

# Stability Monitoring of Soil Slope via Big Data Technology in the Context of the Internet of Things

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## ABSTRACT

The stability of rock and soil masses has become increasingly critical due to large-scale expansion and landfilling, resulting in frequent landslides that pose significant threats to safety and property. Consequently, soil slope stability monitoring is essential. To mitigate slope instability risks, this study investigates soil slope stability monitoring using big data technology within the context of the internet of things. The research examines slope monitoring techniques and summarizes various methods for detecting slope deformation. By monitoring displacement and deformation, the operational status of slopes can be assessed, safety evaluated, disasters prevented, and adverse social impacts avoided. Collected geological data support the development of slope models, enabling analysis under different damage conditions. The findings indicate that 50% damage corresponds to a warning threshold, while 80% damage triggers an alarm. Simulation results show that slope stability increases with higher internal friction angle and cohesion but decreases as the slope angle increases.

## KEYWORDS

Soil Slope, Slope Stability, Internet of Things Background, Big Data

## INTRODUCTION

China's geology and landforms predominantly consist of hills and mountains, with mountainous regions comprising two-thirds of the country's total land area (Wang et al., 2022). A slope generally refers to a surface with a specific gradient formed by natural gravity or shaped by rock and soil processes. It represents a widely applied yet high-risk engineering structure. Slope instability in such formations can readily trigger severe landslides, leading to substantial loss of life and property (Das et al., 2022). Changes in slope stress create potential instability risks, which are easily exacerbated by heavy rainfall or seismic activity. However, the timing and location of such disasters are unpredictable. Therefore, research on slope stability holds critical importance for understanding landslide failures in engineering practice. It significantly contributes to preventing slope disasters, protecting lives and assets, and promoting societal stability (Scaringi & Loche, 2022).

This study presents a slope stability monitoring method based on big data technology. It incorporates "3S" technologies (remote sensing, geographic information systems, global positioning systems) and digital disaster reduction system technologies for data collection and analysis.

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Furthermore, it integrates internet of things (IoT) and cloud computing technologies to enable efficient processing of slope monitoring data (Nguyen & Likitlersuang, 2019; Zhang et al., 2018). Various scholars have also proposed a method combining ZigBee wireless sensor networks with BeiDou satellite communication for remote, real-time landslide monitoring (VandenBerge & McGuire, 2019). Within the context of big data, researchers have systematically developed an IoT and cloud computing integration framework for geological surveying (Alanis, 2018; Eid et al., 2018). These advancements offer innovative solutions for managing geological data and equipment, and have been applied to the construction of geological disaster monitoring systems for high-speed railway slopes (Liu et al., 2024).

This study integrates multi-source data—remote sensing imagery, ground survey data, and IoT sensor data—substantially enhancing the comprehensiveness and precision of slope stability assessments. It employs big data technology for the rapid processing and analysis of large-scale monitoring data, effectively identifying potential landslide risks and improving the speed and accuracy of early warnings (Mohamed et al., 2020). By incorporating machine learning algorithms, such as convolutional neural networks (CNNs), the study enables automated extraction and prediction of slope change trends, addressing the limitations of traditional methods in detecting subtle variations (Quan & Zhang, 2022). The real-time monitoring and early warning system developed from this framework triggers automatic alarms when slope displacement reaches a critical threshold, supporting timely protective actions and reducing disaster risk. This research not only advances slope monitoring technologies but also offers both theoretical and practical foundations for innovation in geological disaster prevention and control systems.

## **METHODS**

The proposed algorithm is based on the back propagation (BP) neural network model and integrates multiple feature extraction techniques with an adaptive learning rate adjustment strategy. Initially, the collected displacement data is standardized by removing outliers and imputing missing values to ensure data integrity. Key feature variables strongly associated with slope stability, such as node displacement and bolt damage degree, are then selected to enhance prediction accuracy. The BP neural network is subsequently trained on historical datasets, with cross-validation used to optimize model parameters and improve generalization. Finally, the trained model is applied to real-time data streams, dynamically updating predictions and issuing warning signals based on predefined thresholds, thereby supporting intelligent slope stability monitoring.

### **Theory of Slope Stability Monitoring**

Slope instability remains a prevalent challenge in contemporary engineering (Liu & Ge, 2022), yet it is difficult to address. This complexity arises from the influence of multiple factors, including engineering geology, topography, hydrogeological conditions, surface water, and geological structures. Common elements monitored in slope stability detection are presented in Table 1. According to relevant geological data, the depth of each soil layer within the excavation area must be determined. The soil types and primary design parameters are presented in Table 2.

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