

Spatial Drillhole Intelligence Prediction System (DIPS): A Digital Twin-Based Approach for Drillhole Risk Detection in Underground Mining

Aune Iyaloo Kamosho¹

¹Byrnecut Mining, Karibib , Namibia

The increasing complexity of underground operations in spatial mining environments demands advanced systems for improving drillhole planning, safety, and decision-making. This study presents the Spatial Drillhole Intelligence Prediction System (DIPS), a digital twin-based platform designed to analyze, predict, and monitor drillhole interactions within a virtual mine environment.

DIPS integrates past diamond drillholes, underground mine design, and as-built workings to simulate drillhole paths in three-dimensional space. Historical diamond drilling data is used to improve spatial pattern recognition, analyze relationships, and support more accurate prediction of potential drillhole interactions. Through spatial analysis, DIPS detects intersections and proximity conflicts between drillholes and underground structures such as drives and other excavations.

Beyond conventional geometric checks, DIPS incorporates a predictive intelligence layer that evaluates drillhole risk using spatial relationships, proximity thresholds, and contextual mine conditions. A rule-based alert engine is implemented to classify drillholes into risk categories and generate warnings for high-risk scenarios before drilling operations commence.

The importance of DIPS lies in its ability to support proactive decision-making in spatial mining by identifying potential drillhole conflicts before they occur. The system helps reduce operational risks, prevent unintended interactions with underground workings, and enhance safety during drilling operations.

An interactive dashboard provides a clear overview of drillhole status, predicted risks, and system alerts, while the digital twin environment enhances spatial awareness by visualizing drillhole paths alongside underground mine layouts, with the open pit included as a reference layer.

The system will be tested using data from Byrnecut underground mining operations at the QKR Navachab Gold Mine project. DIPS offers a scalable and intelligent approach to drillhole verification, combining digital twin technology, predictive analysis, and alert-driven workflows to support safer and more efficient mining operations.