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3D predictive fragmentation model using artificial neural network in Los Bronces deposit

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ABSTRACT

Introduction: drilling and Blasting (D&B) is a critical task in the mining extraction process and considered the first mineral processing step. The D&B results are essential for several downstream activities, such as loading and transporting the ore. Also, D&B plays a critical role in the energy consumption of the comminution process. A key variable from the D&B process is the particle size distribution after blasting (PSD), expressed as the passing size associated with the distribution percentiles.

To model the PSD, the current approach is a two-step procedure known as the Kuz-Ram model. The first step estimates the mean size of the rock fragments using the Kuznetsov model and then predicts the fragment size distribution with the Rosin- Rammler equation. The first step uses blasting variables (explosive mass per drill, relative weight strength of the explosive, rock volume broken per hole) and a rock factor that accounts for rock properties (density, mechanical strength, elastic properties, and structure). The second step models the PSD using a Weibull distribution, with parameters inferred from D&B design parameters such as burden, spacing, bench height, and charge length.

Methodology: the D&B process has similar components to any mineral processing task: the intrinsic rock properties, the control parameters, and a set of results. Unlike comminution or flotation, the blasting process lacks a small-scale test to predict the fragmentation in a 3D context; however, the D&B area generates a geo-referenced PSD database from photographs of the fragmented rocks and the blasting parameters. Additionally, 'Los Bronces' has over 30 geo-scientific variables from the geological, geotechnical, geomechanical and geometallurgical 3D models.

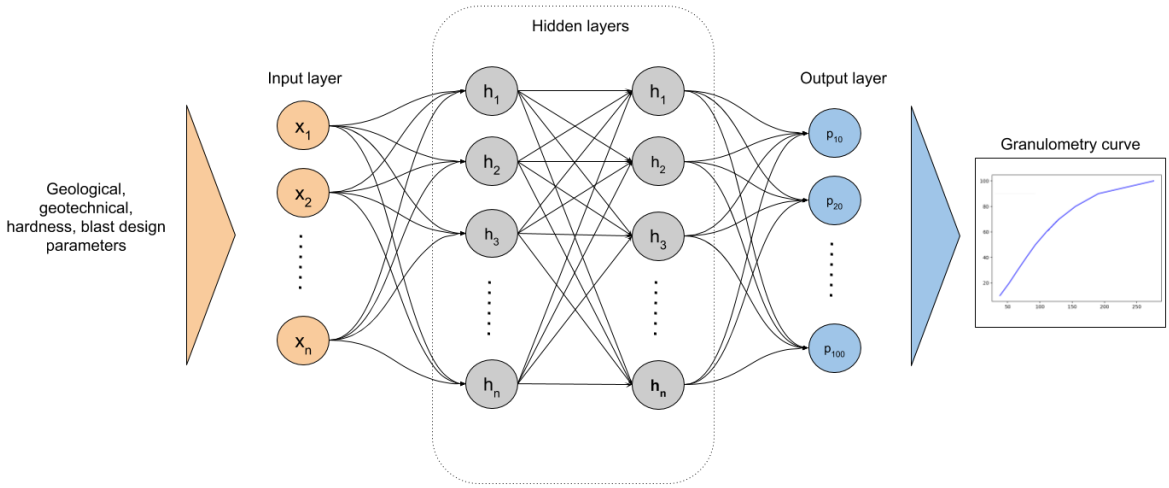

Figure 1 Artificial Neural Network diagram

Given the D&B database and the 3D models, this study presents a 3D predictive model of the complete PSD using an artificial neural network (ANN) based on geological, geometallurgical, geotechnical variables, and PSD data for a set of blasting design parameters (**Figure 1**). The model setup starts with the training, which uses historical data, calibration, and a final model using the entire data set. To validate the model a cross-validation was performed, with excellent results as shown in Figure 2 for three PSD curves comparing real PSD against predicted.

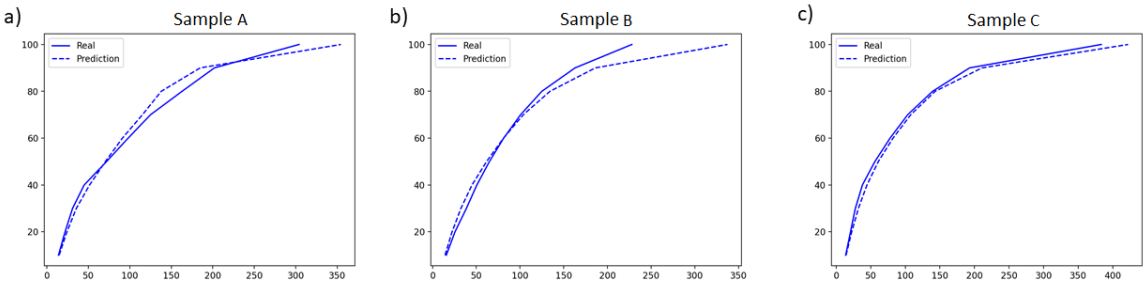

Figure 2 Cross validation results showing the predicted (dotted line) and real PSD (fill line) for three samples

Results and conclusion: the blasting parameters are assigned in the target locations of the block model to predict the PSD by the trained ANN, under the current blasting design criteria, providing a local 3D model of the PSD which is consistent with the training data (Figure 2). Additionally, a confidence metric of the prediction is provided as part of the modelling.

The study illustrates the potential benefit and use of the ANN or non-phenomenological approaches for fragmentation modeling. It also highlights the cautions and proper validations for this type of model to ensure predictability and coherence in the geological-mining context.

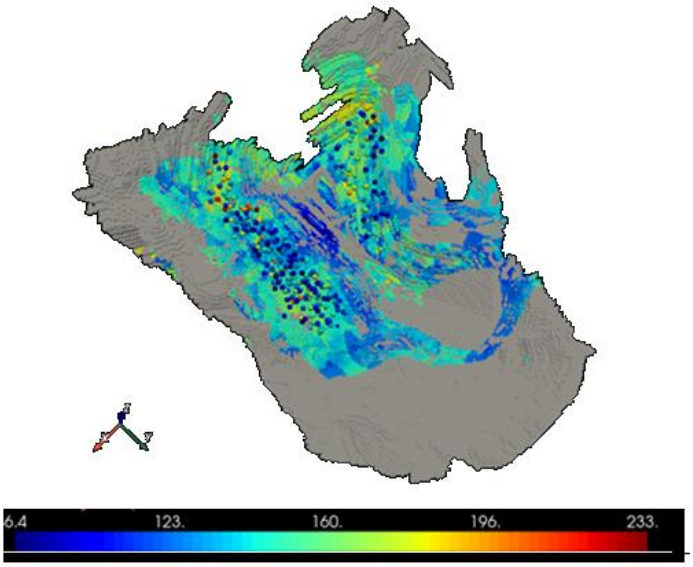

Figure 3 3D P80 prediction using ANN and training data