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ORIGINAL PAPER

Predicting Rock Hardness Using Measurement While Drilling (MWD) Data in a Case Study of Rotary Drilling in an Open-Pit Mine

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Abstract Rock hardness significantly impacts drilling performance and costs. Direct field measurement is challenging, so indirect methods using drilling data have been developed. Measurement while drilling (MWD) records parameters like weight on bit, torque, and penetration rate, which reflect rock properties and conditions. This paper presented a novel approach to predict rock hardness using MWD data, machine learning, and Azure's Data Factory and Databricks services, utilizing Spark techniques. A large MWD dataset from the Sarcheshmeh mine was processed to extract relevant features. Machine learning models, including random forest, gradient boosting machines, and support vector machines, were compared to find the best predictor. Model performance was evaluated using precision, recall, and F1 score. Results demonstrate high accuracy in rock hardness prediction, providing valuable insights for optimizing drilling operations.

Keywords Measurement while drilling · Rock hardness · Mohs scale · Machine learning · Spark · Azure cloud computing

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Introduction

Drilling was a vital process in various fields, such as mining, oil and gas exploration, geothermal energy production, and civil engineering [1]. The use of blasthole drilling data had been identified as advantageous for obtaining rock mass properties, as it is acquired systematically, routinely, and in real-time [2]. Accurate determination of rock mass properties is essential for open-pit mine planning activities, enabling more effective blast designs to achieve improved loading, hauling, and downstream process efficiency [3]. The performance and cost of drilling operations depend largely on the properties of the rock formation being drilled. Many scholars have conducted extensive studies on the classification of rock formations using various parameters obtained from drilling operations. For example, Rostami et al. [4] examined the vibration response of drill bits when passing through rock fissures during drilling, offering insights into how these vibrations can impact the drilling process. Liu et al. [5] investigated the rock formations by analyzing drilling and rotational pressure in bolters. Song et al. [6] and Liu et al. [7] advanced this research by using a combination of support vector machines (SVM) and the minimum enclosing balls classifier to identify coal-rock interfaces, based on penetration rate and vibration data. Moreover, Kernel Fisher discriminant analysis has also been applied to classify rock from coal using well log data [8], providing a robust methodology for real-time stratigraphic classification during drilling.

Rock's hardness was a measure of the resistance of the rock to deformation, penetration, or abrasion [9]. It affected the drilling rate, the wear and tear of the drill bit, the power consumption, and the risk of drilling failures. Therefore, accurate and timely prediction of rock hardness was essential for optimizing drilling operations and planning.

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