Detecting change points in time series of InSAR persistent scatterers using deep learning models

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Abstract

Accurately detecting significant changes in the Earth's surface is essential for timely intervention. As a 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 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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