Challenges in GNSS-based deformation monitoring

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The usability evaluation and data processing methods of GNSS deformation monitoring in challenging environment

With the continuous and increasingly in - depth application of Global Navigation Satellite System (GNSS) deformation monitoring technology, it becomes necessary to set up some monitoring points in challenging environments. These include areas close to buildings, and under trees. In such demanding settings, GNSS satellite signals are severely obstructed. This obstruction gives rise to the multipath effect, frequent diffraction, and cycle slips. These factors not only significantly degrade the quality of GNSS observation data but also present difficulties and challenges for high - precision GNSS deformation monitoring. To assess the usability of GNSS deformation monitoring in these environments, this paper first puts forward a data quality assessment method that takes into account the spatiotemporal distribution characteristics of data quality indicators. Subsequently, a comprehensive evaluation model for GNSS data quality, based on the modified VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), is established. This model serves as a basis for evaluating the applicability of GNSS technology. Moreover, an outlier processing method based on random sample consensus and partial ambiguity resolution is introduced to conduct a comparative analysis of the accuracy of different strategies. Finally, the results of monitoring projects for a tree-obstructed landslide demonstrate that when the environmental complexity is below 46%, an accuracy of less than 2.5 cm can be achieved. At complexity levels below 70%, the accuracy remains better than 4.0 cm. These results confirm the feasibility and effectiveness of the comprehensive evaluation model.

Keywords: Challenging environments, GNSS, Deformation monitoring, Data quality analysis

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Challenges and limitations in geodetic monitoring of landslides, case-study of Viella (Pyrenees mountains) and La Valette (Southern Alps), France

To better understand the kinematics of landslides in mountainous areas, permanent GNSS receivers and reflectors monitored by an automated total station are sometimes installed. The challenge is to describe the surface displacements as accurately as possible with an adequate observation rate (from a few seconds to 1 or 2 hours or more). After a brief review of the methods and equipment used to reduce measurement errors, such as atmospheric refraction, instability of some reference points outside the sliding zone, etc., we describe the processing of terrestrial and GNSS data from two monitored landslides in the Pyrenees (Viella site) and the Southern Alps (La Valette site).

Keywords: Landslide monitoring, Total station, GNSS

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Low-Cost GNSS Ground Monitoring for Land Planning: AI-Integrated Geospatial Solutions

In today's landscape, both natural and man-made features are highly sensitive to millimetric perturbations from land deformation and daily operational activities. However, continuous, automated, and remote monitoring systems are often unavailable or too costly for widespread use. AIPLAN aims to address this gap by safeguarding critical infrastructure through cost-effective solutions. AIPLAN integrates geodetic engineering, Global Navigation Satellite Systems (GNSS), and Synthetic Aperture Radar (SAR) for land deformation. The project focused on creating a cloud-based platform with Real-Time Kinematic (RTK) algorithms for high-precision deformation measurements and employing AI/ML analysis for comprehensive data processing from GNSS. The key innovation of AIPLAN is the development of a deployable system using low-cost GNSS devices, moving away from expensive survey instruments. The AIPLAN device is a compact, cost-effective, high-precision multi-sensor GNSS receiver package, integrating control boards, multi-constellation GNSS chipsets, Inertial Measurement Units (IMU), and IoT modules. It is designed to measure sub-centimetre movements and vibrations in various modes, including RTK and Network

RTK. The project also developed a machine learning system to enhance the accuracy and reliability of low-cost GNSS devices. Filtering techniques and AI algorithms improved data precision. Calibration was performed using corner reflectors, GNSS survey control markers, and geodetic-grade GNSS receivers. The prototype was deployed at a test site, and the 18-month project included testing and validation. Monitoring scenarios on railway tracks, landslide-prone areas, and controlled sites demonstrated AIPLAN's effectiveness and efficiency, making it a valuable tool for infrastructure protection.

Keywords: Low Cost, GNSS, Monitoring