Real-Time Monitoring and Machine Tracking in Large-Scale Underground Mines Using Safety Systems and Machine Learning Techniques

A Skoczylas1, W Koperska2, P Stefaniak3 and P Śliwiński4

1. Research Specialist, KGHM Cuprum Research & Development Centre Ltd., Poland, Wroclaw 53-659. Email: artur.skoczylas@kghmcuprum.com

2. Research Specialist, KGHM Cuprum Research & Development Centre Ltd., Poland, Wroclaw 53-659. Email: wioletta.koperska@kghmcuprum.com

3. Head of Analytics Department, KGHM Cuprum Research & Development Centre Ltd., Poland, Wroclaw 53-659. Email: pawel.stefaniak@kghmcuprum.com

4. Chief Engineer for Production Analysis and Optimization, KGHM Polska Miedź SA, Poland, Lubin 59-301. Email:pawel.sliwinski@kghm.com

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# ABSTRACT

Nowadays, one of the main challenges underground mines face is achieving real-time monitoring of production processes and machinery movements. Effective monitoring systems are crucial to maintaining situational awareness and ensuring the continuity of operations, particularly in dispersed organizations. This knowledge is essential for safe and efficient extraction, up-to-date production reconciliation, and various operational and planning activities, including the use of specialized simulation environments for optimizing production. So far, such monitoring solutions have mostly been implemented in open-pit mining or smaller underground operations. This paper introduces a system for tracking and monitoring machinery, utilizing data from a safety system specifically designed for underground mining enterprises. Originally, the system was developed to detect potential collisions between machines or between machines and workers. However, the need arose to develop validation algorithms, which included error correction and adaptive filtering. This also required integration with ERP systems. Additionally, the system’s infrastructure was upgraded with extra sensors to allow for the registration of machine locations in specific mining zones, such as the heavy machinery chamber, mining areas, and loading/unloading points. In this study, several analytical models, enhanced with machine learning techniques, were developed to track the movement and interaction of wheeled transport machinery, as well as the overall ore logistics within the mining operation. The paper also covers the system's implementation process in the target environment and provides a description of the user interface, which includes manager dashboards for production visualization.