InSAR for deformation monitoring

Tuesday, 08.04.2025, 08:30 - 10:00, Room Haller

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Temporarily Coherent Scatterer Selection for Transport Infrastructure Monitoring with Sentinel-1 InSAR

Interferometric Synthetic Aperture Radar (InSAR) time series analysis enables cost-effective and long-term structural health monitoring of transport infrastructures. However, existing time series methods require the signal of a scatterer to remain coherent over the whole study period to estimate its displacement. With increasing operation time of Sentinel-1 less scatterers are continuously coherent, while the number of temporarily coherent scatterer (TCS) increases. Identifying the time interval TCS are valid at transport infrastructures is key for continuous monitoring. In this study we analyse state-of-the-art TCS detectors in the context of transport infrastructure monitoring and compare the approach for point-like scatterer (PS) pixels based on the amplitude time series with the approach for distributed scatterer (DS) pixels based on the structure of the coherence matrix. We provide a case study for an area west of Alicante, Spain, including demolished and reconstructed highway and bridge to evaluate the methods' performance on a Sentinel-1 stack covering the period from 2014 to 2024. Our results show that the change detected from the amplitude does not necessarily align with the coherent period of the infrastructure. The approach based on the coherence matrix outperforms the amplitude-based method, however at the cost of spatial resolution and computational time.

Keywords: InSAR, Temporarily coherent scatterer, Change detection, Transport infrastructure

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Detecting Change Points in Time Series of InSAR Persistent Scatterers Using Deep Learning Models

Accurately detecting significant changes in the Earth's surface is essential for timely intervention. As one of the key techniques in Interferometric Synthetic Aperture Radar (InSAR), Persistent Scatterer Interferometry (PSI) generates time series data of Persistent Scatterers (PS), which are stable points on the Earth's surface that enable precise displacement measurements over time. While many studies have focused on statistical methods for identifying anomalies in PS time series, few have explored the potential of deep learning for change point (CP) detection. A major challenge with supervised deep learning is the need for large labeled datasets. To overcome this, we implemented a simulation algorithm to generate an extensive set of PS points with corresponding target CPs, reflecting the statistical characteristics of PS time series. To identify changes in slope and intercept, We used two deep learning models: Bidirectional Long Short-Term Memory (BiLSTM), designed for time series data, and U-Net, developed for image data. A spectral analysis technique is applied to remove seasonal components from the time series data before feeding into the networks. The models were evaluated using metrics such as accuracy, F1-score, precision, and recall, and were compared to a Bayesian-based approach. Additionally, the methodology was applied to real PS time series from a study area in Germany. We analyzed the detected CPs along with the neighboring PS time series within a 15-meter radius. The results indicated that the deep learning models outperformed the Bayesian approach in terms of precision, recall, and F1-score with simulated PS time series, highlighting their potential for precise CP detection. Furthermore, the models demonstrated their effectiveness when applied to the real PS time series.

Keywords: InSAR, Change point detection, Persistent scatterers time series, Deep learning

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Mapping building differential deformations over wide areas

SAR interferometry is an active remote sensing technique for measuring and monitoring land deformation. The European Ground Motion Service (EGMS), which is part of the Copernicus Land Monitoring Service, makes use of SAR interferometry to derive consistent and annually updated information about ground displacements related to both natural and anthropogenic phenomena. The EGMS policy is providing its products free of charge. This open new prospectives to fully exploit SAR interferometry data at continental European scale. We propose in this paper a procedure that exploits the EGMS products to derive the differential displacements of buildings and urban structures. The proposed procedure facilitates the generation of a differential deformation map for individual buildings by computing spatial gradient of deformation for each building and then classify them into distinct classes according to their gradient values. The procedure has been illustrated considering the town of Torremolino (Spain). In this case study, using the Basic product of EGMS, a differential deformation map has been generated. In addition, three additional maps have been produced by considering this multisource data: deformation velocity, age of buildings and population density of the study area. These three maps, called ground deformation intensity map, potential damage intensity map and potential impact map, can provide useful information related to the health of buildings, structures and infrastructures and, supporting the associated decision-making.

Keywords: EGMS, Deformation, Differential deformation, Spatial gradient, Building damage

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Joint Use of EGMS and Cosmo-SkyMed InSAR for Assessment of Ground and Structural Deformations: The Case of Como, Northern Italy

Urban ground deformation poses significant risks to structural stability and infrastructure resilience, necessitating advanced monitoring techniques. This study evaluates two critical structural deformation parameters—maximum lowering rate and maximum differential settlement—using Interferometric Synthetic Aperture Radar (InSAR) measurements from COSMO-SkyMed (CSK) and Sentinel-1 (EGMS Level 2b) datasets in Como town, Northern Italy, over the period January 2016 to December 2021. CSK data were processed using Multi-Temporal InSAR (MT-InSAR) techniques, while Sentinel-1 deformation velocities were extracted directly from the European Ground Motion Service (EGMS) portal. A specific geospatial approach was employed to mitigate the impact of localized deformations and simplify single-building analyses without requiring computationally intensive processing steps. The comparison between CSK and EGMS datasets revealed a reasonable level of agreement, demonstrating their complementary strengths in deformation monitoring. Results indicate that 33 buildings were subject to significant lowering rates, while 99 buildings exhibited notable differential settlement. These findings underscore the utility of integrating high-resolution datasets for comprehensive urban deformation assessments. This research contributes to the growing body of knowledge on urban geohazard assessment by highlighting the efficacy of InSAR technologies in structural condition monitoring. The insights gained from this study are expected to inform future applications of InSAR for structural and infrastructure condition assessment and monitoring.

Keywords: Structural Monitoring, InSAR, EGMS, Cosmo-SkyMed, Como