# OptiDrill: Optimizing the Geothermal Drilling Process Using Artificial Intelligence Methods

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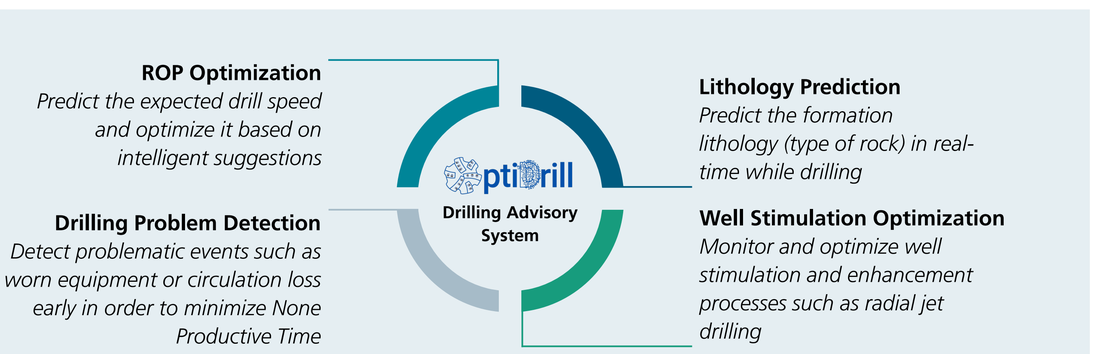
## OPTIMIZATION OF GEOTHERMAL DRILLING OPERATIONS WITH MACHINE LEARNING

The main focus of the research presented here is on the application of artificial intelligence methods in the field of deep drilling technology geared toward geothermal applications. The research has been conducted under the framework of the OptiDrill project which is funded by the European Union's Horizon 2020 programme with the objective of developing a drilling advisory system based on novel downhole sensors and AI methods.

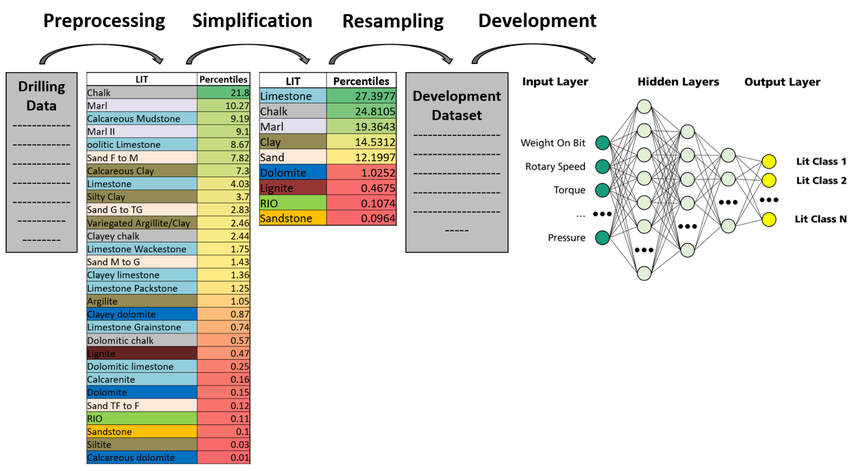



## OPTIDRILL ADVISORY SYSTEM OBJECTIVES

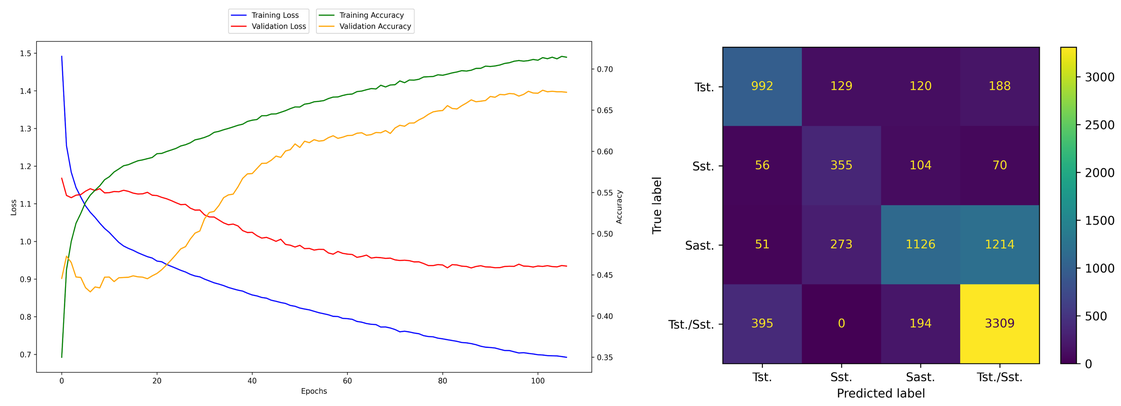
The OptiDrill system includes four AI modules each aiming at the optimization of an individual aspect of the drilling operation including rate of penetration (ROP) prediction and optimization, real-time lithology prediction, drilling problem detection and prediction, and well stimulation and enhancement monitoring and optimization. The AI modules are being developed on the basis of the OptiDrill deep drilling database, novel sensor systems and with the expertise and domain knowledge of the project's consortium members.

### Real-Time Lithology Prediction

One goal of the drilling advisory system's AI modules is the prediction of the lithologies that are being drilled in real-time, based on the drilling process parameters. The workflow used for the data preparation and development is depicted in the figure below. For this module artificial neural networks based models are used for the classification of the drilled lithologies.




*Data preparation and schematic structure of a neural network used for lithology prediction*

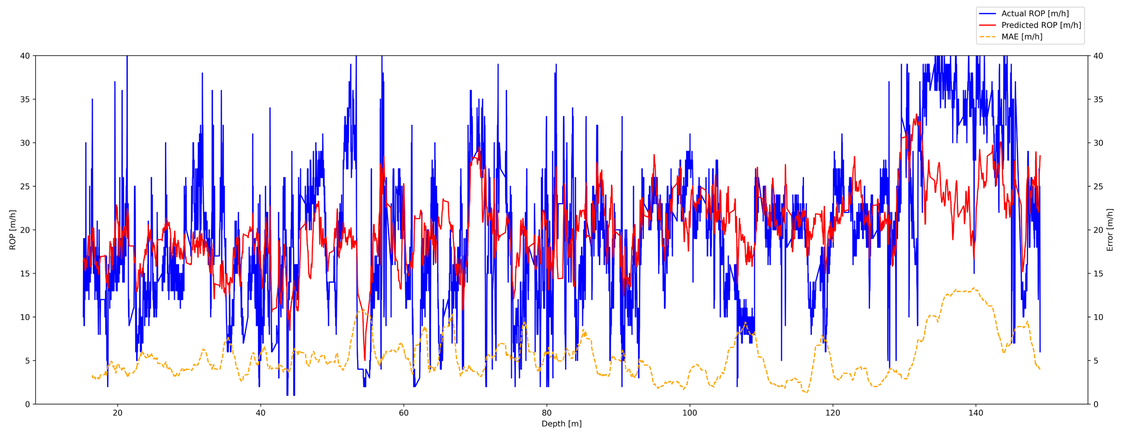



*Training and validation results of a 1D CNN model used for the prediction of the drilled lithology from drilling process parameters with a validation accuracy of around 67%*

Depending on the dataset and approach used, overall accuracies ranging from 65% to 77% and F1 scores ranging from 0.6 to 0.73 could be achieved using a set of 6 typical MWD drilling process parameters including RPM, torque, pressure, mud flow, WOB and ROP.

### ROP Prediction and Optimization

OptiDrill's drilling advisory systems second software modules has the objective of predicting and optimizing the ROP using drilling process parameters that are measured while drilling. Several machine learning approaches such as artificial neural networks, as well as decision tree based models are used to tackle this task.

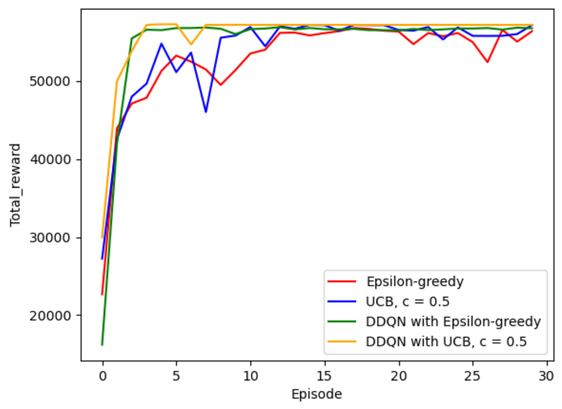



*Validation results of a 1D CNN ROP prediction model with an MAE of 5.2 m/h. The actual ROP is plotted in blue, the predicted in red and the MAE over a window of 100 data points in orange.*

Two different optimization approaches have been implemented based on the ROP prediction models developed beforehand, including one based on testing various possible process parameter scenarios and another one based on the principles of Reinforcement Learning.

### RLA Framework Components:

- (Double Deep) Q-Learning
- Controllable drilling process parameters as actions
  - E.g. revolutions per minute or weight on bit
- Reward calculated based on Mechanical Specific Energy
  - Energy required to remove a unit volume of rock




*Training curves of different RLA plotting the total reward of the number of epochs*

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