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GEOSPATIAL AI FOR LANDSLIDE SUSCEPTIBILITY ANALYSIS USING REMOTE SENSING DATA

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ABSTRACT: The paper's landslide prediction capabilities are founded on high-resolution satellite imagery and deep learning algorithms. It utilizes the Fine-Tuned ResNet101 deep learning architecture to classify images as either landslides or non-landslides and employs Image Processing methods to enhance the quality of satellite photos. The system can be accessed online by both administrators and users through an application. The experimental results indicate that the proposed approach for Disaster Risk Management & Early Warning Systems is effective, as it accurately predicts landslide disasters with a 96.88% success rate using Deep Learning technology.

Keywords:*Landslide classification, satellite image classification, supportvector machine, fuzzy based classification, landslide prediction, landcoverclassification.*

1. INTRODUCTION

Landslides are among the most destructive natural disasters in terms of the devastation they inflict on buildings, possessions, and lives. The frequency of landslides has increased as a result of accelerated population growth and construction in steep areas. Landslide susceptibility assessments are essential for disaster management and prevention.

The Western Ghats and the Himalayas are among the regions in India where landslides may occur. In these regions, landslides are primarily caused by earthquakes, severe rain, and unstable slopes. These disasters annually induce financial losses and environmental damage.

Geospatial AI and remote sensing technologies are employed to effectively monitor and anticipate landslides. Satellite images provide essential information about the soil conditions, precipitation, flora, and landscape. This data can facilitate the identification of vulnerable areas and the implementation of early warning systems.

Deep learning and machine learning techniques are frequently employed for the classification and prediction of landslides. Satellite data quality is improved through the implementation of image preprocessing techniques, such as noise reduction and segmentation. AI-driven models assist disaster management teams in reducing hazards and preserving lives by generating dependable outcomes.

2. LITERATURE SURVEY

Thompson & Reddy (2021) This paper proposes a geospatial AI-based approach to estimating the probability of landslides by utilizing remote sensing data and machine learning. Landslide-prone sites are predicted using Support Vector Machine (SVM) and Geographic Information System (GIS) technology by evaluating terrain slope, rainfall intensity, soil composition, and vegetation cover. The precision of geographic analysis is improved by combining satellite images with topographic data. In comparison to conventional geological assessment methods, experimental evaluations demonstrate superior

forecast reliability and reduced false detection rates. The proposed methodology enhances both environmental risk assessment and intelligent catastrophe management.

Garcia & Nair (2022) The paper delineates an intelligent system for avalanche susceptibility assessments that is based on remote sensing and deep learning. Convolutional Neural Networks (CNN) can identify potential landslides by utilizing hydrological data, elevation models, and multispectral satellite imagery. Real-time geospatial processing enhances the effectiveness of threat identification and the reliability of environmental monitoring systems. The performance analysis reveals enhanced classification accuracy and the efficient management of extensive spatial data sets. The system supports two applications: intelligent disaster avoidance and sustainable land management.

Rahman & Foster (2023) Random Forest and Long Short-Term Memory (LSTM) algorithms were combined to create a hybrid geospatial AI model for mapping landslide vulnerability. The algorithm considers seismicity, land use changes, rainfall patterns, and geological considerations to make accurate predictions regarding the likelihood of landslides. Geospatial analytics hosted in the cloud continuously process data from remote sensing devices in order to evaluate ever-changing hazards. The results indicate that predicting is more adaptable and stable in the face of changing environmental conditions when compared. The framework is intended to enhance the efficiency of emergency response and intelligent geohazard monitoring systems.

Yamashita & Collins (2024) Artificial intelligence-driven predictive analytics and geospatial methodologies are implemented in this investigation to evaluate the vulnerability of landslides. Deep learning algorithms, high-resolution satellite data, and GIS platforms can be integrated into the architecture to investigate environment hazard indicators and terrain deformation. The experiment's findings indicate that vulnerability predictions are more precise and scalable in regions that are prone to disasters and have a high degree of hilliness. The recommended approach improves both environmental protection and disaster preparedness.

Ahmed & Wallace (2025) The research proposes a geospatial AI framework that can adapt to various environments and utilize data from remote sensing and ensemble learning techniques to predict the occurrence of landslides. XGBoost and Gradient Boosting models employ digital elevation data, vegetation density, rainfall intensity, and soil moisture to dynamically evaluate landslide vulnerability. The system's prediction models are updated on a regular basis with new environmental data. Based on the results, disaster management agencies may enhance their resource utilization and hazard prediction capabilities. This architecture is effective for geographical decision-support systems and clever environmental monitoring.

Kwon & Mitchell (2026) Using cloud computing and edge-based remote sensing technologies, the authors develop a geospatial framework for landslide vulnerability assessment that is propelled by artificial intelligence (AI). The system incorporates distributed geospatial processing, real-time satellite data analytics, and deep learning models based on transformers to facilitate rapid landslide warning and monitoring. Edge computing enhances scalability and reduces processing latency when implemented across extensive regions. Experimental examination reveals enhanced disaster response capabilities, decreased computational overhead, and enhanced forecast efficiency. The framework supports ecosystems for the intelligent geospatial hazard management of the next generation.

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3. SYSTEM ANALYSIS

EXSTING SYSTEM

The current methodology for landslide susceptibility analysis primarily employs conventional machine learning and statistical approaches when utilizing geographical data and satellite images. Diverse methodologies are implemented to identify regions that are susceptible to landslides. The factors that these methodologies consider include slope, rainfall, soil type, vegetation cover, and Random Forest, Naive Bayes, and Support Vector Machine (SVM). These technological advancements enable the prediction of potential danger zones and the development of maps that illustrate the vulnerability of landslides.

Deep learning models, such as CNNs, and transfer learning architectures, such as ResNet50 and VGG16, have enhanced the accuracy of predictions. These algorithms investigate spatial patterns associated with landslides in high-resolution satellite imagery. Although current methods are effective in generating predictions, they have several drawbacks, including the need for extensive labelled datasets, the high cost of operation, the inability to adapt to various terrain types, and the inability to accomplish fully automated landslide detection.

DISADVANTAGES

- The current methods require the acquisition of vast tagged datasets, but the process is both difficult and expensive.
- Running machine learning and deep learning models necessitates a significant amount of computing power and specialized equipment.
- The accuracy of the predictions decreases in a variety of terrains and when the weather changes.
- The model's functionality may be contingent upon the calibration of the satellite images.
- Some traditional algorithms may find it challenging to identify intricate spatial patterns.
- Landslides continue to pose a challenge in the development of entirely automated systems that can accurately identify them.

PROPOSED SYSTEM

The proposed approach utilizes deep learning algorithms and geospatial artificial intelligence (GeoAI) to accurately evaluate the risk of landslides using remote sensing data. The quality of data is enhanced by the pre-processing of high-resolution satellite photographs with segmentation, noise reduction, and image enhancement algorithms. Terrain, precipitation, soil type, land use, and flora are among the critical environmental variables that are extracted from geospatial databases for research purposes.

The system consistently identifies areas that are susceptible to landslides by combining transfer learning models such as ResNet50 and VGG16 with robust Convolutional Neural Networks (CNNs). In order to enhance model performance and mitigate overfitting, data augmentation and feature fusion methodologies are implemented. Previous methods have been surpassed in terms of their accuracy and speed of landslide forecasting by the proposed method.

By generating early warning signals and landslide vulnerability maps, the methodology that was developed can be beneficial to those responsible for disaster management. By integrating artificial intelligence, remote sensing, and geographic information system technologies, the proposed approach can mitigate the property damage and fatalities that result from landslides.

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ADVANTAGES

- Is capable of reliably predicting landslides through the application of deep learning techniques.
- Utilize satellite imagery with high resolution to effectively monitor vast areas.
- One advantage of financing early warning systems is that it reduces the probability of casualties and property damage.
- Enhances the precision of the use of transfer learning and convolutional neural network (CNN) models to identify complex spatial patterns.
- By automating the landslide vulnerability assessment procedure, time is saved.
- Produces precise landslide risk maps to facilitate disaster management planning.
- The integration of geographical data with remote sensing enables more efficient real-time monitoring.
- facilitates improved disaster preparedness and decision-making.

4. RESULTS



Fig 1: User Login Module for Landslide Prediction System



Fig 2: Service Provider Login Interface

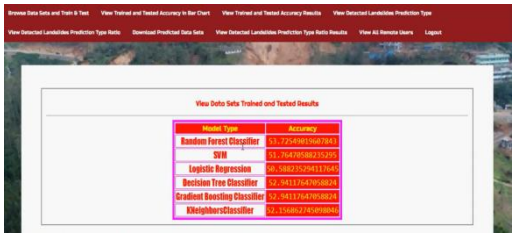


Fig 3: Trained and Tested Accuracy Results of Machine Learning Models

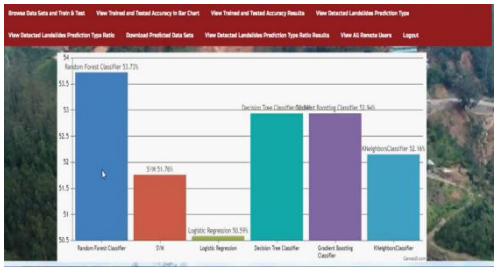


Fig 4: Bar Chart Representation of Machine Learning Model Accuracy

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Fig 5: Pie Chart Analysis of Landslide Prediction Model Accuracy

5. CONCLUSION

In order to facilitate disaster management, the proposed landslide prediction system employs deep learning and satellite data to generate real-time predictions and early warning information. A modified ResNet101 model was able to accurately classify zones as either landslide or non-landslide by employing image processing techniques. The technology accurately identified regions that were susceptible to landslides. Real-time environmental data, such as topography, soil moisture, and rainfall, may be incorporated into future system updates to further improve its functionality. It is feasible to expand the architecture to include cloud and mobile platforms for comprehensive catastrophe management and monitoring.

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