CIRQUON

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Abstract-*In dangerous and disaster-prone areas, realtime monitoring and exploration play a vital role in mitigating risks and improving rescue efforts' effectiveness. This topic is based on a microcontroller-based Disaster Surveillance Rover paired with a Remote Monitoring Unit. The system focuses on efficient environmental monitoring through a combination of sensors including ultrasonic sensors for detecting obstacles, PIR sensors for motion detection, MQ5 sensors for detecting gas leaks, MLX90614 infrared sensors for measuring temperatures, KY-037 sensors for measuring noise levels, and SW-420 vibration sensors for measuring vibrations. Communication relies on NRF24L01 modules facilitating efficient and reliable long-distance data transfer, while the remote unit utilizes a 16x2 I2C LCD to show real-time sensor data. Motivation involves four DC motors with L298N motor drivers driven by an 11.1 volts lithium-ion battery pack. The power management system uses buck converters to generate 5 volts and 3.3 volts voltage supply lines to operate the sensors and communication modules. The entire system uses the standalone ATmega328P chipset, which costs about 4000 Rs.*

I. INTRODUCTION

Disasters result in situations where humans find it difficult to enter the environment, making real-time monitoring and analysis crucial for the management of disasters.

Conventional methods involve manual inspection techniques, which take time, are risky, and inefficient in emergencies, resulting in the inability to collect relevant data from the disaster site. To address this problem, robotic systems can be considered an excellent way of carrying out remote monitoring and exploration tasks. Robotic systems can access hazardous terrains, collect data on the environment, and provide continuous feedback to operators without putting human lives in danger. This paper presents the design of "Cirquon" a Circuit based intelligent Disaster Surveillance Rover with Remote Monitoring Unit. In this system, several types of sensors have been used. These include ultrasonic sensor for detecting obstacles, PIR sensor for detecting motion, MQ5 for detecting gases, MLX90614 temperature sensor, KY-037 sound sensor, and SW-420 vibration sensor. The system is controlled by the ATmega328P microcontroller and uses the NRF24L01 communication module. Real-time data is displayed on 16×2 I2C LCD screen while L298N motor drivers control four DC motors. The system operates with the help of a regulated lithium-ion battery. The system is designed at an approximate cost of 4000Rs.

II. LITERATURE REVIEW

Ivan Maza, et.al [1] proposed a networked aerial/ground robotic system having distributed task allocation for disaster management, where efficient coordination among the UAVs and UGVs can be done effectively. From this paper, the idea for coordinating and efficiently doing the operation in dangerous situations has been adopted.

Stefan Schwaiger, et.al [2] proposed an unmanned ground vehicle for performing in hazardous situations using multiple specialized sensors. The system was reliable in terms of providing safe environment for operation. In this research work, multiple environmental sensors for detecting environmental factors have been used.

Abel Girma et.al [3] designed an IoT-based autonomous system for search and rescue operations emphasizing on communication and coordination of multiple robots in operation. In this project, wireless communication technology is used for real time transmission of data.

S. Vijay Shankar, et.al [4] proposed an IoT-based Human detection robot which could be utilized in rescue missions during disaster. This system was efficient in detecting the presence of human through sound and movement sensing. Ning Li, et.al [5] designed an advanced quadruped rescue robot for search operations in post-disaster situations with complex and rugged terrain, showing enhanced mobility and stability. This contribution highlights the significance of efficient mobility for navigation in complex environments. Bruno E. Henriques, et.al [6] suggested an environmental mapping technique with coordination between aerial and terrestrial robots to provide accurate environmental analysis. From this work, the notion of real-time data acquisition and environmental monitoring has been adopted.

R. V. Kumar, et.al [7] worked on swarm robotics and its application to disaster management through multi-robot coordination schemes. The technique showed Scalable and flexible response capability. From this work, the approach of efficient coordination in the system has been used.

Zhi-Yong Shu, et.al [8] introduced a rescue robot design with efficient mobility and sensing for disaster management operations. From this contribution, the concept of efficient integration of mobility with sensing for effective environmental monitoring has been adopted.

III. OBJECTIVE

1. Design and construct an automated rover using the microcontroller ATmega328P for continuous environmental monitoring.
2. Incorporate multiple sensor components to sense obstacles, monitor movement, gas leakage, temperature, sound, and vibrations.
3. Establish wireless communication between the sensor module and the receiving module using the NRF24L01 component.
4. Construct a motor-driven rover using the L298N motor driver IC that can be used in dangerous environments.
5. Design a small and economical setup costing less than 4000 Rs.

IV.MOTIVATION

There are some situations where it is necessary to perform an immediate, safe evauations of potentially hazardous areas, without endangering human lives in any way. The example of the Sangareddy building falling down in Telangana, India, during the month of June 2025 proves the importance of gaining immediate access to potentially hazardous areas along with gathering data instantly.

V. REQUIREMENT ANALYSIS

1. Real-time monitoring using multiple sensors.
2. Reliable wireless communication (150–200 m).
3. Fast operation and response.
4. Compact and lightweight design (1.5 kg).
5. Durable battery system.
6. Efficient power management.
7. Easy remote control.
8. Obstacle detection capability (up to 50 cm).
9. Stable and accurate sensor reading.
10. Continuous data transmission to remote unit.

VI.DESIGN

A. Sequence Diagram

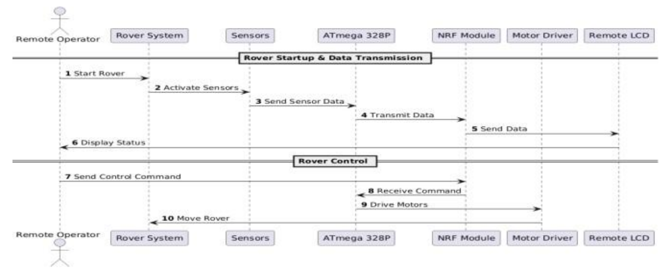

Fig. 1. Sequence Diagram

B. Use Case Diagram

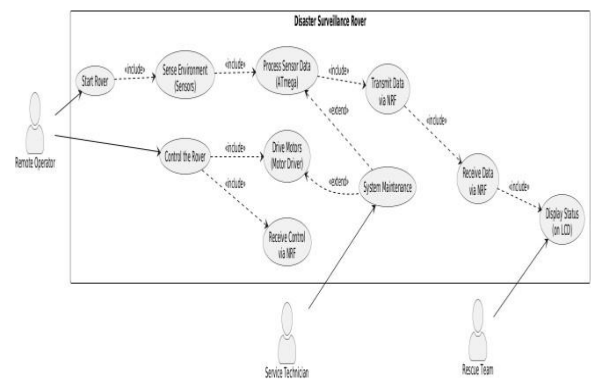

Fig. 2. Use-Case Diagram

VII. BLOCK DIAGRAM

As illustrated in Figure 4.3, the block diagram shows the integration of sensors, motors, and wireless communication technologies in the disaster surveillance robot by the ATmega328P microcontroller. The HC-SR04 sensor detects obstacles in the path of the robot while the HC-SR501 PIR sensor detects movements around the vehicle. The hazardous gases in the environment are detected through the MQ5 sensor while the temperature is sensed by the MLX90614 sensor. Vibrations and sounds are detected by the SW-420 and KY-037 sensors, respectively. The ATmega328P is the controlling element that gets the data from each and every sensor installed in the robot and controls the system's operation. The real-time data collected by the sensors is transmitted to the remote unit through the NRF24L01 wireless module. The wheels of the robot are controlled by the L298N motor driver while the LM2596 step-down module is used to regulate the voltage levels to 5V and 3.3V.

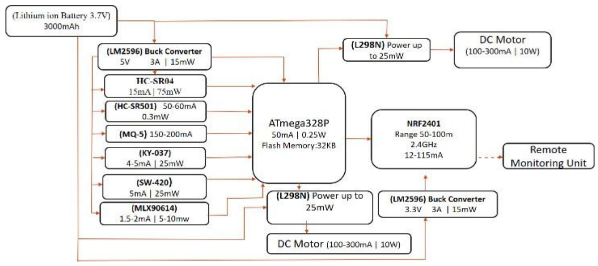

Fig. 3. Block Diagram

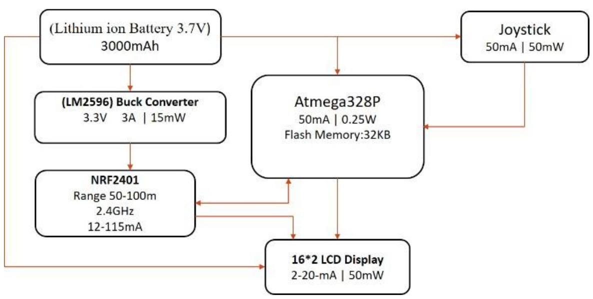

Fig. 4. Block Diagram (Remote Monitoring Unit)

VIII. CIRCUIT DIAGRAM

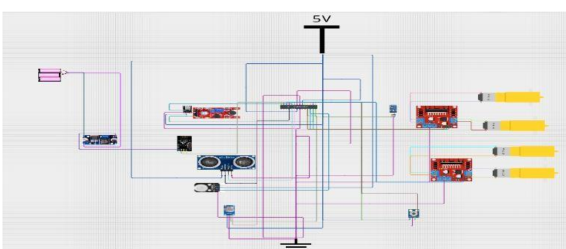

Fig. 5. Circuit Diagram

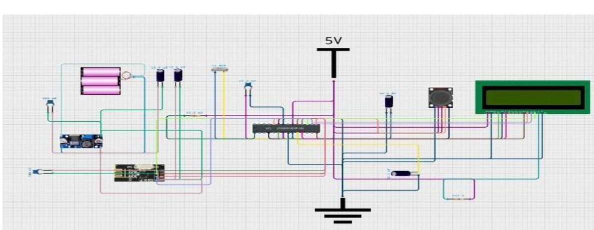

Fig. 6. Circuit Diagram (Remote Monitoring Unit)

The remote monitoring device is centered on the ATmega328P microcontroller that connects the functionalities of wireless communication, display, and control. Data received in real time from the rover in the form of signals is transferred wirelessly using the NRF24L01 module and reaches the ATmega328P microcontroller. The microcontroller processes the data and displays it live through the LCD 16x2 display via an I2C connection. The microcontroller not only processes and displays data, but also controls the rover through the transmission of command signals using the joystick module. Wireless transmission of the commands is also carried out via the NRF24L01 module. For power supply, an LM2596 voltage regulator is used to convert the input voltage to a stable output of 3.3V for the NRF module.

IX. RESULT AND DISCUSSIONS

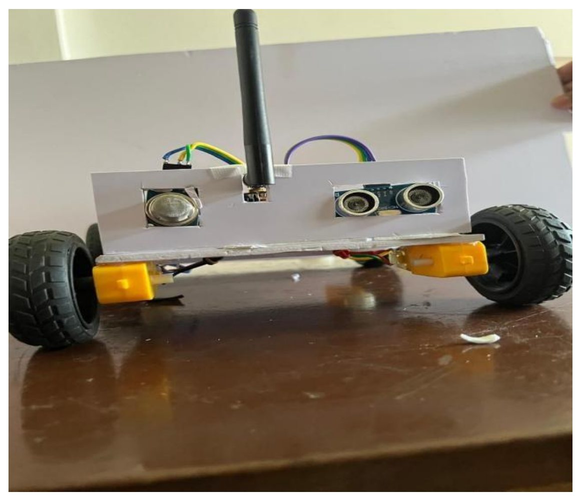

Fig.7. Prototype

X. CONCLUSION

Finally, the Disaster Surveillance Rover with Remote Monitoring Unit has been effectively designed and implemented as a useful application for hazardous environment monitoring. Initially, the system was assembled using a breadboard design and later organized within a compact PCB design utilizing the EasyEDA platform. Integration of the ATmega328P microcontroller and such sensors as the HC-SR04 ultrasonic, HC-SR501 PIR, MQ5 gas, MLX90614 temperature, KY-037 sound, and SW-420 vibration sensors allows efficient and accurate environment monitoring through detection of obstacles, presence of people, gas leaks, temperature fluctuations, sound, and vibrations. Collected data is transmitted via the wireless communication system using the NRF24L01 transceiver module to a remote monitoring unit, where it is presented by means of the OLED screen. Besides, the joystick interface allows effective control of the rover movements. All in all, the system can function efficiently under challenging conditions. In conclusion, it is necessary to emphasize that the created Disaster Surveillance Rover withRemote Monitoring Unit has proven itself to be an effective tool for monitoring hazardous environment conditions remotely and safely. It significantly limits the participation of people in disaster environments. Moreover, the system shows the efficient work of the wireless communication system and embedded devices and can serve as a good basis for future developments.

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