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ARTIFICIAL NEURAL NETWORK APPROACH TO PROVIDE FAILURE PRECURSORS IN JOINTED ROCK MASS AT THE ACUTO FIELD LAB

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Purpose: Strain effects on jointed rock masses to the action of environmental (and specifically thermal) stressors, to be seen as preparatory factors of possible failures, is up today relevant topic in view of strategies for prediction of rock block instabilities. These strategies that can be implemented are among the most different, but when long monitoring time series are available, innovative machine learning represent useful tools to achieve this goal. For this purpose, data from the multi-parametric monitoring system operating in the Acuto Field Lab (central Italy) were treated following artificial neural network (ANN) approaches able to detect correlation between dependent and independent variables and support the inference of the cause-to-effect relationship between forcing actions and induced deformations before the ultimate failure.

Methods: The Acuto Field Lab, managed by the Earth Sciences Department of "Sapienza" University of Rome, has been operating since 2015 in an abandoned limestone quarry. The multi-parametric monitoring system, set to an acquisition timestep of 1 minute and consisting in a fully equipped weather station, a thermocouple on rock and strain gages, has been installed on 20m3 rock block prone-to-fall. Starting from the already acquired six years monitored time series, an ANN analysis has been performed to recognise out of range deformations (i.e., potentially plastic) cumulated daily as effect of thermal cycles. A training, test and validation datasets were composed of day-by-day rock mass thermal excursion and the related daily strain. About the latter was verified whether its elastic nature, basing on theoretical deformation range based on the suffered thermal excursion and rock linear thermal expansion coefficient of the material, or non-expected (i.e., potentially plastic) strain, when higher or lower than the expected elastic deformation value was registered. A valuable set of environmental potential stressors was associated with the training dataset. It was composed of temperature range calculated the air and rock matrix considering over different moving time windows, the excursion of both maximum and minimum temperatures, air humidity vs. dew point, rainfall, wind intensity.

Results: The ANN was designed to distinguish elastic or plastic rock mass deformation and to discriminate the most significant environmental stressors acting on the jointed rock mass. The classification resulted in a very high-quality performance, with precision and accuracy of about 80% and AUC of 0.87. A Feature Importance Analysis made it also possible to identify the most relevant environmental features. Partial dependence plots allowed to study the relationship between the feature values and the classification obtained.

Conclusions: The instrumentation installed in the Acuto Field Lab offers the opportunity to collect in real-time a large amount of multiparametric data. Our preliminary analysis demonstrates that such instrumental measures set, characterised by high precision and high temporal frequency, represents an optimal application context for machine learning approaches and big data analysis. The results highlight a promising perspective on using neural network methods to systematically investigate the effects of environmental stressors on joint rock mass contexts. These results also represent a valuable starting point toward the implementation of real-time deformation forecasting systems based on IoT technologies.