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Integrating Remote Sensing and Geotechnical Data for Enhanced Disaster Risk Management

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Abstract

The integration of remote sensing and geotechnical data is emerging as a powerful approach for enhancing disaster risk management (DRM) strategies. Remote sensing technologies offer timely, large-scale, and cost-effective observations, while geotechnical data provide crucial insights into the mechanical and physical behavior of soils and rocks. This paper explores how combining these datasets improves hazard assessment, early warning systems, and resilience planning for disasters such as landslides, earthquakes, and floods. Case studies are discussed to illustrate the practical implications of the integration, and a framework is proposed for effective data fusion, enabling more accurate predictions and mitigation strategies.

Keywords: *Remote Sensing, Geotechnical Data, Disaster Risk Management, Landslides, Flood Monitoring, Data Integration*

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INTRODUCTION

Disaster Risk Management (DRM) has gained unprecedented importance in recent decades due to the increasing frequency and intensity of natural hazards. Remote sensing, with its ability to capture high-resolution spatial and temporal data, plays a critical role in hazard detection and monitoring. Geotechnical data, on the other hand, provides on-the-ground measurements that reveal the strength, stability, and composition of terrain materials. When integrated, these two datasets enable a more comprehensive understanding of hazard mechanisms, leading to better preparedness and mitigation efforts.

REMOTE SENSING IN DISASTER MANAGEMENT

Remote sensing technologies, such as optical imaging, synthetic aperture radar (SAR), and LiDAR, allow for continuous and large-area monitoring of the Earth's surface. In disaster management, they are used for real-time hazard detection, damage assessment, and recovery monitoring. For example, SAR data can penetrate cloud cover, making it invaluable for flood monitoring during storms.

GEOTECHNICAL DATA FOR HAZARD ASSESSMENT

Geotechnical data includes parameters such as soil type, cohesion, internal friction angle, permeability, and moisture content. These factors are essential in understanding how terrain will respond to extreme events. For instance, landslide susceptibility mapping requires both surface observations and subsurface geotechnical measurements to be accurate.

DATA INTEGRATION FRAMEWORK

The integration process involves aligning spatial datasets, ensuring consistency in coordinate systems, and applying data fusion techniques. Machine learning models and GIS platforms are increasingly being used to merge remote sensing imagery with geotechnical datasets, producing hazard maps with higher predictive accuracy.

CASE STUDIES

In the 2013 Kedarnath floods in India, remote sensing data helped in identifying blocked river channels, while geotechnical analysis revealed slope instability zones. In Japan, the

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integration of InSAR data with borehole measurements improved earthquake damage predictions in soft soil regions.

BENEFITS AND CHALLENGES

The benefits include enhanced accuracy of hazard models, improved early warning systems, and better-informed decision-making. Challenges involve data incompatibility, high costs of field surveys, and the need for skilled personnel to interpret complex datasets.

CONCLUSION

The synergy between remote sensing and geotechnical data presents a transformative opportunity for disaster risk management. Future research should focus on developing cost-effective integration techniques, improving real-time data acquisition, and enhancing predictive models through AI and machine learning approaches.

Parameter	Remote Sensing Contribution	Geotechnical Contribution
Landslide Monitoring	Slope movement detection via InSAR	Soil shear strength and cohesion analysis
Flood Risk Assessment	Water spread mapping via SAR	Permeability and soil saturation measurements
Earthquake Damage Prediction	Surface deformation mapping	Subsurface soil stiffness and liquefaction potential

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