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Landslide displacement forecasting using deep learning and monitoring data under different slope conditions

Ascanio Rosi[1], Lorenzo Nava[1], Edoardo Carraro[2], Cristina Reyes-Carmona[3], Silvia Puliero[1], Kushanav Bhuyan[1,4], Oriol Monserrat[5], Mario Floris[1], Sansar Raj Meena[1,4], Jorge Pedro Galve[3], and Filippo Catani[1]

[1]Machine Intelligence and Slope Stability laboratory, Department of Geosciences, University of Padova, Padua, Italy
[2]Geomorphological Systems and Risk Research, Department of Geography and Regional Research, University of Vienna, Universitätstraße 7, 1010 Wien, Austria
[3]Departamento de Geodinámica, Universidad de Granada, Avda. del Hospicio, s/n, 18010 Granada, Spain
[4]Centre for Disaster Resilience, Department of Applied Earth Sciences, Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, 7514 AE Enschede, the Netherlands
[5]Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Geomatics Research Unit, Barcelona, Spain

Accurate landslide early warning systems are a trustworthy risk-reduction method that may greatly minimize human and economic losses. Several machine learning algorithms have been investigated for this goal, underlying the impressive potential in prediction capability of Deep Learning (DL) models. Despite this, the only DL models evaluated so far are the long short-term memory (LSTM) and Gated Recurrent Unit (GRU) algorithms. Several alternative DL algorithms, however, are appropriate for time series forecasting problems. In this research, we evaluate, analyze, and present seven DL approaches for the forecasting of landslide displacement: LSTM, 2xLSTM, bidirectional LSTM (Bi-LSTM),Multilayer perception (MLP), 1D convolutional neural network (1D CNN), GRU, and an architecture build of 1D CNN and LSTM (Conv-LSTM). The study examines four different landslides with varying geographical locations, geological conditions, time step size, and measuring devices. Two landslides are placed in an artificial reservoir scenario, whereas the other two are affected only by rainfall. The findings show that the MLP, GRU, and LSTM models can produce accurate predictions in all four situations, with the Conv-LSTM model outperforming the others in the Baishuihe landslide, which is extremely seasonal. There are no discernible variations in performance between landslides within and outside constructed reservoirs. Furthermore, the study finds that MLP is better suited to forecasting the largest displacement peaks, whilst LSTM and GRU are better suited to forecasting smaller displacement peaks. We feel that the outcomes of this study will be extremely beneficial in developing a DL-based landslide early warning system (LEWS).