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Evaluation of Hybrid Prediction Models for Accurate Rate of Penetration (ROP) Prediction in Drilling Operations

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Abstract

The precise prediction of the rate of penetration (ROP) is of utmost importance for optimizing drilling operations and minimizing costs while increasing efficiency. However, the complex and nonlinear nature of the drilling process can pose significant challenges in achieving accurate ROP predictions. To address this challenge, multiple hybrid prediction models have been developed, and their accuracy in ROP prediction has been compared.

To accomplish this objective, we created three different hybrid models, including Artificial Neural Network – Genetic Algorithm (ANN-GA), Artificial Neural Network-Particle Swarm Optimization (ANN-PSO), and Support Vector Regression (SVR) to estimate ROP. These models were trained and tested using drilling data collected from surface sensors, including drilling parameters such as weight on bit (WOB), revolutions per minute (RPM), flow rate, ROP, and drilling torque.

The hybrid models were able to accurately estimate the ROP for the given drilling conditions and lithologies by utilizing these parameters. Furthermore, the models' accuracy and effectiveness were assessed by training and testing them using the collected drilling data.

Upon evaluating the performance of the three algorithms, our study shows that SVR (Support Vector Regression) outperformed ANN (Artificial Neural Network) in accuracy and precision when predicting the target variable. SVR consistently provided more accurate and precise predictions, capturing the underlying patterns in the data effectively. While ANN-GA (Artificial Neural Network with Genetic Algorithm) performed better than ANN-PSO (Artificial Neural Network with Particle Swarm Optimization) in the training dataset, it exhibited lower accuracy during testing. This highlights the importance of evaluating algorithm performance in both training and testing scenarios. The

results also emphasize that complexity doesn't always lead to better predictions. SVR offers a promising choice for accurate and reliable predictions, but further research is needed to explore the contrasting performances and optimize these algorithms.

Reference:

Aoun, A. E., Rabiei, M., Rassouli, V., Khetib, Y., Kost, O., Abes, A., Kaunain, A., & Khouissat, A. (2022). Machine Learning Based Mechanical Earth Model: A Case Study. *56th U.S. Rock Mechanics/Geomechanics Symposium, June*. https://doi.org/10.56952/arma-2022-0522

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Evaluation of Hybrid Prediction Models for Accurate Rate of Penetration (ROP) Prediction in Drilling Operations

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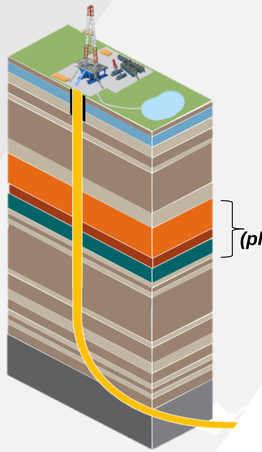
Introduction

- Importance of precise ROP prediction: ROP prediction plays a crucial role in optimizing drilling operations, minimizing costs, and enhancing overall efficiency.
- Challenges in accurate ROP prediction: The complex and nonlinear nature of the drilling process poses challenges for accurately predicting ROP.
- Hybrid prediction models: To overcome these challenges, several hybrid prediction models have been developed and compared to improve the accuracy of ROP prediction in drilling operations.

Problem Statement

- The accurate prediction of drilling rate of penetration (ROP) is challenging due to the complex and nonlinear nature of the drilling process, geological variability, uncertainties in drilling parameters, and the lack of sufficient data.



Different rock formation type (A, B, C)
(physical characteristics and composition of rocks)

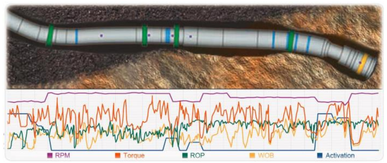
Random schematic of an onshore drilling well with various geological formations

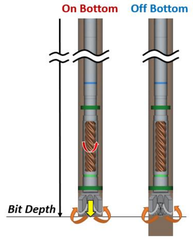
Project Goal

- Develop and compare hybrid prediction models for accurate ROP estimation in drilling operations.
- Address challenges associated with the complex and nonlinear nature of the drilling process.

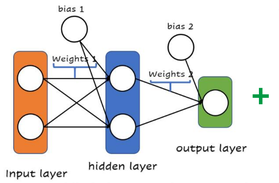
Methodology

1. Data Collection → ***2. Data Pre-processing***

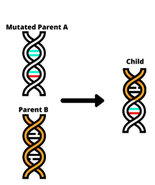




3. Select Learning Algorithms

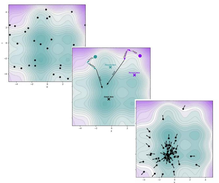


a. Artificial Neural Network

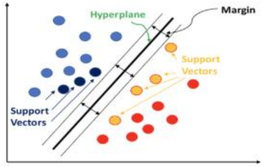


Genetic Algorithm

Or

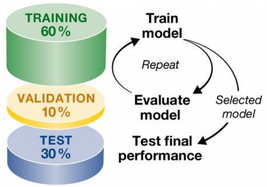


Particle Swarm Optimization

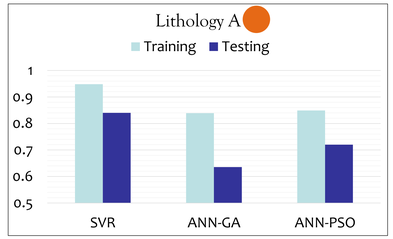


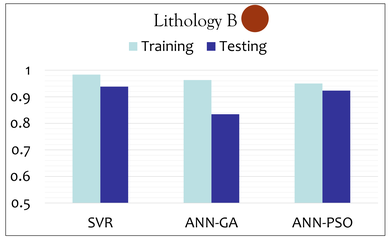
b. Support Vector Regression

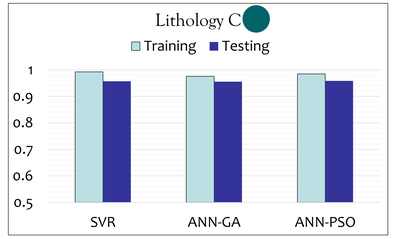
4. Training Candidate Models and Validating



Results







- Accuracy given by each of the selected machine learning model for the three different rock formation.

Conclusion

- SVR outperforms ANN in terms of accuracy and precision for predicting the target variable.it provides more accurate and precise predictions for the target variable.
- ANN-GA outperforms ANN-PSO in the training dataset but exhibits lower accuracy than ANN-PSO during the testing phase.
- SVR excels at capturing the underlying patterns and relationships within the data, thereby generating more dependable predictions.
- Choosing more complex algorithms does not always lead to better prediction results.

References

- Youcefi, M. R., Hadjadj, A., Bentriou, A., & Boukredera, F. S. (2020). Rate of penetration modeling using hybridization extreme learning machine and whale optimization algorithm. Earth Science Informatics, 13(4), 1351–1368. https://doi.org/10.1007/s12145-020-00524-y
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