Simulating Operability of Mining Vehicles via Adaptive Algorithm Transitioning: From Supervised Simulation Learning to Unsupervised Real-World Application

M.Balamurali

Senior Research Fellow (effective from January 1st), University of Sydney, 2008.
Email:mehala.balamurali@sydney.edu.au

Keywords: Autonomous Mining Systems, Operational Efficiency Mining, Mining Equipment Analytics, Adaptive machine learning

ABSTRACT

Productivity and energy efficiency are both dependent not only on inherent machine properties and working place conditions, but also on how the operator manoeuvres the machine. Analysing and understanding the complex behaviour of mining equipment is pivotal in enhancing efficiency, safety, and cost-effectiveness within the mining industry. Traditional methods of monitoring and evaluating these behaviours, though reliable to a degree, lack the dynamic adaptability and scalability required to match the evolving complexities of mining scenarios. This study introduces an innovative approach to mining equipment behaviour analysis by employing an adaptive transitioning strategy from supervised learning models, initially trained in simulated environments, to real-world applications, subsequently improving via unsupervised learning techniques.

The necessity for this adaptive transitioning stems from the critical need to understand nuanced equipment behaviours, including queuing, dumping, loading, and reversing scenarios, under various operational constraints. By initiating the process with supervised learning, the study leverages detailed, simulated data to establish foundational behaviour models. However, recognizing the limitations posed by fixed algorithms in fluctuating real-world mining environments, the research emphasizes the importance of unsupervised learning. This transition is enhanced through the use of pseudo-ground-truthing, wherein the output generated from the supervised sim-to-real method predictions provides a provisional standard for continuous learning and algorithmic evolution.

Furthermore, the study exploits 3D object detection within point clouds, offering robust, detailed, and multi-dimensional insights, thereby significantly understanding, and predicting equipment behaviour and operational logistics. This advanced machine learning method seamlessly transitions from supervised to unsupervised learning, proving crucial for identifying and predicting complex mining equipment behaviours. This approach is set to be integral in autonomous and semi-autonomous mining operations.

A case study in Western Australia's Pilbara region will compare this methodology with traditional GPS tracking, highlighting the benefits of the proposed point cloud-based system in real-world mining environments.

ACKNOWLEDGEMENTS

This work has been supported by the Australian Centre for Field Robotics and the Rio Tinto Centre for Mine Automation, the University of Sydney.