Deep Learning for Predicting Hauling Fleet Production Capacity Under Uncertainties in Open Pit Mines Using Real & Simulated Data

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Keywords: Deep Learning, Hauling Fleet, Open-pit mining, Production capacity, Uncertainty Management

# ABSTRACT

Accurate short‑term forecasting of hauling‑fleet capacity is crucial in open‑pit mining, where weather fluctuations, mechanical breakdowns, and variable crew availability introduce significant operational uncertainties. We propose a deep‑learning framework that blends real‑world operational records (high‑resolution rainfall measurements, fleet performance telemetry) with synthetically generated mechanical‑breakdown scenarios to enable the model to capture fluctuating high‑impact failure events. We evaluate two architectures: an XGBoost regressor achieving a median absolute error (MedAE) of 14.3 per cent and a Long Short‑Term Memory network with a MedAE of 15.1 per cent. Shapley Additive exPlanations (SHAP) value analyses identify cumulative rainfall, historical payload trends, and simulated breakdown frequencies as dominant predictors. Integration of simulated breakdown data and shift‑planning features notably reduces prediction volatility. Future work will further integrate maintenance‑scheduling indicators (Mean Time Between Failures, Mean Time to Repair), detailed human resource data (operator absenteeism, crew efficiency metrics), blast event scheduling, and other operational constraints to enhance forecast robustness and adaptability. This hybrid modelling approach offers a comprehensive decision‑support tool for proactive, data‑driven fleet management under dynamically uncertain conditions.