Disaster Response System

Gowri Shankar A B
Department of Electronics and Communication
Amrita Vishwa Vidhyapeetham
Coimbatore
cb.en.u4cce23001@cb.students.amrita.edu

Abishek R
Department of Electronics and Communication
Amrita Vishwa Vidhyapeetham
Coimbatore
cb.en.u4cce23003@cb.students.amrita.edu

Dinesh Karthik V
Department of Electronics and Communication
Amrita Vishwa Vidhyapeetham
Coimbatore
cb.en.u4cce23008@cb.students.amrita.edu

Karthick B
Department of Electronics and Communication
Amrita Vishwa Vidhyapeetham
Coimbatore
cb.en.u4cce23021@cb.students.amrita.edu

Abstract — The disaster response system allows administrators to identify heavily landslide-affected areas by accessing a new map that highlights damaged routes and locations. This enables them to plan alternative evacuation routes. Additionally, administrators can swiftly input disaster details, access essential contact information, determine the shortest and safest routes, and locate nearby shelters or resources.

Keywords — Shortest path, Pre-disaster and Post-disaster Topology, Graphs, Dijkstra's Algorithm, Latitude, Longitude.

I. INTRODUCTION

In mountainous terrains or hilly regions, landslides pose a major threat to lives and infrastructure during the period of heavy rainfall. This project is designed to respond to landslide events effectively. This system employs a graph-based model (map before landslide) that maps an area's infrastructure (NGO's, hospitals, shelters, roads), through a graph-based model that identifies optimal evacuation paths and resource supply routes using shortest path algorithm (map after landslide.

The system prioritizes emergency services, such as rescue teams and medical supplies, ensuring that the most affected parts receive immediate aid. Additionally, a decision tree-based model that organizes the disaster response into multiple levels with hospitals, speciality units, shelters as the sub levels.

II. LITERATURE SURVEY

A. Landslide Risk and Infrastucture vulnerability

Landslides in mountainous regions like Wayanad(Kerla) and Darjeeling(West Bengal) are often triggered by seasonal monsoons which affects the infrastructure which also includes hospitals, roads and shelters.

In Wayanad the heavy monsoons followed by deforestation and soil erosion increases the chances of landslide. Meanwhile, Darjeeling with its steep topography and dense population faces frequent landslide.

B. Analysis of Past incidents

For an instance, Wayanad faced severe landslide in July 2019 and August 2024 affecting around 2000 households during each occurrence. 16% of overall area of Wayanad is prone to landslide.

Recently in 2024 there were logistical hurdles in resource allocation which resulted in delay for nearly 40% of the affected areas. These areas experienced a long wait time with many people going without assistance for over 18 hours.

Taking Darjeeling for an example, in July 2021 Darjeeling experienced a severe landslide due to topical monsoon season which led to extensive damage across villages and towns. Around 1200 households were damaged and were cut off from any aid for 14 hours due to inaccurate mapping of the path.

III. METHODOLOGY

A. Data collection and Mapping

Fetched the boundary of Wayanad and Darjeeling from OSM (Open Street Map) . By taking the boundary of each areas, acquired the nodes and edges of each road ending and stored the values of nodes and edges in their respective GEOJSON (Geographic JavaScript Object Notation) files.

The nodes and edges are plotted in a separate graph which will be used for the tracking of path.

Each and every hospitals, fire stations, NGO's, shelters of the respective locations are taken manually with their latitude and longitude as their keys and stored in a separate GEOJSON files for each amenities.

Now with the use of these GEOJSON files, a Pre-disaster Topology graph is plotted which contains all the hospitals, fire stations , NGO's and shelters in the respective locations. This servers as the main graph/ map before the occurrence of landslide with this graph/map the Post- disaster map is simulated.

B. *Evacuation Route Planning*

- **Pre-Landslide Route Calculation**: Computing shortest paths on the initial (pre-landslide) graph/map to ensure optimal evacuation plans are prepared beforehand.
- **Graph Initialization:** The amenities are represented as a weighted, directed graph where each node indicates an important location (hospitals, shelters, NGOs), and each edge represents a road or pathway with an assigned weight based on distance.
- **Pathfinding**: Using Dijkstra's algorithm, computing the shortest paths from high-risk zones or populated areas to emergency shelters and hospitals. Dijkstra's algorithm will identify the least-cost path (in terms of distance) by traversing nodes and updating distances until the optimal routes are stored. This establishes the primary evacuation routes for preemptive planning.
- **Node and Edge Modification**: After a landslide, affected areas are marked by removing nodes and edges that represent blocked roads and damaged structures. The modified graph reflects these changes to recalculate evacuation routes using Dijkstra's algorithm.
- **Re-Evaluation of Paths**: Use Dijkstra's algorithm on the updated graph to find the shortest paths to accessible shelters and hospitals, allowing for efficient evacuation even with changed routes.

C. *Evacuation Process*

An hierarchy based tree is displayed after the input of latitude and longitude to guide the sequence of operations for evacuation process to be more efficient and beneficial.

By keeping the area of occurrence as the start or let's say root we can devise a hierarchical process or a tree form to guide to evacuation operation for saving more lives and efficient resource allocation.

Basically this evacuation process is divided among 5 teams,

i) Medical Response Team

ii) Rescue and Evacuation Team

iii) Resource and Supply Management Team

iv) Fire and Emergency Services

v) Infrastructure and Support Team

Each team is given with a set of evacuation operations which could be followed according to the situation or circumstances present in the disaster occurred area. This could enhance the flow, swiftness and accuracy of the evacuation process even during a severe landslide.

The Infrastructure and Support Team analyses the Post-disaster Topography by checking the Post- landslide map and marking the damaged roads, buildings , hospitals, and other amenities which are affected by landslide. This team plan for the alternate routes by check the Post-landslide map with the shortest paths to the respective locations after the landslide and gives that set of instructions to the other teams which are involved in the evacuation process.

The Medical Team analyses the nearby hospitals and according severeness of the injury the injured and taken to the respective speciality units and make the first aid and immediate unit care operations to take place in the landside occurred part.

The Rescue and Evacuation Team first does the tracking of the paths to the respective locations form the landslide affected area then categorizes into the transport of injured to hospitals or shelters or any other amenities. Allocates the transportation required for the evacuation.

In case of a Fire Accident, the Fire and Emergency Services tracks the path to the affected places through the Post-landslide map and also does the debris clearance working in collaboration with the medical and rescue teams.

The Resource and Supply Management Team supplies the needed food, water, sanitation and medicine to the people who all allotted in the shelters.

IV. RESULT

A Pre- landslide map/graph with all the hospitals, fire stations, NGO's and shelters are plotted for the respective locations . Then a landslide is simulated and here all the amenities are marked with the path and affected areas in a separate Post-landslide map/graph. The nodes and edges are connected in a way that the damaged roads cannot be accessed after the landslide.

The Dijkstra's algorithm is employed to find the paths to various destination node from a source node which is the area of occurrence of landslide.

The evacuation option shows the probable sequence of operations of each units(teams) to do the evacuation process in an efficient way.

V. CONCLUSION AND FUTURE SCOPE

This disaster response system offers a structured/organized and efficient way to manage evacuations and resource allocations during landslides, especially in regions like Wayanad where mountainous regions poses significant threats. By implementing Dijkstra's algorithm for calculating the shortest evacuation paths, even under severe conditions, the system ensures that people can be directed along the safest and quickest paths. The use of queues to prioritize emergency services to organize responses based on whether is it critical injury or an fire accident or just accommodate in a shelter. Hierarchy improves the efficiency of resource distribution, ensuring that affected individuals receive timely aid. Ultimately, this system not only improves response times but also ensures the optimal usage and supply of resources, thereby reducing casualties and damage during landslide events.

Integration of Real-Time Data: In future versions, the system can be upgraded to incorporate real-time data from GPS sensors, weather forecasting, and IoT-enabled process. This would allow for automatic map updates and rerouting, making the response system more effective to ongoing changes during disaster events.

User-Friendly Mobile Application: Developing a mobile app for real-time evacuation alerts, route updates, and resource status notifications would improve communication between the response teams and affected residents. The app could also allow residents to report blocked paths or request aid, adding another layer of real-time input to the system.

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