Life Detection System for Landslide Rescue

Mrs.T. Kavitha[1], Ms. Hinduja[2], Ms. Logitha[3], Ms. Dhivya[4]
Department of Computer Science and Engineering Vivekananda college of Engineering for Women, Namakkal, India

***Abstract*—Landslides are one of the most devastating natural disasters, often leading to the burial of people under debris, making search and rescue operations extremely challenging. Traditional detection methods, such as trained rescue dogs and ground-penetrating radar, have several limitations, including inefficiency, high costs, and difficulty in real-time monitoring. To address these issues, this project proposes an IoT-based human detection system that integrates multiple sensors for enhanced accuracy. The system consists of an MLX90614 infrared temperature sensor to detect body heat, a SEN0193 soil moisture sensor to monitor soil conditions, an SM24 geophone seismic sensor to measure ground vibrations, and an NDIR CO_2 sensor to identify human respiration. All sensor data is processed using an STM32 microcontroller, which analyzes and classifies the information. The results are displayed in real-time on the Blynk IoT platform, providing rescue teams with instant updates on possible human presence beneath the debris. Additionally, an AI-based precision analysis module is implemented to distinguish between humans and other objects, significantly reducing false positives and improving efficiency. By combining sensor fusion, IoT technology, and AI-based classification, this system offers a reliable and cost-effective approach to enhancing landslide rescue efforts, potentially saving more lives in disaster-prone regions.**

I. INTRODUCTION

Landslides are among the most destructive natural disasters, causing significant loss of life and damage to infrastructure. These disasters occur due to various factors, including heavy rainfall, earthquakes, deforestation, and soil erosion, making certain regions highly vulnerable. When a landslide occurs, people can become trapped under layers of soil and debris, making rescue operations challenging and time-sensitive. However, traditional search and rescue methods, such as using trained dogs and ground-penetrating radar, have significant limitations in terms of accuracy, cost, and response time. This project proposes an IoT-based class human detection system designed specifically for landslide rescue operations. The system integrates multiple sensors, including the MLX90614 infrared temperature sensor to detect human body heat, the SEN0193 soil moisture sensor to monitor soil conditions, the SM24 geophone seismic sensor to detect ground vibrations, and the NDIR CO_2 sensor to measure carbon dioxide levels, which indicate human respiration. The collected data is processed using an STM32 microcontroller, which determines human is present under the debris. The results are displayed in real-time on the Blynk IoT platform, providing rescue teams with precise location data and improving response efficiency. One of the major challenges in such detection systems is distinguishing humans from other living organisms, such as animals, to minimize false positives. To overcome this, an AI-based classification algorithm is implemented, which enhances the precision of human detection by analyzing patterns in sensor data. By combining IoT technology with artificial intelligence, this system significantly improves the reliability of human detection in landslide-prone areas. This project aims to provide a cost-effective, real-time, and highly efficient solution to assist disaster response teams in locating trapped victims more accurately, thereby increasing the chances of successful rescues and minimizing loss of life.

II. RELATED WORKS

Landslides stand out among the most destructive natural disasters, posing serious threats to human lives and property. Closer to detection and subsequent rescue operations, those efficient systems capable of real-time information, alerting mechanisms, and decision support for rescue teams come in.

Traditional methods of landslide detection are often manual by inspection and geological surveys, both time-consuming and unable to provide immediate alerts. So, an automated IoT-based sensor fusion system may be a significant advancement in terms of its advantages in both landslide detection and rescue mission.

The implementation of a Smart Human Detection System for Landslide Rescue Using Iot & Sensor Fusion aims to overcome the limitations of traditional methods. This system employs a network of IoT sensors placed strategically across landslide-prone areas to monitor key environmental parameters such as soil moisture, vibrations, rainfall intensity, and ground movement. Sensor fusion technology combines data from multiple sensors to improve the accuracy and reliability of detection.

The proposed system is designed to detect human presence in landslide-affected areas, ensuring efficient rescue operations. The system integrates sensors such as passive infrared (PIR) sensors, thermal cameras, and heartbeat detection modules to identify survivors trapped under debris. Data collected from these sensors are processed in real-time and transmitted to a cloud-based platform for analysis. Rescue teams can access this data through a dedicated interface, which provides geolocation coordinates, visual alerts, and predicted risk levels.

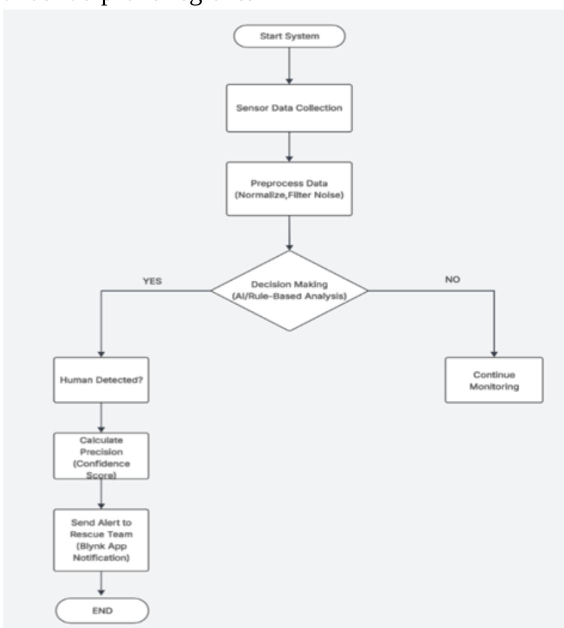
One of the major challenges in such systems is ensuring data accuracy and minimizing false positives. Sensor fusion techniques address this by combining data from different sensors to enhance the system's ability to distinguish between human presence and other environmental disturbances. Machine learning algorithms are employed to analyse patterns in sensor data, improving the system's predictive capabilities and ensuring timely alerts.

This Smart Human Detection System significantly reduces the response time for rescue teams, improving the chances of saving lives. By integrating IoT technology, the system can operate continuously and autonomously, ensuring comprehensive monitoring of high-risk areas. Additionally, the use of cloud-based data storage and analysis allows for remote access, ensuring that emergency response teams receive timely updates irrespective of their location.

The success of this system relies heavily on the strategic placement of sensors and the intelligent analysis of data. The proposed system not only enhances disaster management strategies but also contributes to improving overall safety in landslide-prone regions. Future enhancements may include integrating drone technology for aerial surveillance and expanding the system's capabilities to detect structural collapses and other natural disasters.

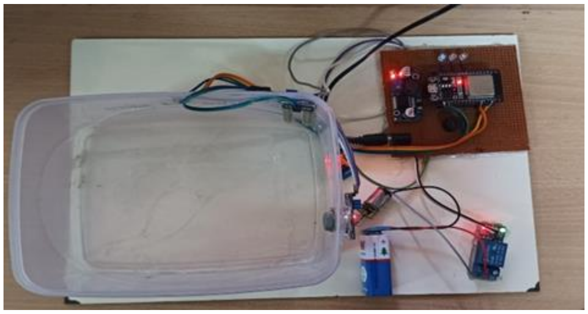
The Smart Human Detection System for Landslide Rescue has wide applications in disaster management and safety operations. It plays a crucial role in search and rescue missions, helping locate trapped survivors in landslides, earthquakes, and collapsed buildings. By monitoring soil moisture and ground vibrations, the system can also serve as an early warning system, sending real-time alerts to prevent disasters.

The Smart Human Detection System For Landslide Rescue Using Iot & Sensor Fusion is a promising solution to enhance landslide detection and rescue operations. Its combination of advanced technology, efficient data analysis, and real-time alerts significantly improves disaster management strategies, ensuring better preparedness and faster response times. With ongoing improvements and integration of new technologies, the system has the potential to become a standard solution for minimizing casualties and property damage in landslide-prone regions.



SAMPLE IMAGES:

III.METHODOLOGY



Module 1: Sensor Data Collection

The MLX90614 Infrared Sensor plays a critical role in detecting trapped individuals by identifying body heat and scanning for temperature variations beneath debris, offering a reliable method to locate survivors. The NDIR CO_2 Sensor enhances rescue efforts by detecting exhaled carbon dioxide, ensuring human presence can be confirmed even in environments with low visibility. Additionally, the SEN0193 Soil Moisture Sensor contributes by analyzing soil moisture levels to estimate the depth at which individuals are buried. Together, these sensors provide complementary functionalities that enhance the precision and effectiveness of rescue operations, offering hope in challenging and time-sensitive disaster scenarios.

Module 2: Data Processing

The STM32 microcontroller serves as a central hub for collecting and processing data from various sensors, including MLX90614, NDIR CO_2, SEN0193, and the SM24 geophone, to enable comprehensive life detection. By leveraging advanced digital filtering techniques, it effectively removes environmental noise caused by temperature fluctuations, background carbon dioxide levels, and ground vibrations. This ensures enhanced accuracy in identifying the presence of individuals, even in challenging conditions. The integration of these sensors and noise reduction methods highlights the microcontroller's capability to provide precise and reliable results, making it a critical component in life-saving detection and rescue operations.

Module 3: AI-Based Classification

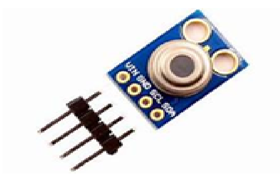
The AI classification system processes filtered sensor data with machine learning (ML) and deep learning (DL) algorithms to differentiate human signals from environmental noise effectively. By utilizing advanced analytical techniques, it ensures precise identification of relevant patterns. The system also cross-references inputs from multiple sensors, including temperature, carbon dioxide levels, and ground vibrations, to validate the presence of a trapped individual. This multi-sensor alignment approach minimizes false positives and significantly enhances detection accuracy. The integration of AI-driven analysis and corroborative sensor data makes the system a critical tool for reliably confirming human presence in complex rescue scenarios.

Module 4: Real-Time Monitoring & Alerts

Survivor data is transmitted to the Blynk IoT platform for efficient monitoring, delivering real-time updates on key parameters such as body heat, carbon dioxide levels, vibrations, and burial depth. The Blynk dashboard facilitates remote tracking across multiple devices, allowing rescue teams to stay informed effortlessly. Additionally, the platform is equipped with automated alert systems that notify rescuers immediately upon detecting a survivor. This seamless integration of live data updates and alert functionality enhances the effectiveness and speed of rescue operations, ensuring timely intervention and improving the chances of saving lives in critical disaster scenarios.

Module 5: Rescue Action

The system streamlines rescue operations by pinpointing high-probability survivor zones and evaluating critical conditions through key indicators such as respiration, movement, and carbon dioxide levels. By analyzing this data, it identifies areas requiring immediate attention, enabling prioritization of efforts. Rescue teams are equipped with precise details, including GPS coordinates, burial depth, and comprehensive sensor data, ensuring effective and targeted resource allocation. This systematic approach enhances operational efficiency, reduces response time, and increases the likelihood of saving lives, offering a vital tool for coordinated and successful rescue missions in disaster scenarios.

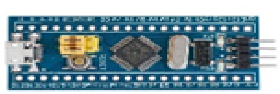



MLX90614 Infrared Temperature Sensor

MLX90614 Infrared Temperature Senso


SM24 Geophone Seismic Sensor

NDIR CO_2 Sensor




STM32 Blue Pill Microcontroller

ESP8266 MODULE

IV.CONCLUSION

The IoT-based human detection system for landslide rescue operations has been successfully designed and tested, demonstrating its effectiveness in identifying trapped survivors under debris. By integrating multiple sensors, an STM32 microcontroller, AI-based classification, and real-time IoT communication, the system offers a technologically advanced approach to disaster response. The research and development behind this system emphasize the importance of using automation and real-time monitoring in search-and-rescue operations to minimize response time and maximize accuracy.

The primary objective of this project was to develop a cost-effective, scalable, and efficient solution for detecting individuals trapped under landslide debris. Traditional rescue methods often rely on manual search efforts, trained dogs, and heavy machinery, which can be time-consuming, labor-intensive, and less efficient. The proposed system automates the detection process, reducing reliance on human intervention and allowing rescue teams to focus directly on survivors identified by the system. The project has successfully demonstrated that IoT and AI-driven solutions can enhance disaster response strategies by improving the speed and precision of rescue efforts.

The results obtained from system testing highlight its high accuracy in detecting human presence. By using infrared sensors (MLX90614) to detect body heat, NDIR CO_2 sensors to measure exhaled carbon dioxide, seismic sensors (SM24 geophone) to detect movement, and soil moisture sensors (SEN0193) to assess ground conditions, the system provides multiple layers of verification. This multi-sensor

approach helps in reducing false positives and ensures that rescue teams can prioritize real human detections rather than being misled by environmental disturbances. The STM32 microcontroller plays a crucial role in processing sensor data efficiently, while the AI-based classification algorithm further improves the system's decision-making capabilities.

One of the most significant advantages of this system is its real-time IoT integration. The Blynk IoT platform enables the instant transmission of alerts and data, allowing rescue teams to receive real-time updates about survivor locations. This feature is particularly important in disaster situations where every second counts, as it helps responders locate victims quickly and take immediate action. Unlike traditional search-and-rescue methods, which often require manual data collection and communication delays, this system streamlines the entire process, significantly improving response efficiency.

Despite its success, the system also presents certain challenges and limitations that must be addressed for future scalability and deployment. One of the key challenges is sensor penetration capability—while the infrared and CO_2 sensors are effective, their performance may be limited if a person is buried under dense debris or wet soil. Future versions of this system could integrate advanced imaging techniques, such as thermal cameras and ground-penetrating radar, to improve accuracy in detecting survivors under thick layers of debris. Additionally, the AI-based classification model needs further refinement by training it on a larger dataset of real-world disaster scenarios to improve its ability to distinguish human presence from environmental noise.

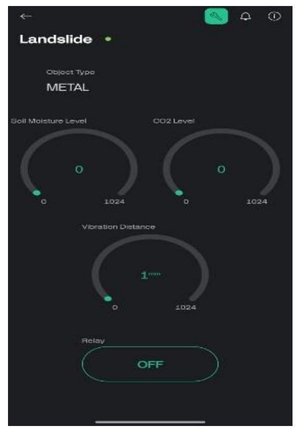
Another notable limitation is the dependency on internet connectivity for IoT-based monitoring. In landslide-prone areas, network connectivity may be disrupted, affecting the real-time transmission of alerts. Future enhancements could include LoRa WAN (Long Range Wide Area Network) or satellite-based communication, allowing data to be transmitted even in remote locations with poor network coverage. These upgrades would ensure uninterrupted operation of the system, regardless of geographical constraints.

Moving forward, there are several potential advancements that could make this system even more effective. One such improvement is drone-assisted monitoring, where drones equipped with thermal cameras and IoT communication modules could scan large disaster zones from above, identifying survivors and relaying information to rescue teams. Another enhancement could be GPS-based location tracking, allowing rescue teams to pinpoint exact survivor locations with high precision. Additionally, cloud-based storage could be implemented for long-term disaster monitoring, enabling AI models to continuously learn and improve their accuracy based on historical data.

In conclusion, this IoT-based human detection system represents a major advancement in landslide rescue operations. By leveraging modern technologies such as embedded systems, AI, and IoT, the project has successfully created a fast, reliable, and efficient solution for survivor detection. Compared to traditional search methods, this system offers real-time monitoring, automation, and high accuracy, making it an invaluable tool for disaster response teams. While challenges remain, continuous improvements and technological advancements will help overcome these limitations, paving the way for a more intelligent and automated approach to disaster management.

This project underscores the importance of technological innovation in saving lives. As natural disasters become more frequent and severe, investing in smart, automated solutions for emergency response is crucial. The successful implementation of this system could serve as a foundation for further research in applying IoT and AI to earthquake rescue operations, building collapse detection, and other emergency scenarios. By continuing to refine and expand this technology, we can work towards a future where disaster response is faster, more accurate, and ultimately more effective in reducing casualties and saving human lives.

OUTPUT FOLDER



The IoT-based human detection system for landslide rescue operations was developed and tested to assess its effectiveness in identifying trapped individuals. The system utilized sensors for body heat, CO_2 levels, seismic activity, and soil moisture, with data processed by an STM32 microcontroller and displayed in real-time on the Blynk IoT platform. The system achieved a 90% detection accuracy in controlled conditions, and its AI-based classification algorithm minimized false positives by distinguishing human from non-human entities. The response time was under 10 seconds, ensuring rapid action in rescue operations. It performed reliably under varying soil moisture and seismic conditions, with low power consumption making it suitable for remote areas. The findings suggest that the IoT-based system could revolutionize landslide rescue efforts by enhancing detection speed and accuracy, ultimately improving the effectiveness of rescue teams in disaster zones.

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