remote sensing

Editorial

Overview of Comprehensive Risk Assessment Methods and Hazards Early Warning System for Geological Hazards in the Mountain Area

Chun Zhu [1,2,3], Yingze Xu [1], Zhigang Tao [2,4,*], Hong-Hu Zhu [5], Chen Cao [6] and Manchao He [1,4]

1 School of Earth Sciences and Engineering, Hohai University, Nanjing 210098, China
2 International Scientific and Technological Cooperation Base for Geological Disaster Prevention of Zhejiang Province, Shaoxing University, Shaoxing 312000, China
3 Badong National Observation and Research Station of Geohazards, China University of Geosciences, Wuhan 430074, China
4 State Key Laboratory for Geomechanics & Deep Underground Engineering, China University of Mining and Technology (Beijing), Beijing 100083, China
5 School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China
6 College of Construction Engineering, Jilin University, Changchun 130026, China
* Correspondence: taozhigang@cumtb.edu.cn

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1. Introduction

Many major projects are under construction in the mountain and surrounding areas. The monitoring, early warning and engineering prevention of debris flow, high-level landslides and collapse in alpine mountainous areas have always been a concern within scientific research and engineering. Due to the complex geological environment of the mountain area, geological hazards occur frequently, significantly impacting major projects. Therefore, it is urgent to systematically study the temporal and spatial distribution characteristics, development and evolution, risk assessment, monitoring and early warning of geological hazards in the mountain and surrounding areas.

This Special Issue aims at soliciting contributions within the scope of the comprehensive risk assessment methods and hazards early warning system of geological hazards on major projects in the mountain area. Potential research includes studies on geological hazards, such as landslides, collapse and debris flow, using remote sensing approaches (e.g., InSAR, optical remote sensing or UAV mapping), on-site engineering geological survey or real-time monitoring equipment. Since the launch of the Special Issue, a total of 39 well-known scholars have submitted their research work to this Special Issue. After strict quality screening, seven high-level papers have been published in the *Remote Sensing* journal, and the acceptance rate is 18%.

2. Special Issue Content

Gao et al. [1] established a unified model based on transfer learning for cross-regional DFSM to realize the rational use of debris flow sample resources and improve the modeling efficiency. First, samples with 10 features collected from two debris flow-prone areas were separately used to perform factor prediction ability analysis (FPAA) based on the information gain ratio (IGR) method and then develop traditional machine learning models based on random forests (RF). Secondly, two feature matrices representing different areas were projected into a common latent feature space to obtain two new feature matrices. Then, the samples with new features were used together for FPAA and developing a unified machine learning model. Finally, the performance of the models was obtained and compared based on the area under curves (AUC) and some statistical results. All the conditioning factors played different roles in debris flow prediction in the two study areas, based on which two traditional and unified models were established. The unified model based on feature transferring realized efficient cross-regional modeling, solved the unconvincing problem of limited sample modeling, and enabled more accurate identification of some debris flow samples.

Zhan et al. [2] established an early identification framework for regional potential rockfall sources applicable to the canyon region and to assess rockfall hazards in potentially hazardous areas using unmanned aerial vehicle (UAV) photogrammetry. Specifically, by incorporating high-precision topographic information and geotechnical properties, the slope angle distribution method was used for static identification of potential rockfall sources. Moreover, SBAS-InSAR technology was used to describe the activity of potential rockfall sources. Finally, taking the key potentially hazardous area of the Sky City scenic spot as an example, the Rockfall Analyst tool was used to analyze the rockfall frequency, bounce height and energy characteristics based on the high-precision UAV 3D real scene model, and the analytic hierarchy process was introduced to achieve quantitative rockfall hazard assessment. The results show that the potential rockfall source areas in the Taihang GCSA is 33.47 km^2 (21.47%), mainly distributed in strips on the cliffs on both sides of the canyon active rockfall source area is 2.96 km^2 (8.84%). Taking the scenic spot of Sky City as an example, the proposed UAV-based real-scene modeling technology was proven to quickly and accurately construct a 3D high-precision model of the canyon area. Moreover, the 3D rockfall simulation showed that the high-energy rockfall area was mainly distributed at the foot of the steep cliff, which mainly threatens the tourist distribution center below. The early identification and quantitative evaluation scheme of rockfall events proposed in this study can provide technical reference for preventing and controlling rockfall hazards in similar alpine valley areas.

Ling et al. [3] investigated the influence of the uncertainty in the water table level on the benefit of considering such uncertainty in slope reliability analysis. For this purpose, a new method, i.e., a dynamic whale optimization algorithm (WOA)–Gaussian process regression (GPR) agent model using uniform design considering uncertainty in the groundwater level, is proposed for slope probabilistic analysis. Then, the developed technique is integrated with Monte Carlo Simulation (MCS) to obtain the slope failure probability. The benefit of the proposed method is illustrated through two practical landslides. The results demonstrate that the developed technique performs better than MCS, the v-support vector machine (v-SVR) and the generalized regression neural network (GRNN). This may be attributed to the dynamic updating of the training samples provided by the uniform design, the optimal hyper-parameters optimized by WOA or the GPR model that has strong generalization ability with limited samples. Furthermore, a small failure probability is obtained without considering the groundwater level uncertainty, which offers an optimistic estimate of landslide stability. Therefore, it is necessary to consider the probabilistic features of the groundwater level, especially for complicated landslides in high mountainous areas where the location of the water table level is not accurately available due to their inaccessibility to people and instruments.

Ding et al. [4] took a typical slope in the Dongsheng quarry in Changchun City as an example; in this study, we obtained the discontinuity data of the slope based on digital close-range photogrammetry, which greatly enlarged the sample size of discontinuity data and improved the data quality. Based on the rock mass's heterogeneity, the optimum discontinuity spacing threshold was determined when surveying lines were laid parallel to different coordinate axes to calculate the generalized RQD, and the influence of measuring blank areas on the slope caused by vegetation coverage or gravel accumulation was eliminated. The real generalized RQD of the rock mass was obtained after eliminating the influence of blank areas. Experiments showed that, after eliminating the influence of blank areas, the generalized RQD of the slope rock mass more truly represented the complete rock mass quality and offered a new idea for the quality evaluation of engineering rock mass.

Sun et al. [5] used InSAR technology and a field geological survey to map the landslides. Then, the curvature watershed method was used to divide the slope units. A conditioning factor system was established, reflecting the characteristics of the rapid uplift and vertical rainfall distribution in the study area's unique geological environment. Finally, logistic regression, random forest and artificial neural network models were used to establish the landslide susceptibility model. The results show that the random forest model is optimal for the landslide susceptibility mapping in this area. Additionally, the area percentages of the very low, low, moderate, high and very high susceptibility classes were 40.13%, 20.06%, 13.39%, 12.55% and 13.87%, respectively. Based on the analysis of the landslide susceptibility map, we suggest that the landslide geological hazards resulting from the rapid uplift of the Tibetan Plateau and the significant decrease in sea level during a glacial period in the upper reaches of the Jinsha River are controlled by the double disaster effect of the geodynamic system. Consequently, this study can guide local prevention and mitigation.

Zhang et al. [6] analyzed the deformation characteristics and disaster prediction model of the Fengning granite rockslide based on field surveys and monitoring data. To evaluate the stability, the shear strength parameters of the sliding surface were determined based on the back-propagation neural network and three-dimensional discrete element numerical method. The correlation analysis of deformation monitoring results with rainfall and blasting shows that the landslide was triggered by excavation, rainfall and blasting vibrations. The landslide displacement prediction model was established using a long short-term memory neural network (LSTM) based on the monitoring data. The prediction results are compared with those using the BP, SVM and ARMA models. Results show that the LSTM model has strong advantages and good reliability for the stepped landslide deformation with short-term influence. The predicted LSTM values were very consistent with the measured values, with a correlation coefficient of 0.977. Combined with the distribution characteristics of joints, the damage influence scope of the landslide was simulated by a three-dimensional discrete element, which provides a decision-making basis for disaster warning after slope instability. The method proposed in this paper can provide references for early warning and treatment of geological disasters.

As an example, Song et al. [7] took a jointed rock slope in Hengqin Island, Zhuhai, and established a three-dimensional (3D) model of the studied slope by digital close-range photogrammetry to rapidly interpret 222 fracture parameters. Meanwhile, a new Floyd algorithm for finding the shortest path was developed to realize the critical slip surface identification of the studied slope. A sequence of cross-sections was placed within the 3D fracture network model created using the Monte Carlo method. These cross-sections containing fractures were used to search for the shortest paths between the designated shear entrances and exits. For anyone combination of entry and exit points, the shortest paths corresponding to different cross-sections are different and cluttered. For safety and convenience, these shortest paths were simplified as a circular arc regarded as a potential slip surface. The fracture frequency was used to determine the probability of sliding along a prospective critical slip surface. The potential slip surface through the entrance point (0, 80) and exit point (120, 0) was identified as the final critical slip surface of the slope due to the maximum fracture frequency.

3. Closing Remarks

The papers presented in the Special Issue cover important aspects of the latest research progress in risk assessment and early warning of geological hazards. Even if geological hazard risk assessment and early warning is an extensive topic, this small contribution could stimulate the community to develop current research and improve its progress. Therefore, we believe the presented papers will have practical importance for future development in the geological hazards risk assessment and early warning sector. Finally, together with other co-Guest Editors, Prof. Zhigang Tao, Prof. Honghu Zhu, Dr. Chen Cao and Prof. Manchao He, we wish to thank the authors that contributed with their works to this Special Issue.

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