Postprint: An Automated Wide-Area Landslide Hazard Risk Assessment Method Integrating InSAR, Large Vision Models, and GIS Spatial Analysis

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Abstract

Precise identification and risk assessment of landslide hazards are critical for landslide disaster prevention and mitigation. However, current engineering practices primarily rely on visual interpretation of remote sensing imagery and expert field identification, which limits work efficiency. Interferometric Synthetic Aperture Radar (InSAR) technology can detect millimeter-level surface deformation and is currently widely applied for rapid localization of regional landslide hazards. This study selected Zhouqu County, Gansu Province as the test area. Based on Sentinel-1 satellite imagery from 2017-2023, Stacking-InSAR technology was employed to obtain the surface deformation field of the region. A multi-scale feature fusion network based on gating mechanisms was used to automatically identify landslide hazards detected by InSAR and associated elements. Addressing the characteristic that landslide disasters typically occur in the sliding zone rather than the initiation zone, this paper constructed a landslide hazard sliding zone algorithm that considers surface deformation characteristics to simulate the potential disaster extent of landslides. On this basis, following disaster system theory, a landslide hazard risk assessment index system was constructed from three aspects: hazard-inducing factors, disaster-forming environment, and hazard-bearing bodies. Through multi-source remote sensing data-driven approaches and utilizing geographic information spatial analysis technology, the risk of landslide hazards was comprehensively evaluated. A total of 53 landslide hazards were identified in Zhouqu County, with the majority being medium-to-low risk. Specifically, there were 3 high-risk, 4 relatively high-risk, 11 medium-risk, 18 relatively low-risk, and 17 low-risk hazards. Field verification confirmed the accuracy of the algorithm in hazard location identification and risk level classification. This study constructed an automated risk

assessment methodology system for regional landslide hazards that integrates InSAR deformation monitoring, artificial intelligence target recognition, and GIS spatial analysis technology. This system significantly improves the efficiency and accuracy of early identification and risk assessment of landslide disasters, providing scientific and efficient technical support for regional landslide disaster risk management and emergency response.

Full Text

Preamble

An Automated Regional-Scale Landslide Hazard Risk Assessment Method Integrating InSAR, AI Visual Foundation Models, and GIS Spatial Analysis

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Abstract

Precise identification and risk assessment of landslide hazards are critical for disaster prevention and mitigation efforts. However, current operational practices primarily rely on visual interpretation of remote sensing imagery and expert field surveys, which imposes significant limitations on work efficiency. Synthetic Aperture Radar Interferometry (InSAR) technology, capable of detecting millimeter-level surface deformation, has been widely applied to rapidly locate regional-scale landslide hazards.

This study selected Zhouqu County, Gansu Province as the experimental area. Using Sentinel-1 satellite imagery from 2017–2023, we employed Stacking-InSAR technology to obtain the regional surface deformation field and utilized a gated multi-scale feature fusion network to automatically identify landslide hazards and associated elements from InSAR detections. Considering that landslide disasters typically occur in sliding zones rather than initiation zones, we constructed a landslide hazard sliding zone algorithm that incorporates surface deformation characteristics to simulate potential landslide disaster ranges. Following disaster system theory, we established a landslide hazard risk evaluation index system encompassing three aspects: hazard factors, disaster-formative environment, and hazard-bearing elements. Driven by multi-source remote sensing data, we comprehensively evaluated landslide hazard risk using geographic information system (GIS) spatial analysis techniques.

In Zhouqu County, a total of 53 landslide hazards were identified, predomi-

nantly classified as medium-to-low risk: 3 high-risk, 4 relatively high-risk, 11 medium-risk, 18 relatively low-risk, and 17 low-risk hazards. Field verification confirmed the algorithm' s accuracy in both hazard location identification and risk classification. This study constructs an integrated automated risk assessment methodology for regional-scale landslide hazards that combines InSAR deformation monitoring, AI target recognition, and GIS spatial analysis technologies. This approach significantly improves the efficiency and accuracy of early landslide identification and risk assessment, providing scientific and efficient technical support for regional landslide disaster risk management and emergency response.

Keywords: InSAR; deformation accumulation zones; landslide; artificial intelligence; risk assessment

Note: Figure translations are in progress. See original paper for figures.