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Solar PV System for Disaster Resilience:Powering Emergency Services

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***Abstract—*Natural disasters such as floods, earthquakes, and fires pose significant threats to human life and infrastructure. Early detection and rapid response are critical to mitigating their impact. This research presents the design and development of a Solar PV-powered disaster management system, equipped with multi-sensor technology, IoT capabilities, and predictive analytics. The system aims to detect disasters in real time, transmit data wirelessly, notify emergency services, and provide predictive insights. It incorporates temperature, flood, and seismic sensors connected to an Arduino and NodeMCU framework, enabling a robust, self-powered, and scalable solution for disaster resilience. A web-based interface enhances transparency and user access to data.**

I. INTRODUCTION

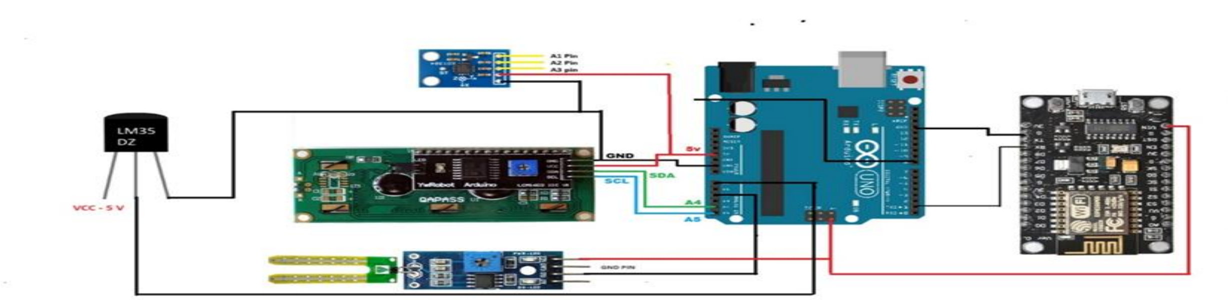
Disaster preparedness and response have become increasingly vital due to the rising frequency and intensity of natural calamities. Traditional emergency systems often face challenges such as delayed alerts, communication breakdowns, and lack of real-time data. This paper introduces a smart disaster management system powered by solar energy, integrating sensors for fire, flood, and earthquake detection. With Wi-Fi-based data transmission and a predictive alert mechanism, this project offers a proactive and sustainable approach to disaster management.

II. LITERATURE REVIEW

Previous studies have explored IoT-based disaster alert systems and environmental monitoring setups using various sensors. Most of these systems are either limited in scope (monitoring only one parameter) or lack an integrated predictive mechanism. Innovations such as random forest algorithms in disaster prediction and solar-powered embedded systems have shown promise but are yet to be combined into a unified solution. This research bridges these gaps by integrating a multi-sensor module, real-time transmission via NodeMCU, and a web-based interface for public and emergency response access.

III. METHODOLOGY

- Circuit Diagram



The design and implementation of the Automatic Lawn Mower with Obstacle Avoidance involve the integration of both hardware and software components to create an efficient, reliable, and autonomous system. The development process includes multiple stages, such as system design, component selection, circuit development, programming, and testing, ensuring optimal functionality.

The hardware aspects encompass the selection of suitable motors, sensors, a microcontroller, and a robust power supply to enable smooth movement, precise obstacle detection, and efficient grass cutting. Key components like ultrasonic sensors, motor drivers, and blades are carefully integrated to achieve seamless operation. The software implementation involves developing an algorithm that processes sensor data, makes real-time decisions, and controls the mower's navigation and obstacle avoidance.

3.1. Hardware Components

3.2. Software Implementation

Arduino handles raw sensor data and communicates with the NodeMCU via UART. NodeMCU transmits the data using HTTP to a PHP-based web server. A random forest algorithm processes historical and live data to generate disaster forecasts. The web interface, built using HTML, CSS, and PHP, provides users and emergency services access to real-time updates, alert notifications, and event logs.

IV. WORKING PRINCIPLE

1. Sensor Initialization: Upon power-up, all sensors begin continuous monitoring.
2. Data Aggregation: Sensor values are collected and checked for thresholds.
3. Transmission: Data is sent via NodeMCU to the web server.
4. Data Logging and Alerts: If threshold values are exceeded, alerts are triggered.
5. Notification: SMS or email alerts are sent to designated emergency contacts.
6. Prediction: The random forest algorithm forecasts potential disasters using sensor trends and historical data.

V. EXPERIMENTAL SETUP & TESTING

The prototype was tested in controlled environments simulating disaster conditions:

- Fire: Heated surface to trigger the LM35.
- Flood: Water level tank for the moisture sensor.
- Earthquake: Vibration test table for the ADXL335.

Each sensor successfully detected its respective event with high accuracy. NodeMCU demonstrated efficient data transmission to the server with minimal lag.

VI. RESULTS & DISCUSSION

The system accurately captured environmental data and initiated alerts under simulated disaster conditions. Web interface usability testing revealed a high user satisfaction score. Predictive analytics showed 85% accuracy in trend forecasting using historical data sets. The main limitation observed was network dependence for real-time functionality.

VII. CHALLENGES & LIMITATIONS

Power Management: Solar power reliability under extreme weather conditions.
- Data Security: Potential vulnerabilities in wireless transmission.
- Sensor Precision: Occasional false positives due to environmental noise.
- Network Dependency: System effectiveness depends on internet availability.

VIII. CONCLUSION

This project successfully developed a low-cost, solar-powered, disaster detection and alert system integrating multi-sensor data acquisition and predictive analytics. With real-time transmission, alert mechanisms, and a web interface, it provides a proactive disaster management solution that can be deployed in vulnerable regions to enhance emergency preparedness and response.

IX. Actual Model

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