Enhanced deformation monitoring by means of data fusion II

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HeMOC: a Project for Monitoring of Cultural Heritage in the City of Como, Italy

In the second half of 1900 the city of Como has been intensely affected by land subsidence, especially in the "Convalle" historical area near the lake. Its effects may cause concerns to the conservation and safety of cultural heritage (CH) buildings located in the city centre. Supported by funding from the NextGenEU program, the HEMOC ("HEritage MOnitoring in Como") project has main objective to design and implement a network of seven new permanent GNSS stations. These stations are based on low-cost GNSS technology, which allows continuous 3D observation for monitoring CH sites in town. GNSS-based observations are integrated with in-situ monitoring data and will be used to calibrate ground-deformation maps obtained from Advanced DInSAR processing of high-resolution CosmoSkyMed data. The results of the monitoring sensors are implemented in a digital platform for data storage and visualization.

Keywords: Cultural Heritage, GNSS, InSAR, Monitoring

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Classifying surface displacements in mining regions using differential terrain models and InSAR coherence

This study focuses on classifying height differences in the area of the Marcel mine in the Upper Silesian Coal Basin, using UAV photogrammetry, UAV laser scanning, and InSAR coherence data. The Random Forest (RF) algorithm was selected for this purpose. The RF classifier used features calculated based on the digital terrain model of differences, InSAR coherence data, digital terrain, and surface models with their derivatives. Besides the 6-day coherence to capture temporal coherence variability, key statistical parameters of the time series were calculated. The model achieved an accuracy of 79% and an F1-score of 81%, effectively distinguishing mining-related displacements from other classes. The results indicate that incorporating InSAR coherence improved the separation of classes, but certain limitations, such as data resolution and the temporal similarity of features, suggest the need for further research.

Keywords: DoD, InSAR coherence, Random Forest classification, UAV photogrammetry, UAV laser scanning

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Ensembling satellite monitoring and numerical cartography towards the safety assessment of infrastructures

This paper explores new technologies that can advance the state-of-the-practice in safety assessment and health monitoring of existing infrastructures. In this context, Multi-Temporal interferometric Synthetic Aperture Radar techniques combined with the use of digital models of infrastructures represent a powerful integration to conventional approaches in the monitoring and assessment of structural safety of infrastructures. Although the interferometric method is widely used for ground deformation investigations, using displacement data from satellite observation in structural monitoring is less investigated. The joint use of multi-frequency satellite radar data provided by the European Space Agency Copernicus project and Italian Space Agency will be explored. The paper introduces the workflow implemented for processing satellite radar data from the X-band COSMO-SkyMed constellation by the Italian Space Agency over the unicipality of Modena (Italy). An open-source workflow based on Multi-Temporal Interferometric technique and Persistent Scatterers Interferometry is adopted, enabling the detection of displacements of stable targets and the generation of corresponding time series. Radar data products, derived from the processing of both COSMO-SkyMed and Sentinel-1 data, are analyzed in a Geographic Information System alongside the available geospatial dataset of infrastructures. This approach enables the extraction of displacement components related to the ground and infrastructures. The method's potential for characterizing infrastructures behaviour is assessed through the analysis of selected case studies. The results aim to establish the foundations for a method capable of assessing infrastructure safety.

Keywords: Persistent Scatterer Interferometry, Numerical cartography, Infrastructure safety assessment

D. Tondas

An open-source Python library developed for GNSS & InSAR integration

The unification of GNSS (Global Navigation Satellite System) and InSAR (Interferometric Synthetic Aperture Radar) observations is a sophisticated procedure due to their different spatio-temporal characteristics, including discrepancies in spatial and temporal resolution, measurement geometries, environmental constraints, and sensitivity to deformation components. Effective long-term ground deformation monitoring requires a comprehensive three-dimensional displacement vector, particularly addressing the north-south component, where InSAR has lower sensitivity. Moreover, the integration algorithm must be scalable and capable of ingesting non-linear ground movements to support an automated and robust deformation monitoring system. Hence, the integration procedure demands advanced methodologies that reconcile discrepancies and ensure consistency while leveraging the complementary strengths of GNSS and InSAR.
This paper introduces an original, open-source Python library designed for the seamless integration of GNSS and InSAR data. The library addresses all the aforementioned challenges, enabling the fusion of permanent GNSS observations with InSAR radar data for reliable and long-term ground deformation monitoring. The library extends the existing approach of integrating geodetic techniques by supporting simultaneous application of three InSAR computational techniques: DInSAR (Differential InSAR), SBAS (Small BAseline Subset), and PSI (Persistent Scatterer Interferometry). Furthermore, the radar observations can be derived from three independent orbits, with the flexibility to incorporate up to nine elements (pixels or PSI points) per computational method. The core of the library relies on the Kalman filter algorithm, which generates a time series of six calculated parameters (three North, East, Up components and their velocities).

Keywords: GNSS, InSAR, Ground deformations, Data integration, Open-source Python library