Study on Prediction of Fragmented Rock Velocity at Bench Blasting Using Machine Learning (AI)

Cooperative Program for Resources Engineering
Laboratory of Rock Engineering and Mining Machinery
2TE22845G Ezatullah Rawnaq

1. Introduction

Blasting is a widely used and cost-effective technique in the mining and civil engineering sectors for breaking hard rock formations using explosives. While this process is crucial for these industries in terms of breaking rock effectively, it can also lead to several environmental impacts. One notable concern is flyrock (**Figure 1**), where refers to rock fragments propelled beyond the immediate blasting area due to the force of an explosion. This phenomenon poses risks to nearby equipment, structures, and human safety, making it a critical concern in mining and construction sites. Therefore, accurately predicting the outcomes of blasting operations, including the potential for flyrock, is essential for enhancing blasting efficiency and mitigating adverse effects. This study discusses the applicability of machine learning to predict the flyrock velocity. Additionally, the parameters to affect the flyrock velocity is assessed.

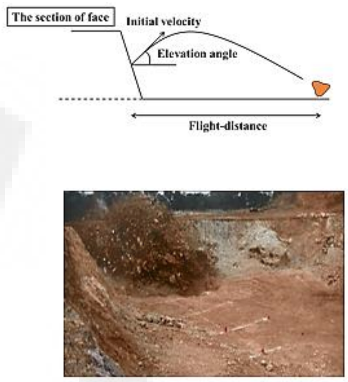

Figure 1. *Flyrock at bench blasting*

2. Data Preprocessing

The study involved collecting and preprocessing blasting data (**Table 1**) from mine site located in Kagoshima, to prepare for analysis with machine learning techniques. 72 blasting data are used in this study. The preprocessing phase included handling missing values, selecting relevant features, and splitting the data into a training set for algorithm training and a testing set for evaluating the performance of the machine learning models using chosen evaluation metrics.

***Table 1**. Data from field blasting test.*

	Feature	min	mean	max
	Burden (m)	1.5	2.2	3
	Spacing (m)	1.5	2.0	2
	Bench Height (m)	3.5	8.3	11.5
	Powder Factor (kg/t)	0.1	0.14	0.24
Inputs	Charge Volume (kg)	37.2	111.9	209.5
	UCS (MPa)	2.6	102.8	304.0
	BTS (MPa)	0.5	10.0	26.0
	Crack density (C/m)	0.18	0.57	1.38
	Density (kg/m^3)	1505	2175	25667
Output	Flyrock Velocity (m/s)	7.1	20.3	48.2

3. Methodology

This research employed machine learning techniques to predict flyrock velocity based on nine inputs shown in (**Table 1**). Four distinct machine learning algorithms including Random Forest, Decision Tree, Linear Regression and Gradient Boosting were utilized for this purpose.

4. Results

The obtained results demonstrate the effectiveness of all tested models in accurately predicting flyrock velocity. Random Forest model shows superior performance compared to Linear Regression, Decision Tree, and Gradient Boosting models. The ability to predict flyrock velocity allows for the calculation of a safe blasting zone, as there is a strong correlation between the velocity and distance of rock fragments. The study also identified burden, powder factor, and density as critical parameters influencing flyrock velocity (**Figure 2**). Based on the results, maintaining sufficient burden and minimizing the powder factor are recommended when the impact on surrounding, e.g., equipment, structures, and human safety, is suspected due to flyrocks in surface mining.

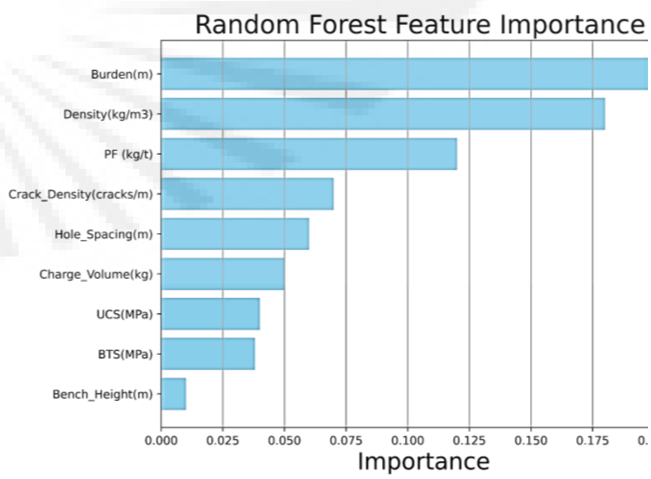

***Figure 2**. Feature importance for flyrock velocity*