control unit. It is the heart of the robot which can perceive the information from sensors and perform actions on the environment through actuators. The esp8266 wifi module is also interconnected to the Arduino Uno to control the robot remotely through the internet. The mobile robots can be employed to detect landmines using non-contact metal detectors buried under land. This metal detector detects the presence of metal objects buried under ground. This sensor is connected to Arduino Uno, finds any metal object in the ground, and sends the notification to the mobile phone. Metal detection operations by robots avoid human intervention and save human life. The gas sensor is one of the important components which can monitor the environment around the surrounding area.

MQ 135 gas sensor is used for detecting poisonous gases like Ammonia, Sulphide, Benzene steam and other harmful gases.

The motion of the objects can be detected using Passive Infrared Sensor(PIR). It is used to sense the movement of objects like people, animals and other objects and alerts the user of motion in an area. The ultrasonic sensor can be used in the robot for detecting the distance of the obstacle from the robot. This sensor measures the distance to a wide range of objects regardless of colour, shape, or surface texture. The robot is also connected with a camera which can be used to monitor surveillance of the area by capturing the video.

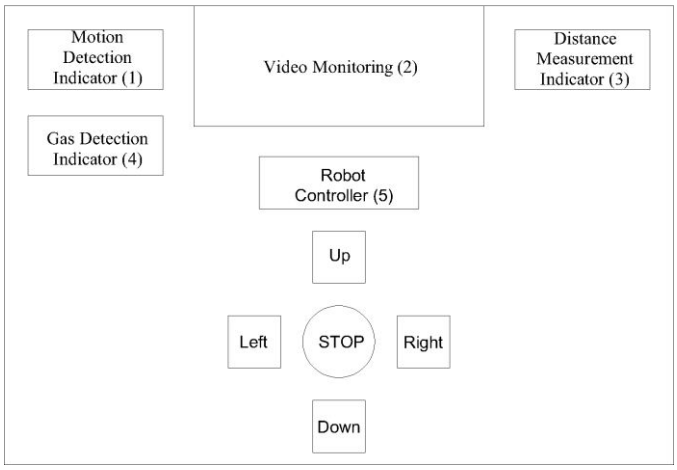

Fig-3: The software user interface of the multi-purpose mobile surveillance robot

The Figure. 3 shows the schematic representation of the user interface created on a mobile phone. The portion 1 shown in the above figure indicates presence or absence of motion of objects. The portion 2 of the figure indicates the visualization of the streaming video. The 3rd portion displays the distance of the obstacle from the robot. The 4th portion indicates the status of the concentration of gas. The 5th portion, robot controller which includes left, right, up, down and stop control of the robot.

4. Experimental setup, Results & Discussion

The figure 4 shows the IoT enabled multi-purpose field surveillance robot. Which is fabricated by integrating hardware and software. The hardware components are assembled, interconnected and communicated through the internet with the help of mobile phone. The algorithm - 1 shows the working of the proposed robot to control remotely using WiFi receiver and mobile phone.

Step - 1: Power on the robot.

Step - 2: Check for proper supply to the motor driver, arduino Uno, WiFi module, sensors and motors.

Step - 3: Check for internet connectivity between robot and mobile phone.

Step - 4: Login into mobile robot framework in mobile phone.

Step - 4: Control (left, right, forward and backward) the robot through a mobile phone.

Step - 5: If any obstacle or metal or gas is detected by the robot, it sends that information to the respective authorities.

Step - 6: Otherwise the robot keeps on moving in the specified direction and repeats step 5.

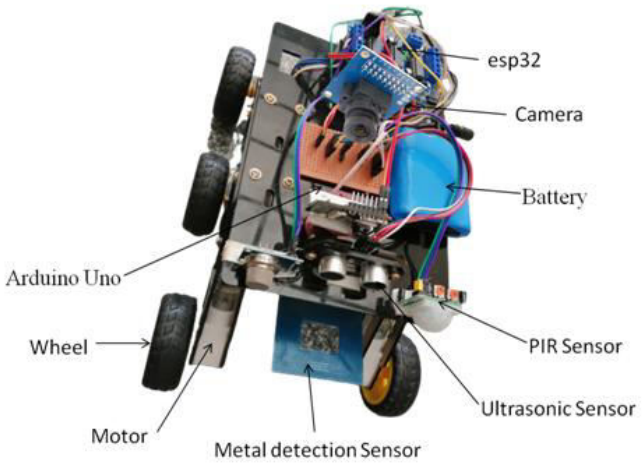

Fig – 4: Fabrication of IoT enabled multi-purpose field surveillance robot

The user interface and the framework of the mobile robot control and monitoring as shown in figure 5. This framework is designed using the blynk IoT platform. The user interface consists of control buttons for controlling the movements of the robot, display of the gas, motion, metal status and video streaming.

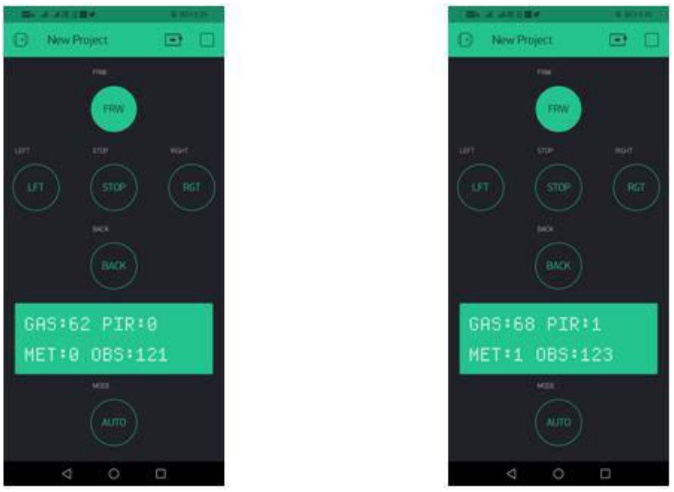

Fig – 5: Mobile Robot control screen

4. Conclusions

The IoT enabled multi-purpose field surveillance mobile robot successfully designed, fabricated, integrated and tested with the help of advanced hardware and software platforms. This robot successfully detected metal, toxic gases, motion of the object, and object distance. It is also captured images and sent to the remote system. Finally the proposed robotic system deployed and tested on the field. The future work will be extended based on artificial intelligence, machine learning and deep learning, mobile robots for specific applications.

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