ABSTRACT

Displacement Forecasting in Mining Areas using Satellite SAR Interferometry and Machine Learning

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Underground mining activity has a significant impact on the ground surface, which is manifested as ground surface displacement that poses a threat to civil infrastructure. Monitoring and forecasting of ground deformation caused by mining activities is crucial for effective planning of mining operations and reducing their impact on the surface. In recent years, the method of satellite-based SAR interferometry (InSAR) has been applied to the measurement of displacements in mining areas due to its high spatial and temporal resolution. This method can provide a considerable amount of data on ground surface movements. Machine learning methods are being applied in a growing number of fields due to their effectiveness in processing large data sets, finding patterns in the data and exploring hidden relationships in the data.

The dissertation investigated the application of vertical ground surface displacement measurements by InSAR methods in an underground mining area to create data-driven machine learning models. These models were adapted to forecast future displacement values by using historical displacement data in time series forecasting. The research was carried out in the Legnica-Głogów Copper Belt area, where underground mining of copper ores is carried out, affecting the ground surface.

InSAR time series processing methods: the Persistent Scatterer InSAR (PSInSAR) method and the Small Baseline Subset (SBAS) method, were used in the analysis of satellite radar imagery to measure the time course of displacements in the study area for the period from 20 May 2016 to 26 October 2020. In addition, a transformation of displacements from acquisition geometry of satellite data to vertical and horizontal displacement geometry was performed using satellite data acquired from two orbits. The vertical displacement values measured by remote sensing method were verified with the obtained levelling data.

The study further investigates the application of selected statistical methods, machine learning algorithms and neural networks, used in time series forecasting, to create predictive models based on InSAR measurement data. The research focused on the potential of using machine learning models as global data-driven models, trained on datasets of time series with similar characteristics. The study showed that global machine learning models outperformed baseline methods by up to 45%. The model with the highest forecast accuracy was the Ensemble model using a set of regression models.

The results of interdisciplinary research carried out in the dissertation are a contribution to the understanding of the processes occurring on the surface as a result of underground mining operations. The developed models can be used to predict surface displacements, providing a tool to support decision-making processes in planning mining operations.

Keywords: ground surface displacement, subsidence, mining area, satellite SAR interferometry, machine learning, neural networks, time series forecasting

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