Automated MWD data processing and unified database building
Automatiserad MWD databehandling och uppbyggnad av en enhetlig databas

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BeFo Report 242, 2024

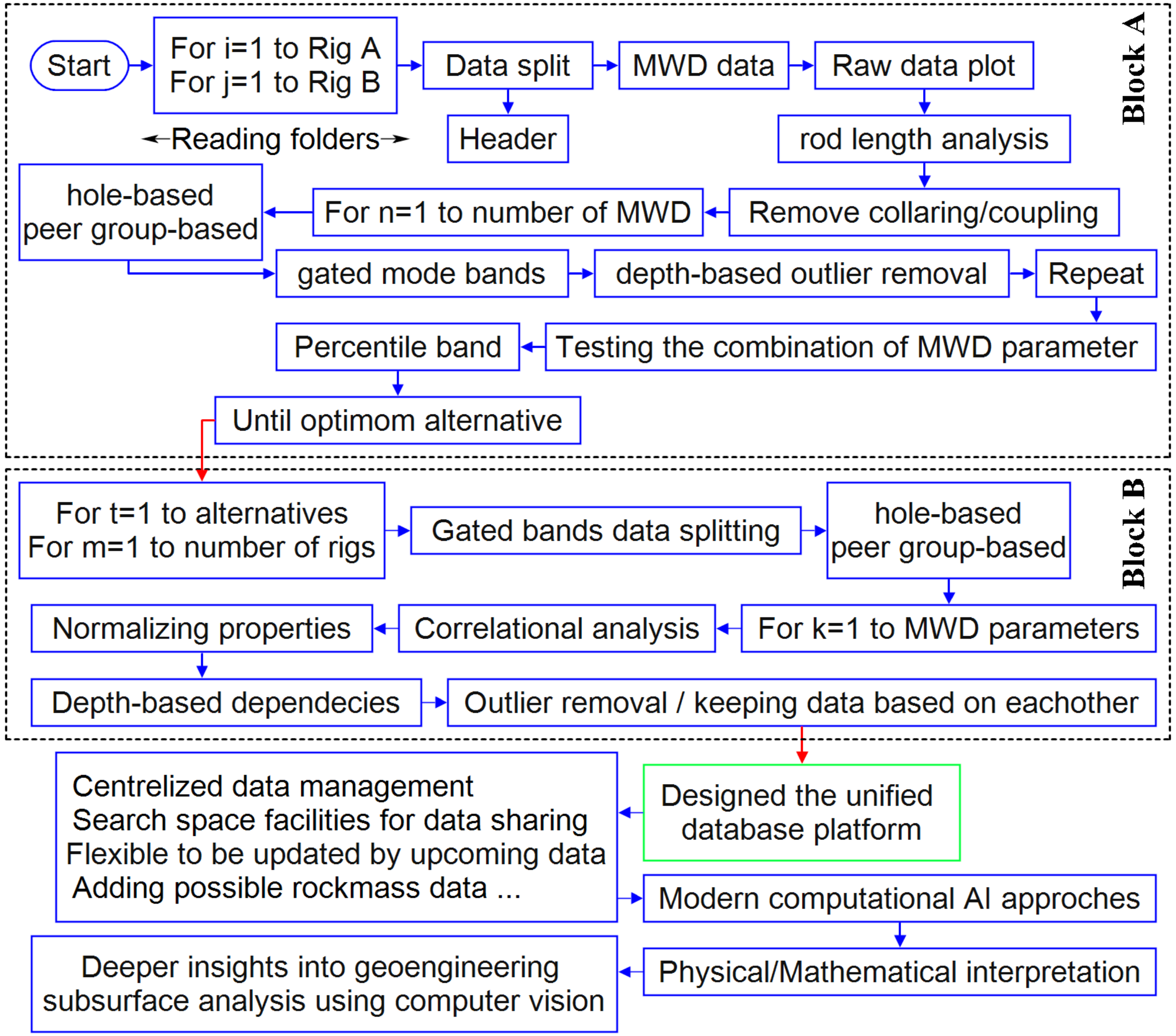
Background

Continuous forecasting of the ground conditions ahead of the tunnel face during construction projects like tunneling is of great interest. Nowadays, in tunneling projects, analyzing the acquired measurement-while-drilling (MWD) data has been demonstrated to be a helpful method for assessing the rock mass conditions. However, the MWD is a monitoring technique that provides significant large records and analysis of a large amount of generated data not only is time-consuming.

Aims

The purpose of this work is to provide a generalized and automated tool for large amounts of MWD data filtering and normalization in order to help in more appropriate grouting design systems, at the mean time to investigate the possibilities of applying artificial intelligence (AI) on MWD data for predicting bedrock quality conditions and designing appropriate grouting systems.

Methodology



The filtering and normalization procedure includes several inner nested loops and mimic an automated process for MWD data processing, where the input data are automatically filtered and normalized and then transferred to the centralized space to store and create an unified database.

Figure 1. Simplified diagram of applied automated MWD processing procedure and generating unified database

Results - Filtration

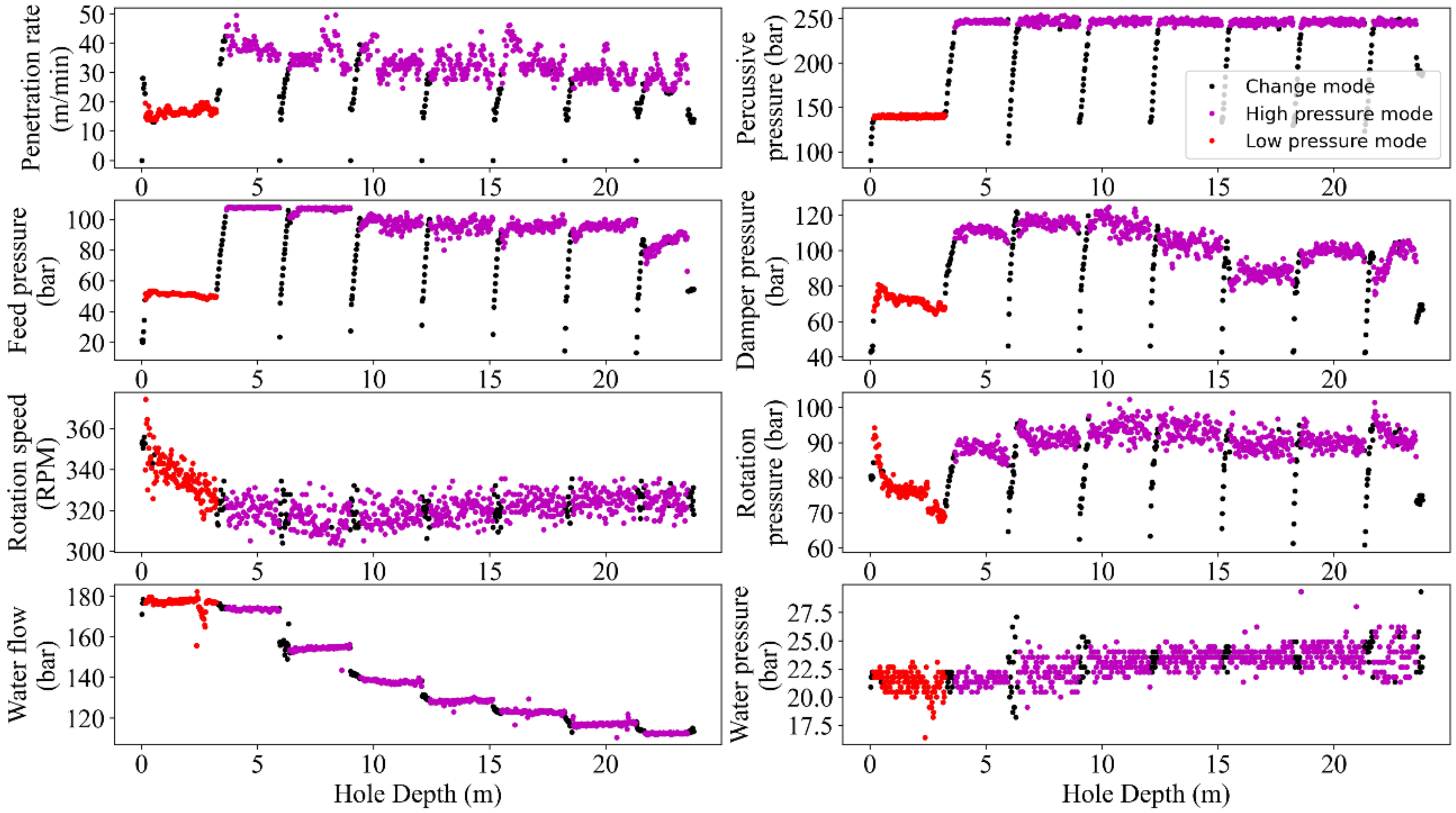


Figure 2. A visualized sample of carried out efforts for hole-based data filtering. Black dots represent Change mode, purple dots represent High pressure mode and red dots represent Low pressure mode.

The combination of *HP-PR* showed the most optimum results and thus selected as the MWD parameters to define the gated band and percentile filters. The gated bands were applied on *HP* and the percentile was applied on *PR* to remove the outliers. It should be noted that the filtering procedure simultaneously is applied on the other MWD parameters, i.e. removing one data from *HP* means eliminating the entire row of data for all parameters. Referring to the definition of mode filter, the gated bands can be used to split the data into three modes, including high/change/low modes (Figures 2).

Results - Normalization

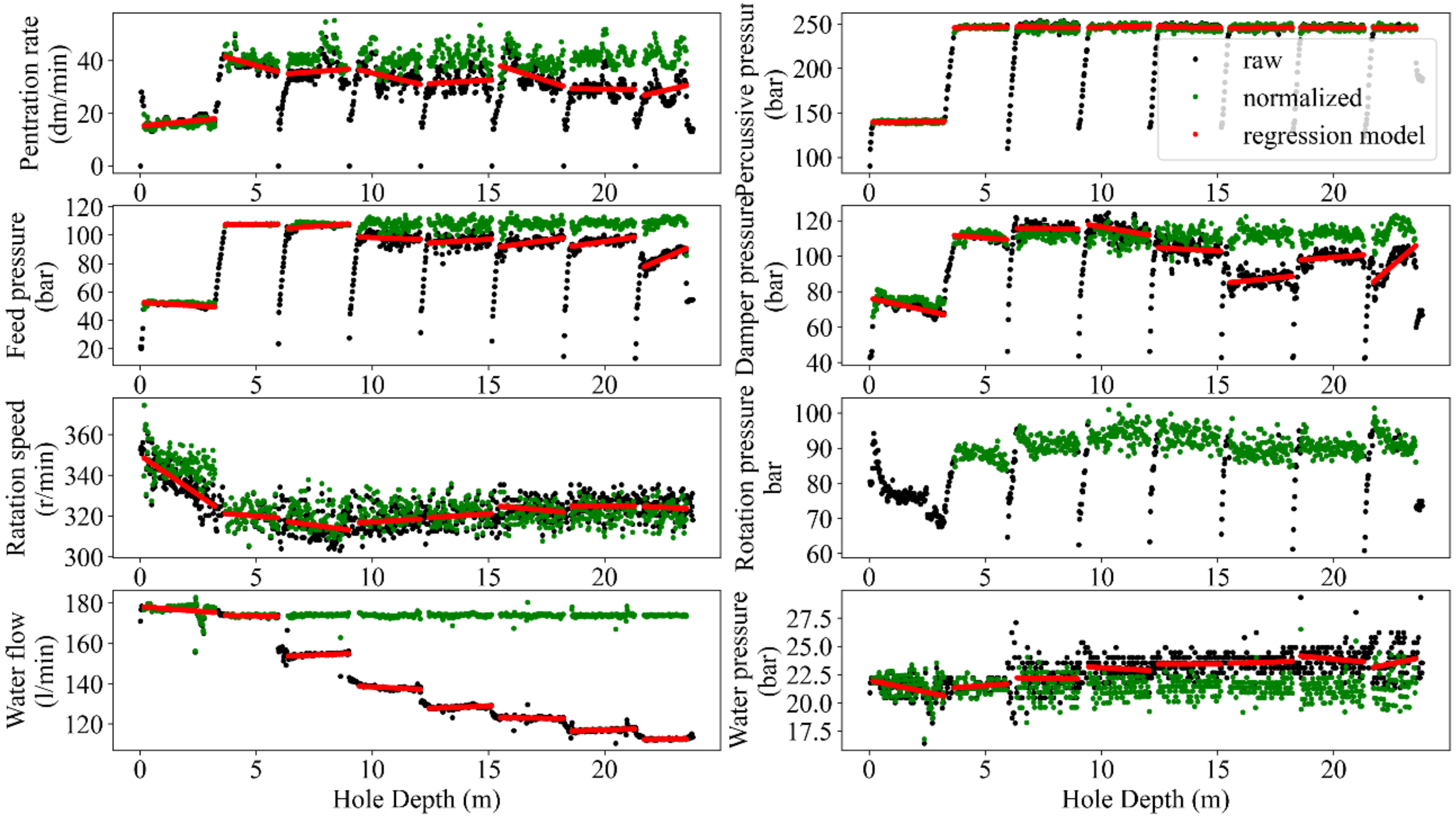
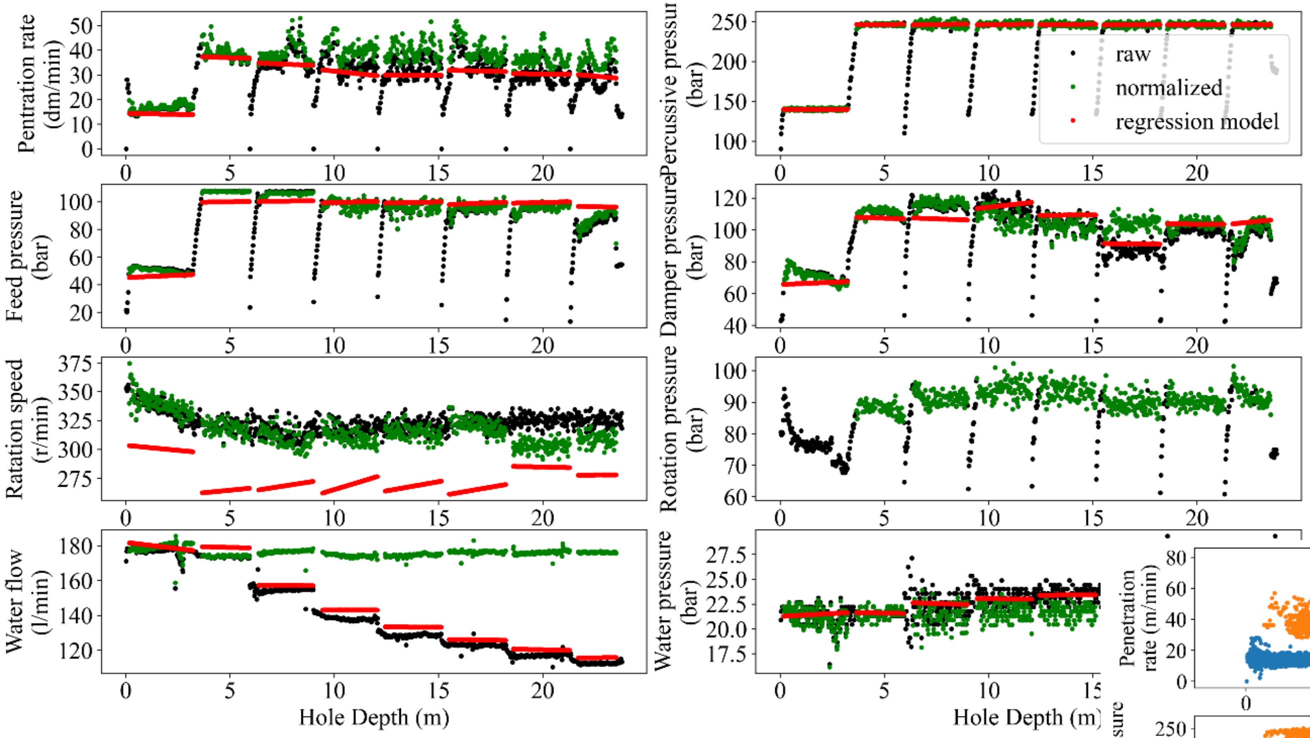


Figure 3. Pattern identification and trend analysis between the normalized and un-normalized MWD data (hole-based). Raw data (black dots), normalized data after removing the hole depth dependency (green dots) and adopted regressions for each rod length (red lines).

- Normalization after filtering can assist in removing signals caused by systematic drilling behaviors that may affect the accuracy of the data.
- As it aims to scale the data, then easier comparison among different datasets particularly data from different rigs/drilling conditions is allowed.
- It can highlight smaller changes that may be masked by larger variations in the data.
- Adjusted/scaled data can improve the visual clarity of the data, making it easier to identify trends and patterns.

Results - Normalization



The result of hole and peer group-based depth normalization (single hole and fan holes) are shown in Figure 3 and Figure 4. The red lines are the regressions adoted for each rod length. The apodted regressions based on peer group data (Figure 4) were doncducted for each parameter from all rods from one fan with respect to High/low modes (Figure 5).

Figure 4. A visualize sample of pattern identification-trend analysis between the normalized and un-normalized MWD data (peer group-based).

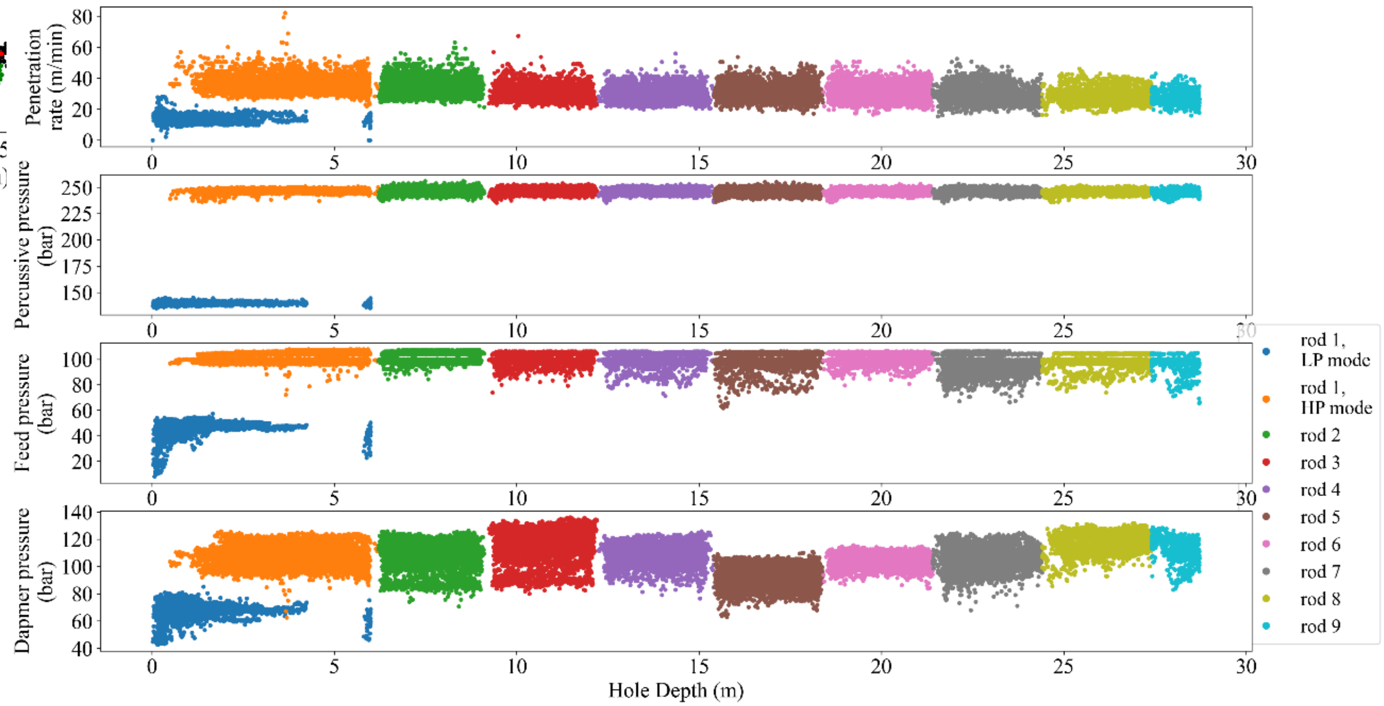


Figure 5. Rod length checking through splitting of merged data for all rods from one umbrella (Checking the mode capability in splitting the high (orange) and low (dark blue) pressure values for rod 1)

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Results - Databse

Figure 6. Schema for the PostgreSQL database design

A centralized database was designed using PostgreSQL platform because of its robustness and open source object-relational database system. Then, the raw and processed data were transferred into this datacenter. Due to the developed automated coding it can continuously be updated using new upcoming data

Summary and Conclusions

- An entire automated process for filtering, normalizing and database creation for big MWD data in both hole and peer group-based was developed.
- The distinguished states in data (high/low/change mode) using the adopted mode, long term average and percentile gated bands showed efficiency in removal of the noisy data caused by rig components, i.e. collaring and coupling effects from rod extensions. The applicability of normalizing process in removing the hole depth dependencies of MWD data were evaluated using correlational analysis.
- As a result, the hole-based normalizing method showed better performance in removing the hole depth dependencies and stepwise problem in MWD data.
- The presented procedure can generally be applied on any retrieved MWD data from each drill rig.
- The established MWD data center can structure and manage a big amount of MWD and grouting data to facilitate storing and extracting.
- Incorporating the database with other geomechanical data sources can provide more accurate and realistic physical interpretations from MWD and grouting data.