Mine Automation and Data Analytics (MNC305)

Mini Project | Ashutosh Kumar | 20JE0206

Title: Predicting rock type while drilling along drill hole using SVM model

Introduction -

Drilling is one of the unit operations in the mining industry. It is mostly done for the purpose of explosive charging and slope stability in opencast mines and roof support in underground workings. During this operation, there may be the possibility of facing numerous difficulties, one among which is the uncertainty of rock type at greater depths. While drilling in-setu rock mass, there is no guarantee of smooth drilling forever. There could be sudden occurrences of rock discontinuities or variation in rock characteristics like strength, hardness, porosity, density etc. These variations could lead to inaccurate estimation of charge decking, roof support, deterioration in productivity etc.

In this project work, I have prepared a model using SVM method of supervised learning which classifies the rock type into two categories of hard and medium formation based on different drilling parameters. It offers the capability of defining the geological and geo-mechanical characteristics of the rock mass during drilling.

Objective -

- Classification of rock formation strength (Hard or not) in order to enhance the degree of reliability while roof bolting and explosive charging.
- Optimize the drilling process by providing accurate and timely information to the drilling crew, enabling them to make informed decisions and adjust the drilling parameters accordingly.
- Improve the safety by reducing the need for traditional wireline surveys and providing valuable data for upcoming rock formations while drilling.
- Improve drilling efficiency, reduce drilling risks, and increase the success rate of reaching the targeted rock strata.

Methodology -

Drilling data set available has a number of parameters such as weight on bit, rotary speed, torque, rate of penetration (ROP), which were recorded while drilling, at fixed interval of depths. This also includes the characteristics of rock formation as hard or medium. This characterization is definitely related with the said parameters. For example, low rate of penetration will be recorded in the hard rock formation. Similarly, a large set of records ensure this is also related to other drilling parameters.

There are total 174 data points, each having a total of 6 features. These data points are first trained and tested. They are split into train data and test data. Here, test data is having 20% data points while rest are in the train data. Based on the trained data, it evaluates the inputs of test data, and then compares the result with the actual output of test data.

SVM works by mapping data to a high-dimensional feature space so that data points can be categorized, even when the data are not otherwise linearly separable (This gets done by Kernel function of SVM classifier). A separator between the categories is found, then data is transformed in such a way that the separator could be drawn as a hyperplane.

The mathematical function used for the transformation is known as the kernel function, and can be of different types, such as linear, polynomial, radial basis function, sigmoid. Each of these functions has its characteristics, its pros and cons, and its equation, but as there's no easy way of knowing which function performs best with any given dataset, we usually choose different functions in turn and compare the results. The one having the best accuracy is considered for the modelling.

Results and Discussion -

In the model, I chose kernel as linear due to the said reason. Accuracy score with linear kernel comes out to be 0.97. I chose Kernel coefficient (gamma) to be auto. This means the model automatically chooses the distance of influence from the decision boundary. C denotes the penalty that I want to impose on the incorrectly placed data points with respect to the hyperplane. C=2 means 2 units of penalty on each data point which is wrongly identified.

It then builds the SVM model and then the train data gets fitted in the model. Then, the predict output evaluated based on the test input, and ultimately is compared with the test output. This ultimately gives the classification report.

CLASSIFICATI0N REPORT DISCUSSION:

	precision	recall	f1-score	support
0	0.96	1.00	0.98	27
1	1.00	0.88	0.93	8
accuracy			0.97	35
macro avg	0.98	0.94	0.96	35
weighted avg	0.97	0.97	0.97	35

Precision –

Precision measures how many predicted positives are actually positive. Output 0 is having 0.96 precision while 1 is having 1.00 precision. This means the model predicted the output 0 correctly with 96% precision and output 1 correctly with 100% precision.

Recall –

Recall is the proportion of actual positives that are correctly identified by the classifier. Here, 100% of output 0 has been correctly identified by the model, while 88% of output 1 has been correctly identified.

F1-score –

F1-score is the harmonic mean of precision and recall and it gives a more comprehensive view of the classifier's performance. Here, output 0 has f1-score of 0.98 while output 1 has f1-score of 0.93.

Accuracy –

The SVM model so prepared has an overall accuracy of 0.97. It means 97% of predicted data output match with the test data output.

Model so prepared has an appreciable degree of accuracy and hence reliability. So, it can be used for classification of new data points whether it fall in 1 (hard) or 0 (soft) category. Indirectly, by using this model, miners can achieve optimum fragmentation in opencast blasting, because the type of explosive and its quantity can be determined for a particular section of the drill hole based on the rock type classified. Such improvements in the unit operations certainly increases the productivity and innovate the working in the industry.

Conclusion -

SVM is a type of supervised learning method, which is used in regression and classification of data. SVMs work by finding a hyperplane that separates the data points into different classes while maximizing the margin, which is the distance between the hyperplane and the nearest data points of each class.

In this project, I worked on the drilling data set to classify the upcoming rock along the drill hole to be hard or medium based on the drilling parameters. I built SVM model from the available data to classify the data points in the classes of hard rock or medium rock. The applications drawn out from such classifications could be deployed in measurement of local variabilities, discontinuities in roof during roof bolting in ug mines, management of blast hole deviation in bench blasting, explosive charging in drill holes (decking of charge) based on the type of wall rock, and so on.

This model showcases the algorithm at the backend of the modern automated drilling system. On the field, the drilling system are mounted with different measuring devices and sensors which measures pressure, thrust, torque, bit position, ROP, rotary speed etc., and then fed into the data analyser to draw out the desire result.

Thus, it enables drilling engineers to make informed decisions, resulting in increased drilling efficiency and reduced drilling time. It has also enabled the development of complex drilling techniques, such as directional and horizontal drilling, which have significantly expanded the reach of minerals. As technology continues to advance, this technology will continue to evolve, providing even more accurate and useful data to the industry.

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