Intelligent Hazard Response Rover for Radiated Environments

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Abstract:

There are many different robots used for various tasks, ranging from simple to highly complex ones. Some robots are made to go into places that are too dangerous for people, like areas with radiation. Radiation is a kind of energy that comes from certain sources and moves through space. In this project, we made a robot that can go into radiation-affected areas and collect information about the environment there. We even made our own electromagnetic radiation to show how it works. When the robot gets close to the radiation, it makes a loud noise to let us know. It also has sensors to measure things like temperature, humidity, and harmful gases. Also, it has a camera so we can see what's happening around the robot in real-time on a phone or computer. We can control the robot from far away using a remote control. This kind of robot can help keep areas safe and collect important data, like in forests or open spaces.

***Keywords— Moving mechanism, DC motors, RF transmitter, RF receiver, remote control unit, 89c2051 controller chip, Arduino Uno board, DTH11 sensor, toxic gas detecting sensor, electromagnetic radiation circuit, power transmitting coil, self oscillator circuit, power Mosfets, power receiving coil, buzzer, LCD, rechargeable battery, charger, ESP8266Wi-Fi module, L293D H Bridge IC, ESP-32 Wi-Fi camera*.**

I.INTRODUCTION:

Small intelligent robotic vehicles have advanced significantly for a variety of purposes. These vehicles are vital in fields including Defense, disaster management, animal studies, and data collection in dangerous places. Our project focuses on developing a robotic vehicle specifically for data collection from radiation-impacted locations. Radiation can take several forms, including nuclear, hazardous gas, and electromagnetic radiation (e.g., radio waves, microwaves, infrared, ultraviolet). This includes acoustic radiation, such as ultrasound. Our study focuses on detecting electromagnetic radiation, which involves emitting high-frequency pulses into the air for demonstrations. Our project aims to collect data on environmental parameters, including temperature, humidity, and dangerous gas coordinates. To accomplish this, we use a DTH11 sensor connected to an Arduino board. The parameter values appear on an LCD panel. Ambient temperature is the actual air temperature in the surrounding environment. The DTH11 sensor can measure both temperature and humidity.

To identify dangerous gasses in radiation-affected areas, we employ a universal gas sensor that detects smoke and other poisonous chemicals.

In addition, we include a GPS module to determine the location of hazardous gases.

When the system identifies dangerous gasses, it activates an alarm and shows information on the LCD. Activating the hold button on the remote retains displayed information until the robotic vehicle leaves the affected area. The system detects EMF levels and displays the information until the release key is activated, for remote surveillance information collected is displayed in app through TCP protocol using WIFI module.

The main processing unit is the Arduino Uno development board, with sensors connected to it. Parameter values are shown on an independent LCD screen.

The DHT11 sensor is a low-cost digital temperature and humidity sensor that uses a capacitive humidity sensor and thermistor to measure ambient air parameters. Its digital output can be directly connected to the Arduino board's data pin.

Hardware Requirements :

1. DC motors: Convert electrical energy to mechanical energy, used in robotics and vehicles.

2. RF transmitter: Wirelessly transmits radio signals for data or audio.

3. RF receiver: Receives and decodes radio signals from an RF transmitter.

4. Remote control unit with 89c2051 controller chip: Uses 89c2051 microcontroller chip for wireless device control.

5. Arduino Uno board: Microcontroller board for controlling and monitoring devices.

6. DTH11 sensor: Digital temperature and humidity sensor.

7. MQ3 sensor: Gas sensor for detecting alcohol concentration.

8. Electromagnetic radiation circuit with power transmitting coil: Generates and transmits electromagnetic waves wirelessly.

9. Power receiving coil: Receives wireless power and converts it to electrical energy.

10. Buzzer: Produces sound when electrical signal is applied.

11. LCD: Displays information using liquid crystals.

12. Rechargeable battery with charger: Battery that can be recharged for multiple uses.

13. ESP8266 WI-FI Module: Wireless Transfer of data using Transmission Control protocol.

14. L293D H Bridge IC: Motor driver IC for controlling DC motors speed anddirection.

15. GPS Tracker: Device using GPS to track location.

16. ESP-32 WIFI camera: Wireless camera for video transmission over Wi-Fi.

Software Requirements:

Arduino IDE: To write the code and uploadit to the Arduino Uno, we used the Arduino IDE as our software need. This program makes writing and compiling code easier by including a text editor, toolbar, and menu bar. The code is authored, compiled, and uploaded to the Arduino using a text editor known as a sketch,the Genuine and Arduino board need to be connected in order for the Arduino board and the IDE to communicate.

Keil Software: To create a HEX file, write or import the code, then build the project. Establish a serial port or programmer connection between the microcontroller and the PC, then set up the programmer settings in Keil. Click the "Program" buttonto program the microcontroller after loading the HEX file into the programmer.

II. RESEARCH OBJECTIVES

- It aims to enhance the surveillance system capabilities, especially in perilous settings, utilizing advancements in communication technologies. A key aim is to enable real-time applications, facilitating prompt responses to potential risks or emergencies.

- By incorporating various benefits, such as the integration of a webcam for surveillance and connectivity to Wi-Fi hotspots, the system aims to improve situational awareness and data collection in hazardous areas.

- The proposed system's ability to function as a SMART ROBOT in areas where human entry is prohibited is a significant objective. This capability not only reduces the risk to human life but also allows for the exploration and monitoring of areas that may pose dangers to human operators. Moreover, the inclusion of a stealth coating enhances the robot's stealth capabilities, enabling it to operate discreetly and avoid detection in sensitive environments.

- Another key objective is the system's ability to collect information about the surrounding environment autonomously. By incorporating sensors and data collection mechanisms, the system can gather vital environmental data, such as temperature, humidity, and gas levels, without the need for human intervention. This autonomous data collection capability enhances the system's efficiency and effectiveness in monitoring and assessing hazardous environments.

- Overall, by achieving these objectives, the proposed system aims to reduce costs and minimize human losses in hazardous areas. Through the integration of advanced communication technologies and autonomous functionalities, the system enhances situational awareness, data collection, and response capabilities, ultimately improving safety and security in high-risk environments.

III. PROJECT EXECUTION

Electromagnetic Radiation:

- A self-oscillator L-C tuned circuit is utilized to radiate electromagnetic pulses.
- A self-oscillator circuit with Z44 power MOSFETs.
- These MOSFETs operate in a sequential manner, similar to a push-pull amplifier. When the circuit is energized, It generates electromagnetic pulses with a frequency of 30 kHz, resulting in the generation and radiation of 30,000 magnetic pulses per second.
- Unidirectional energy radiation from the power transmitting coil.
- Maximum energy acquisition occurs when the power receiving coil is positioned parallel to the transmitting coil.
- The power reception coil is located underneath the vehicle. As the vehicle nears the power transmission coil, it collects electrical energy in the form of high-frequency alternating current (AC) pulses.
- A full wave bridge rectifier is used to convert this irregular AC signal into direct current (DC). This rectified DC voltage is then smoothed out by a 1000 microfarad capacitor. After this filtering process, the stabilized DC voltage powers a buzzer, which emits a loud noise when the vehicle is close to the power transmitting coil.

Toxic Gas Detecting Circuit:
The circuit features an MQ3 sensor, renowned for its capability to detect a range of toxic gases like petroleum and CO2.

- The MQ3 sensor's output voltage signifies air quality, with 1.5V denoting good quality and exceeding 1.5V indicating poor air quality.
- An LM324 microcontroller, housing four op-amps, is employed, with only one op-amp utilized in this setup.
- Upon detecting toxic gases, the sensor's output voltage increases, triggering the comparator's output to go high when surpassing the reference voltage.
- The high output signal is then transmitted to an Arduino board programmed to store data upon receiving a high signal from the MQ3 sensor.
- The sensor's output voltage is measured against a predetermined reference voltage at the op-amp's inverting input. If toxic gases are detected, the output voltage from the sensor rises. Should this voltage exceed the reference voltage, the output from the comparator switches to a high state. This high output is subsequently sent to an Arduino board, which is configured to log the data whenever it receives a high signal from the MQ3 sensor.

Gas Sensor:

- The MQ3 sensor can detect various gases such as alcohol, benzine, propane, and methane.
- Upon detecting gas, the system activates a buzzer for 5 seconds and displays GPS coordinates on an LCD screen.

Temperature and Humidity: The DTH11 sensor is capable of measuring both temperature and humidity.we utilize a DTH11 sensor, which is interfaced with an Arduino board. When the system detects the presence of harmful gases, an alarm is activated, and the LCD displays the information accordingly.

Monitoring Visuals: You need to set up the Arduino IDE for ESP32 development and install the ESP32 board support. Then, you connect your ESP32-CAM to your computer using a USB-to-Serial adapter.

Programming: Write your code in the Arduino IDE or another compatible IDE. This code will configure the ESP32-CAM, initialize the camera, connect it to a network (if needed), and define what it should do with the captured images or videostreams.

Camera Configuration: Configure the camera settings such as resolution, frame rate, and image format. This can be done in the code using libraries like the Camera Web Server or Camera Web Server Basic.

Capture Images or Video: You can capture images or video streams using functions provided by the camera libraries. These images or video streams can be stored on a microSD card, sent over a network, or processed in real-time.

Networking: If you want to stream video or upload images to a server, you need to connect the ESP32-CAM to a network. This can be done using Wi-Fi, and you'll need to provide the SSID and password of your network in the code.

Integration: Once everything is set up and working, you can integrate the ESP32- CAM into your project. This might involve mounting it on a chassis, connecting it to other sensors or modules, and designing a housing for the entire system if needed.

Remote Control Unit:
Utilizes an 89c2051 microcontroller chip with 2KB of internal ROM memory.

- Interfaced with four control keys, allowing the generation of four different command codes.
- When a key is activated, an 8-bit digital code is generated from the output of the microcontroller chip.
- The digital code is transmitted via an RF transmitter and receiver operating at 433MHz.
- Communication link established between the devices through antennas.
- The digital code is mixed with the 433MHz carrier frequency, modulating the signal before transmission.

RF Transreceiver: The RF transreceiver facilitates communication between the rover and remote devices.

Camera Module: The robot should be equipped with a high-resolution camera module to capture images and videos of the environment. This camera should be capable of streaming live video to a remotemonitor.

LCD Display: An LCD display can be used to show real-time data collected by the robot's sensors. This could include radiation levels, temperature, and gas concentrations.

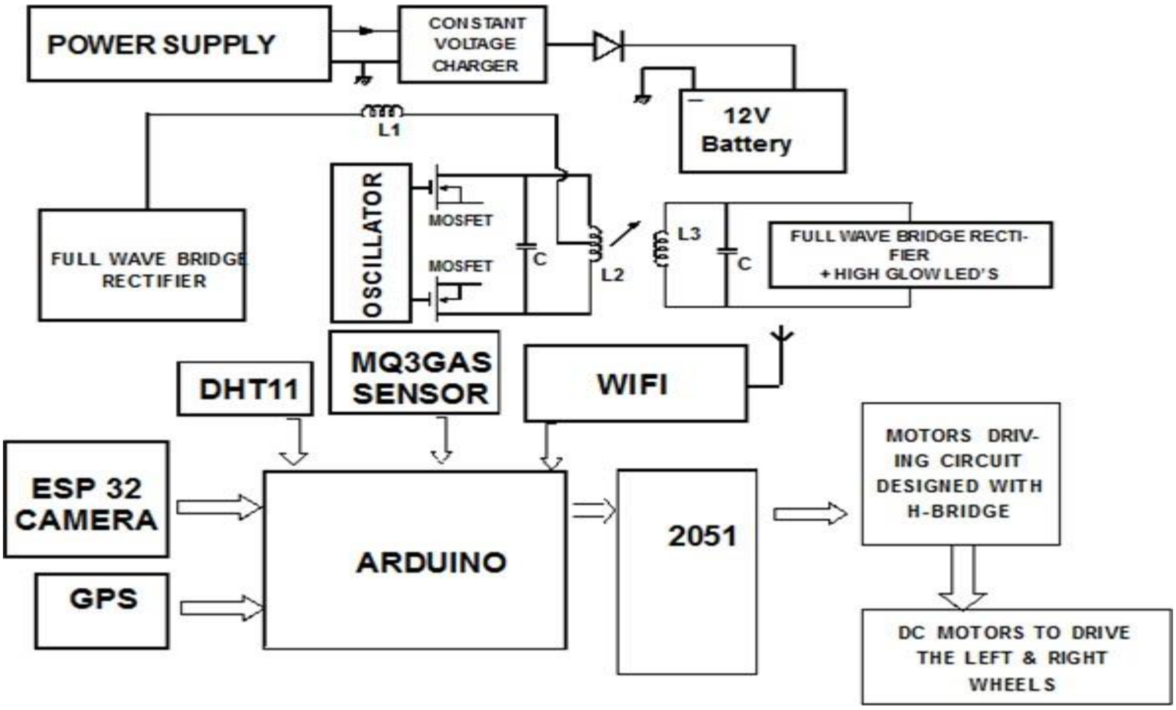
Arduino Board: These functionalities, including gas sensing detection, rover movement, visual monitoring, and remote control mechanisms, are integrated using an Arduino board.

Wi-Fi Module: The Esp8266 wifi module on board the rover is used to transmit WIFI signals to smart devices like phone, laptops, etc. It helps users to access the high speed network. The WIFI module consists of predetermined credentials for establishing connection with external devices.
The WIFI Module uses standard communication protocols (e.g., TCP/IP, UDP) to transmit data packets securely and efficiently to remote endpoints.

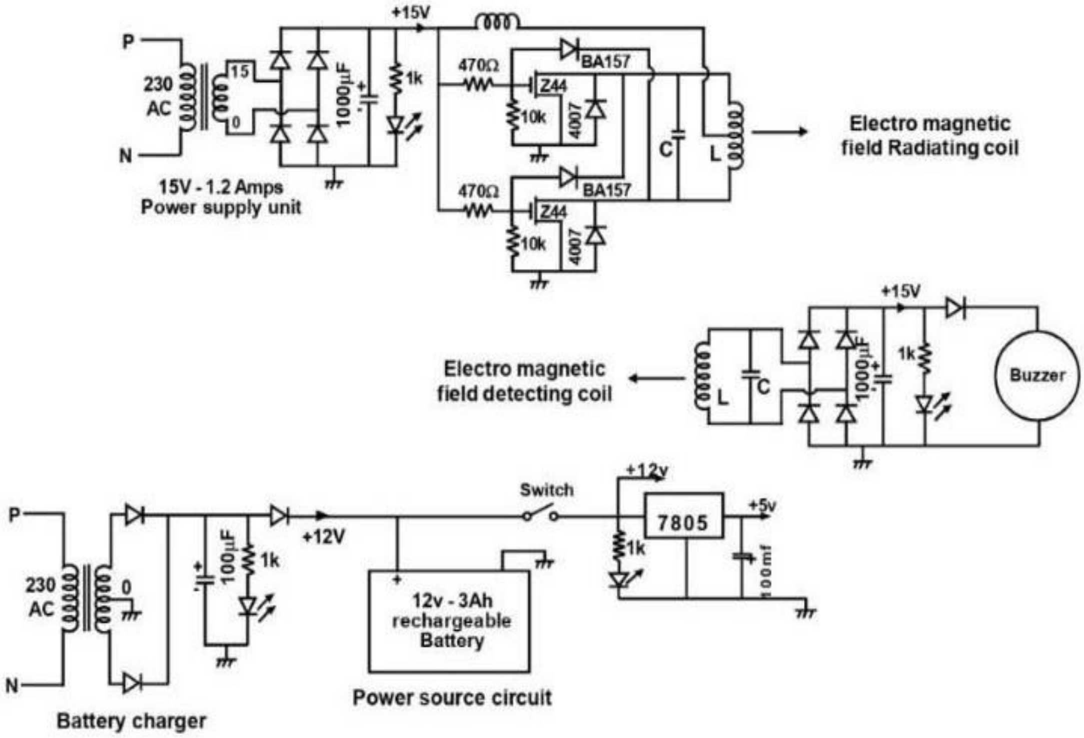
- The phone connects to the wifi module to establish a data link, Once connected to the phone network, the WiFi module sends and receives data packets containing information from the rover's sensors, cameras, and other onboard systems. This data could include environmental parameters, telemetry, video feeds, and any other relevant information for hazard response operations.
- The WiFi module facilitates communication between the rover and external devices, such as the ESP32 camera WiFi module. This integration allows for live data streaming from the rover's onboard cameras to remote devices, enabling real-time monitoring and situational awareness for operators andemergency responders.

Rover Movement Mechanism:

- The rotation speed of the left and right wheels independently, the rover can move forward, backward, turn left, or turn right.
- For instance, to move forward, both left and right wheels rotate forward at the same speed. To turn left, the left wheel is slowed down or stopped while the right wheel continues to rotate forward(counterclockwise). Conversely, to turn right, the right wheel is slowed down or stopped while the left wheel continues to rotate forward(clockwise).
- This differential speed control creates a turning motion, allowing the rover to change direction without needing a separate steering mechanism like that found in conventional vehicles.



Block Diagram of Response Rover.



Architecture of Radiation Detection Circuit and Sample EMF Radiating Coil.

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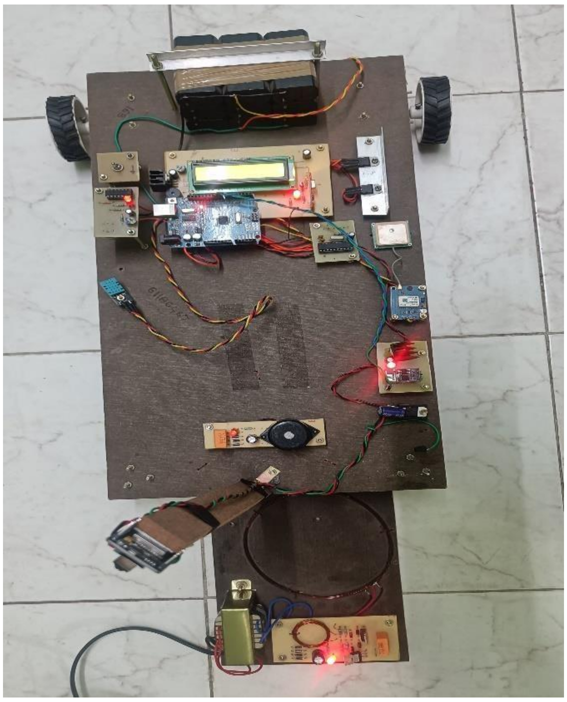
IV FINDINGS AND RESULTS

1. Electromagnetic Induction:

- ✓ It has been effectively integrated into our prototype for demonstration purposes. The circuit is adept at detecting alternating current (AC) induced within it, which activates the receiver circuit. Upon detection of this induced current, a buzzer is triggered, generating an alert sound to notify users of the occurrence. This implementation showcases the practical application of electromagnetic induction in our project, enhancing its functionality and usability.



2. Environmental Sensing :

- ✓ We employed a DHT11 sensor to precisely measure the temperature and humidity levels in the surroundings. Additionally, we integrated an MQ3 sensor to effectively detect the presence of toxic gases in the environment.
- ✓ By utilizing these sensors, we were able to obtain real-time data on temperature, humidity, and the percentage of toxic gases present, enabling comprehensive environmental monitoring.

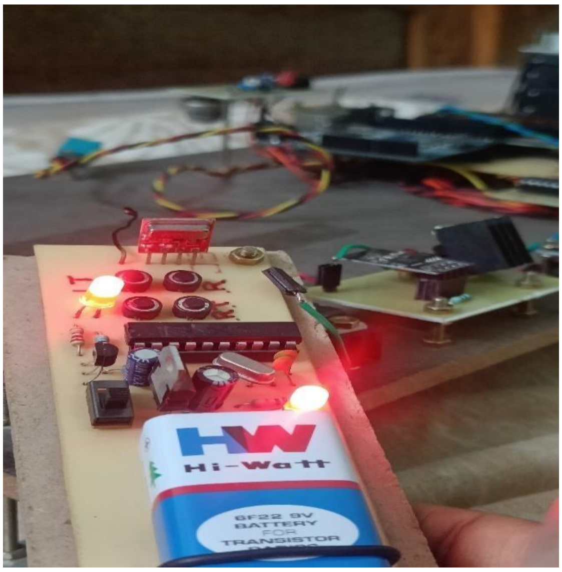
3. GPS Tracking:

- ✓ We've incorporated a GPS module into our robotic system to keep track of its location, especially when it detects gas in the field.
- ✓ It captures and stores location coordinates responding to the detected gas points, providing valuable data for analysis. These coordinates, along with humidity and toxic gas percentage, are displayed on an LCD board, giving

real-time insights into the environmental condition.

3. Remote Control and Monitoring:

- ✓ Utilized RF technology alongside an 89c2051 microcontroller to enable remote control of the robot. Facilitated individual control of DC motors via a microcontroller- operated H-bridge. Incorporated an ESP-32 Wi-Fi camera linked to a smartphone to facilitate remote surveillance of the surrounding area and an ESP8266 WiFi module is used for uploading data to network using TCP protocol.



V. CONCLUSION

In conclusion, our project was dedicated to creating a smart surveillance robot tailored for use in hazardous fields and radiation- affected areas. We successfully integrated various technologies and components to bolster the robot's capabilities and ensure the safety of operators. Our smart surveillance robot proved its effectiveness in navigating hazardous environments and gathering crucial data. The incorporation of electromagnetic induction, environmental sensors, GPS tracking, remote control using RF technology, wireless accessing of data using WiFi module. and the integration of a Wi-Fi camera all contributed to its robust functionality. This project underscores the potential of intelligent robotic systems in enhancing safety and surveillance in high- risk settings. Further research and development hold promise for even more advanced features and applications in the future, paving the way for improved safety measures and enhanced data collection in challenging environments.

VI. FUTURE SCOPE OF THE RESEARCH

The future scope of the research on the Intelligent Robot used to acquire data from Radiation areas with Wifi Camera, are extensive and promising, offering significant potential for advancements in safety and surveillance within high-risk environments. Several key areas for future development stand out, including enhanced sensor integration to broaden the range of data collected, autonomous navigation to enable the robot to navigate complex environments independently, and the incorporation of machine learning and artificial intelligence to enhance decision-making capabilities. Additionally, integrating a robotic arm could allow the robot to interact with its surroundings more effectively, while improvements in wireless communication and networking would enhance data transmission and remote control capabilities. Efforts to enhance energy efficiency and power management could extend the robot's operational endurance, while advancements in data fusion and visualization would facilitate better interpretation of collected data. Integration with cloud services would enable seamless data storage and analysis, while collaboration with emergency response systems could improve coordination during crisis situations. Real- world deployment and testing would be crucial to validate the robot's performance and ensure its effectiveness in practical scenarios.

By incorporating these advancements, the smart surveillance robot could evolve into a highly sophisticated tool capable of effectively navigating and monitoring hazardous environments, thereby mitigating risks and providing critical support to operators in real-time. Such developments have the potential to revolutionize various industries, including nuclear energy, chemical manufacturing, disaster response, and more, ultimately leading to improvements in safety, efficiency, and effectiveness within high- risk settings.

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