Facies Classification using Supervised Machine Learning

Final Machine Learning Project - Sekolah Data Pacmann

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Outline

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Problem Definition & Goals

Problem Definition

Business Problems

- **Oil and Gas companies** need to translate **well measurement data** into lithofacies layer to **better understand** the condition of the **reservoir** being drilled.
- **Manually interpreting** well measurement data that are exponentially growing in volume by reservoir **geologists or geophysicists** must be **subjective** to some extent, leading to **increased uncertainties.**
- Facies definition is sometimes very **time-consuming** activity and **expensive.**

Business Solution

- **Classification of Lithofacies** can be achieved by using **supervised machine learning technique**. This supervised technique used **lithofacies labeled data** to understand the patterns and then **label other data lithofacies** based on trained lithofacies patterns
- In this **research and deployment** we will construct **supervised machine learning** model to **classify lithofacies** using **well-measurement data** to reduce cost and tackle the uncertainty of manual interpretation

Goals

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- **The goal** of this project is to find the **best-supervised machine learning algorithm** for lithofacies classification, and then deploy the pre-application to the server to predict the lithofacies from the well-measurement data

Machine Learning Metrics

1. **Accuracy** 0.5 – 0.6 — How well does the model predicts the true positive and true negative labels from the data input
2. **Adjacent Accuracy** 0.6-0.8 — How well does the model predicts the adjacent facies of the labels
3. **CV Score** 0.5-0.6 — How is the model performance through training and validation data
4. **ROC-AUC Value** 0.8-0.9 — How well the model can separate the True Positive and False Positive

Business Metrics

1. **Cost** — Cost that was spent to interpret the well measurement data
2. **Work Execution Time** — Time spent to interpret the well measurement data

Data Preparation

Dataset

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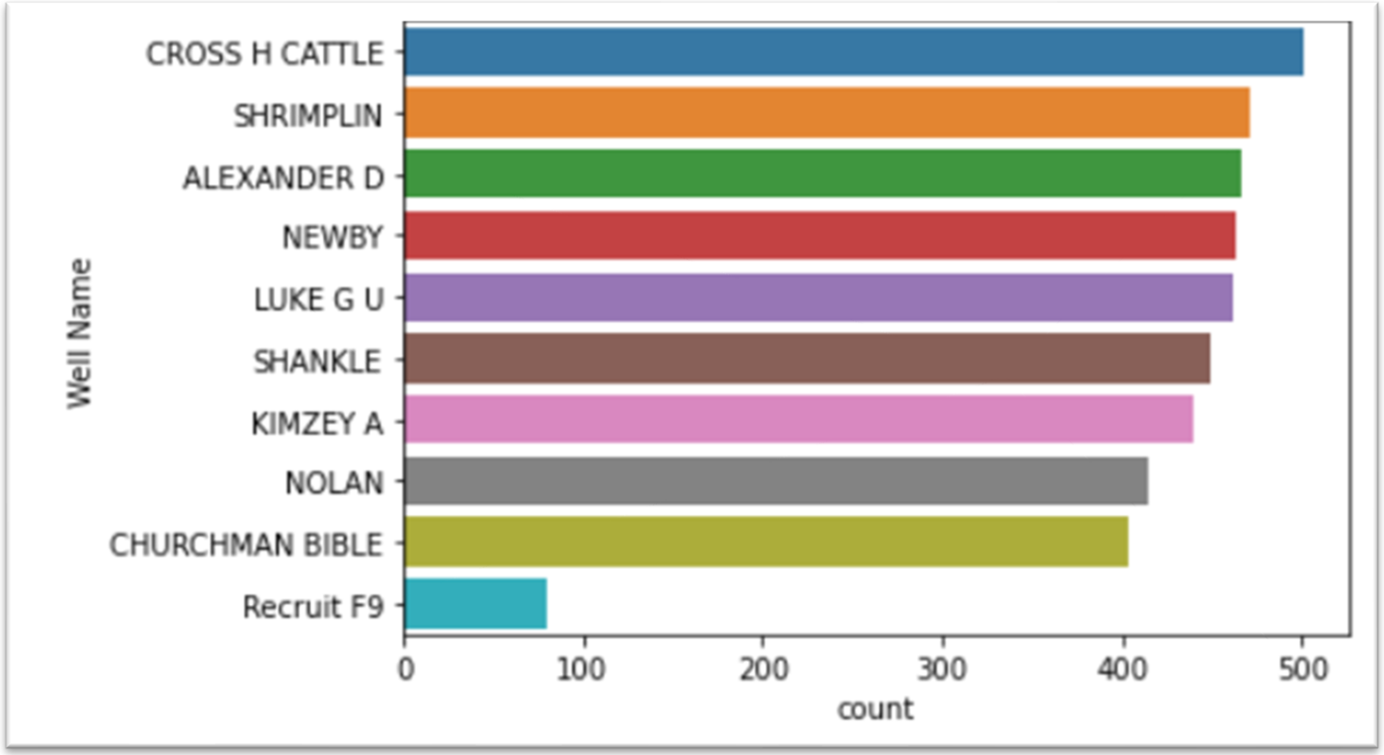
- Dataset are from [Machine Learning Competition in 2016]
- Dataset comprises **11 columns** and **4149 rows**
- There are **3 categorical data**: Facies, Formation, and Well Name
- There are **7 numerical data**: Depth, GR, ILD_log10, Delta-PHI, PHIND, PE, NM_M, RELPOS
- Numerical data consist of **5 Wireline Measurement** and **2 Geological Variable**

	Facies	Formation	Well Name	Depth	GR	ILD_log10	DeltaPHI	PHIND	PE	NM_M	RELPOS
0	CSiS	A1 SH	NOLAN	2853.5	106.813	0.533	9.339	15.222	3.500	1	1.000
1	FSiS	A1 SH	NOLAN	2854.0	100.938	0.542	8.857	15.313	3.416	1	0.977
2	FSiS	A1 SH	NOLAN	2854.5	94.375	0.553	7.097	14.583	3.195	1	0.955
3	FSiS	A1 SH	NOLAN	2855.0	89.813	0.554	7.081	14.110	2.963	1	0.932
4	FSiS	A1 SH	NOLAN	2855.5	91.563	0.560	6.733	13.189	2.979	1	0.909

Dataset



- Dataset consist of data measurement from 9 real well and 1 synthetic well (F9) to compensate category BS (Phyloid-Algae Bafflestone) in other well
- The difference on the amount of data from the real well wasn't so significant, but it is significant in the synthetic well

Data Preprocessing

Data Preprocessing

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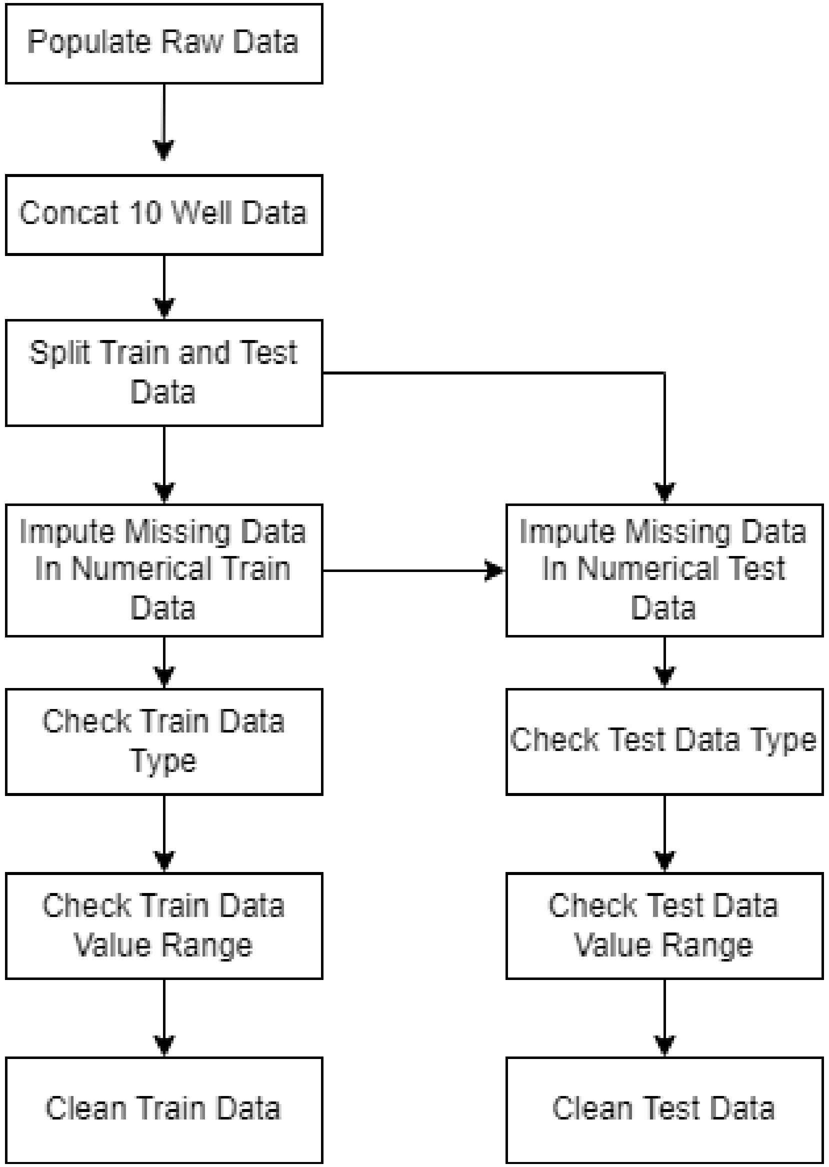
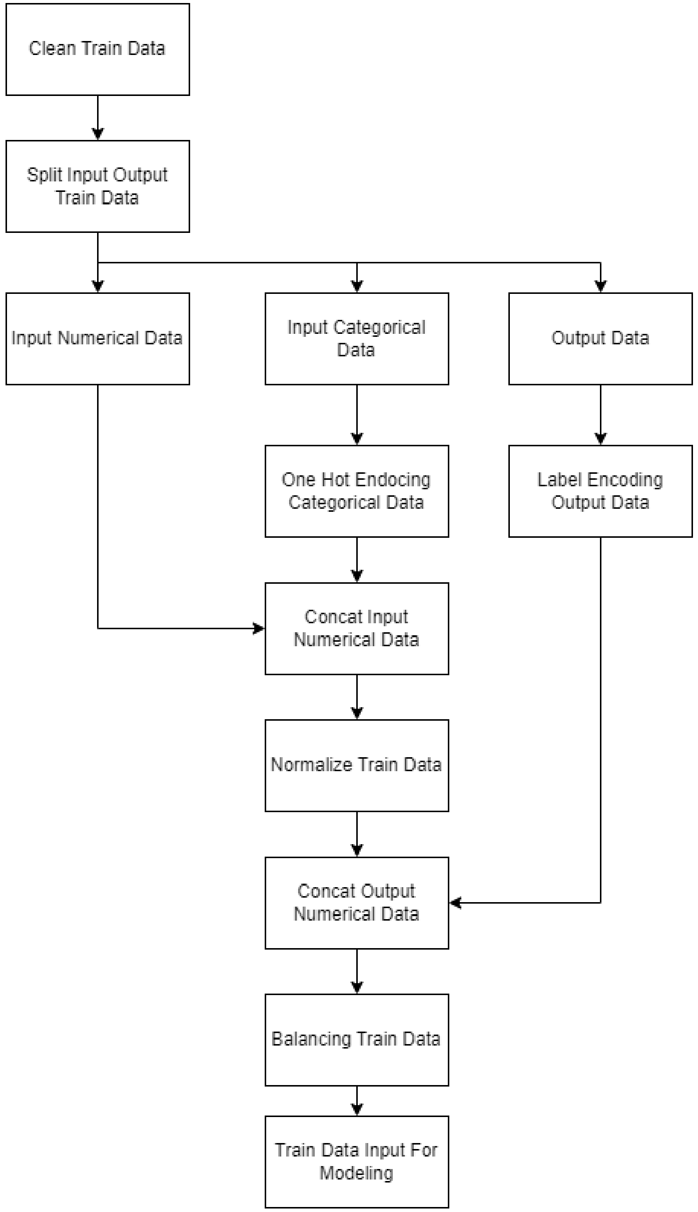


- Raw data is comprised of 10 CSV files that represent the well measurement from 10 different well
- Well ‘CHURCHMAN BIBLE’ was used to become the test data well, and the rest of the 9 well data serve as train data
- There are missing value in numerical data, and then it’s imputed by mean value for every label categories
- Every data in train data and test data checked for data type and important range value

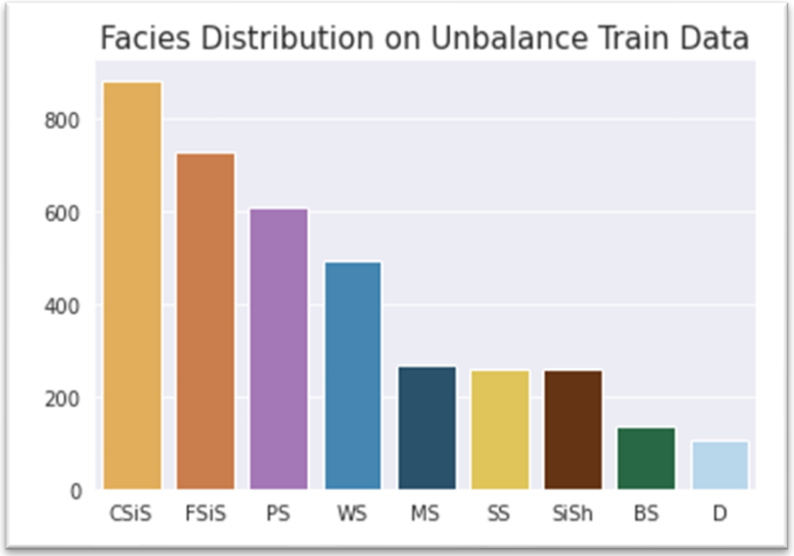
Feature Engineering

Feature Engineering



- Drop feature Formation, Well Name, Depth, and RELPOS, then split numerical, categorical, and output data
- One Hot Encoding for feature NM_M
- Label Encoding for feature output facies
- Normalize Input to have mean = 0 and standard deviation = 1
- Balancing train data using random under sampling, random over sampling, and smote

Facies	Numeric Representation
SS	0
CSiS	1
FSiS	2
SiSh	3
MS	4
WS	5
D	6
PS	7
BS	8



Dataset for Modeling

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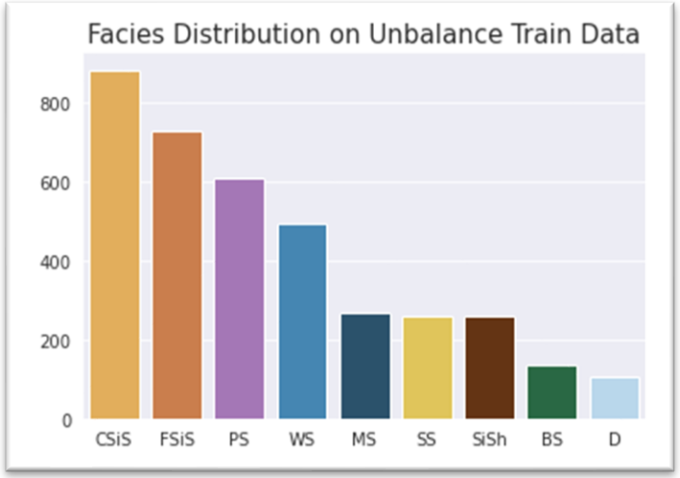
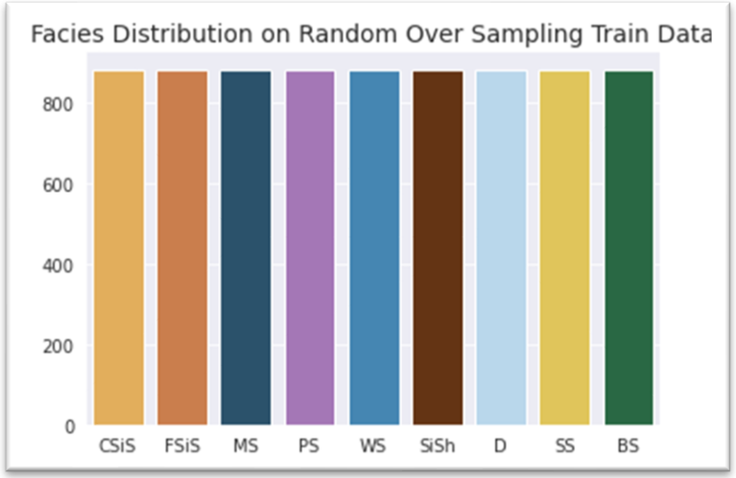
Unbalance



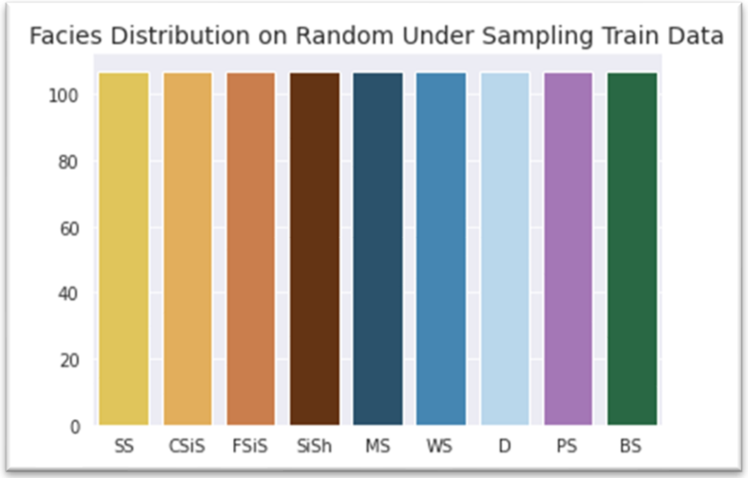
- 3745 data point for training
- Facies unbalance

Random Over Sample



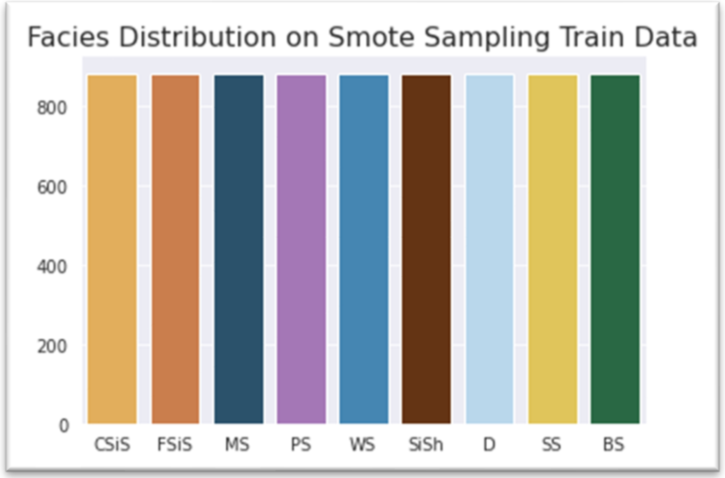
- 7956 data point for training
- Facies balance

Random Under Sample



- 963 data point for training
- Facies balance

SMOTE



- 7956 data point for training
- Facies balance

Modeling

Modeling

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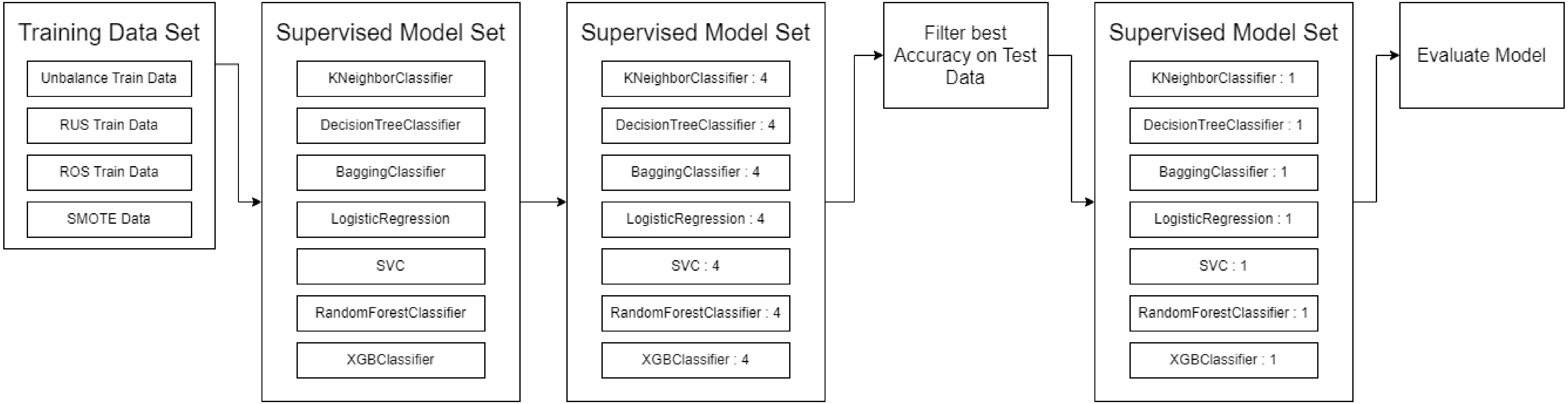
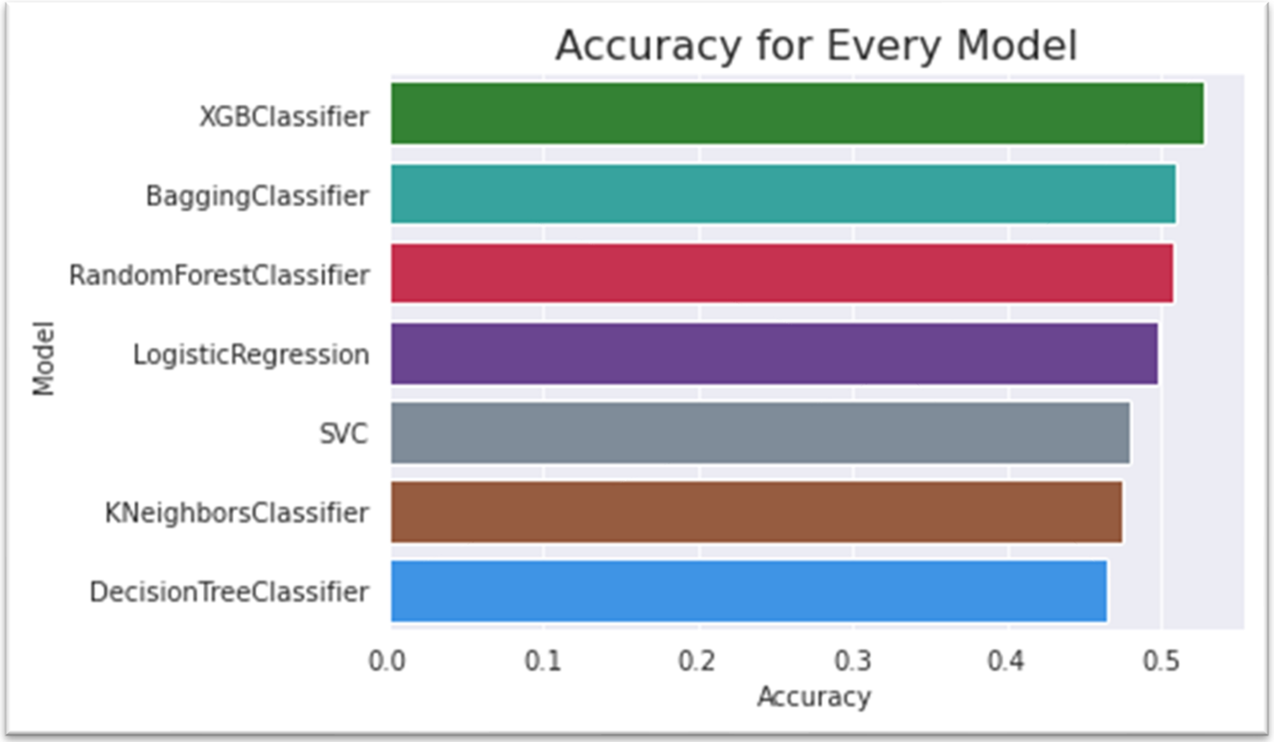


- Seven supervised model algorithm was trained by using four training data set, that will produce 28 machine learning model
- From every algorithm will be picked one with the best accuracy on data test
- From this 7 machine learning model will be picked one the best for facies classifier

Model Evaluation

Evaluation by Accuracy Score



- All model have accuracy below 0.6
- XGBClassifier has the highest accuracy on test data (“CHURCHMAN BIBLE”) for 52.7% and Decision Tree Classifier has the smallest accuracy on test data for 46.5%

Evaluation by Adjacent Accuracy

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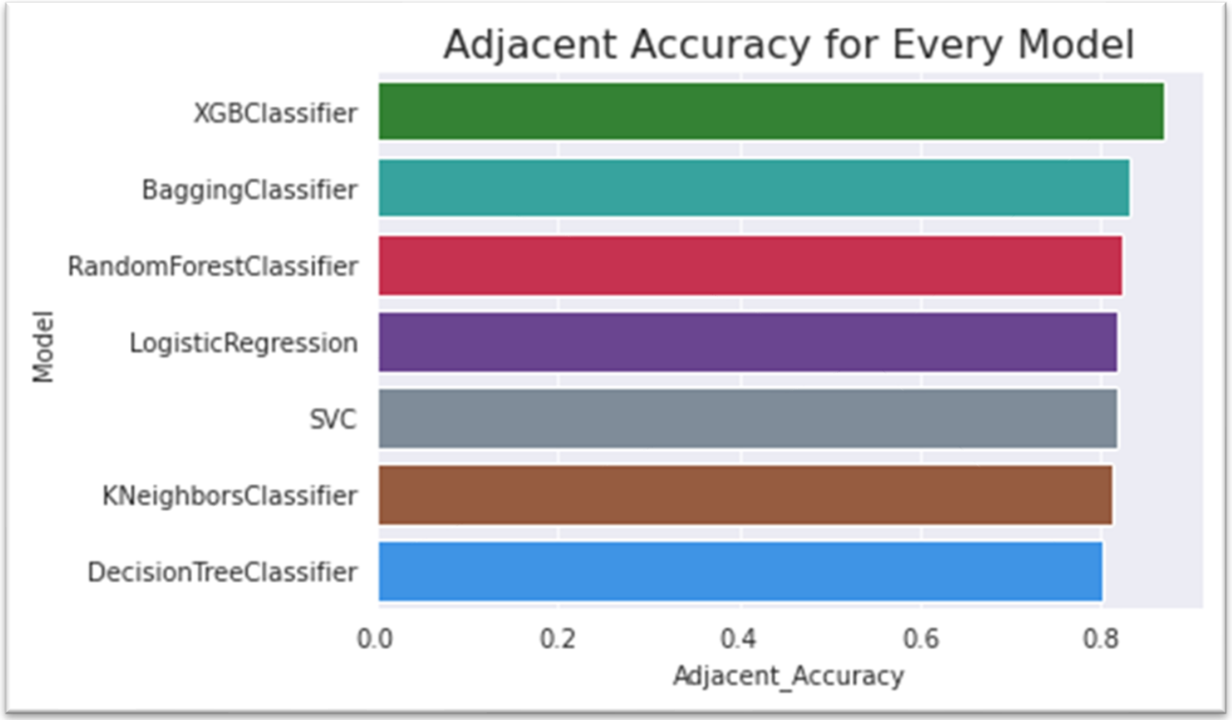

- All model have adjacent accuracy more than 0.8
- XGB Classifier again has the highest adjacent facies value for 86,8% and again Decision Tree Classifier become the model with the smallest adjacent accuracy on test data for 80,2%

Evaluation by CV Score

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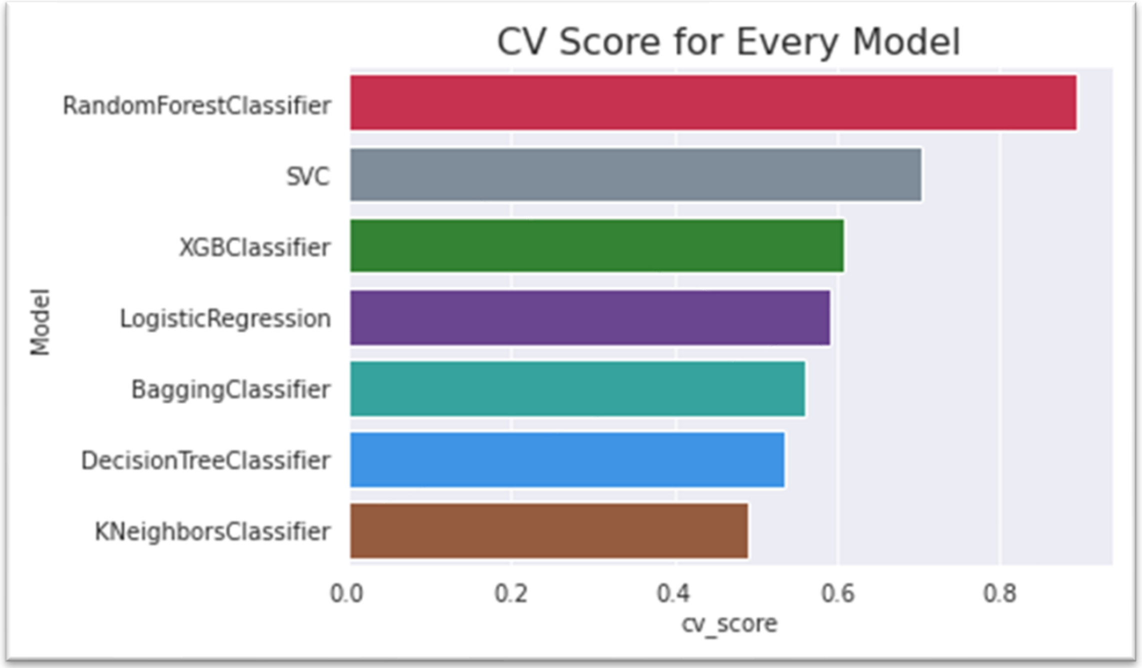
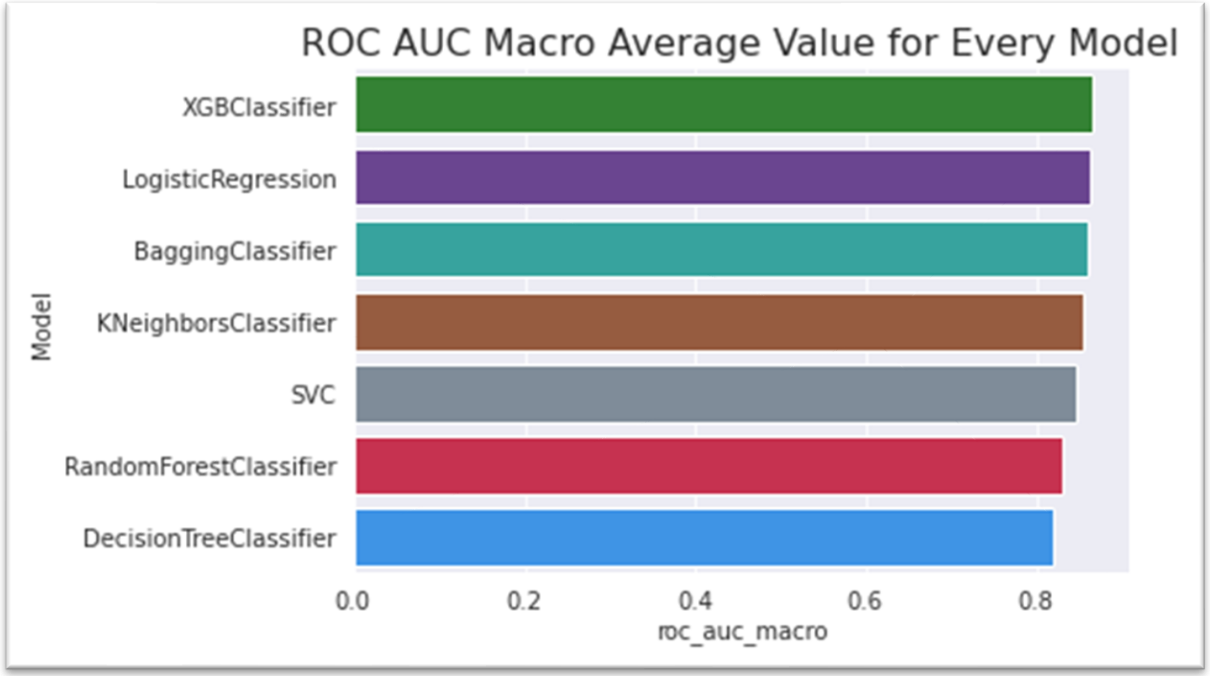
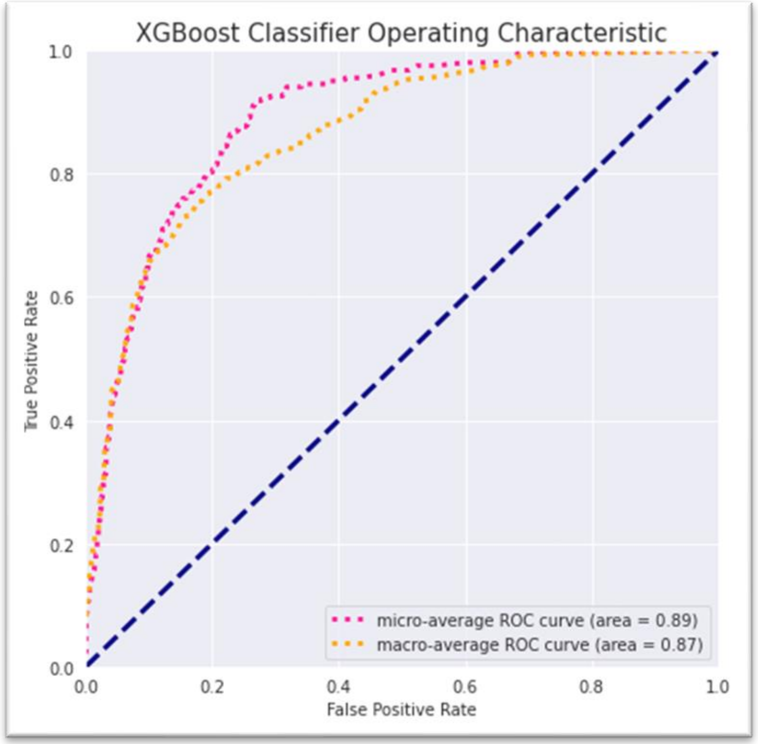


- Random Forest Classifier has the highest cv-score for 89.34%, whereas KNN has the smallest cv-score for 49,1%.
- Random forest and svc have a high difference between CV score and accuracy, we can say that for this two model is overfit on train data, eventhough already pass the cross validation process.
- For acceptable CV Score XGB Classifier has the highest cv score for 60.85% whereas KNN has the smallest cv score for 49,1%.

Evaluation by ROC-AUC





- All model have roc-auc more than 0.8
- XGB Classifier has the highest ROC-AUC score of 86.5% whereas Decision Tree Classifier has the smallest roc-auc score of 82%.
- For multi-class classification ROC-AUC curve was constructed by computing average TPR and FPR for every category.

Evaluation by Prediction Result

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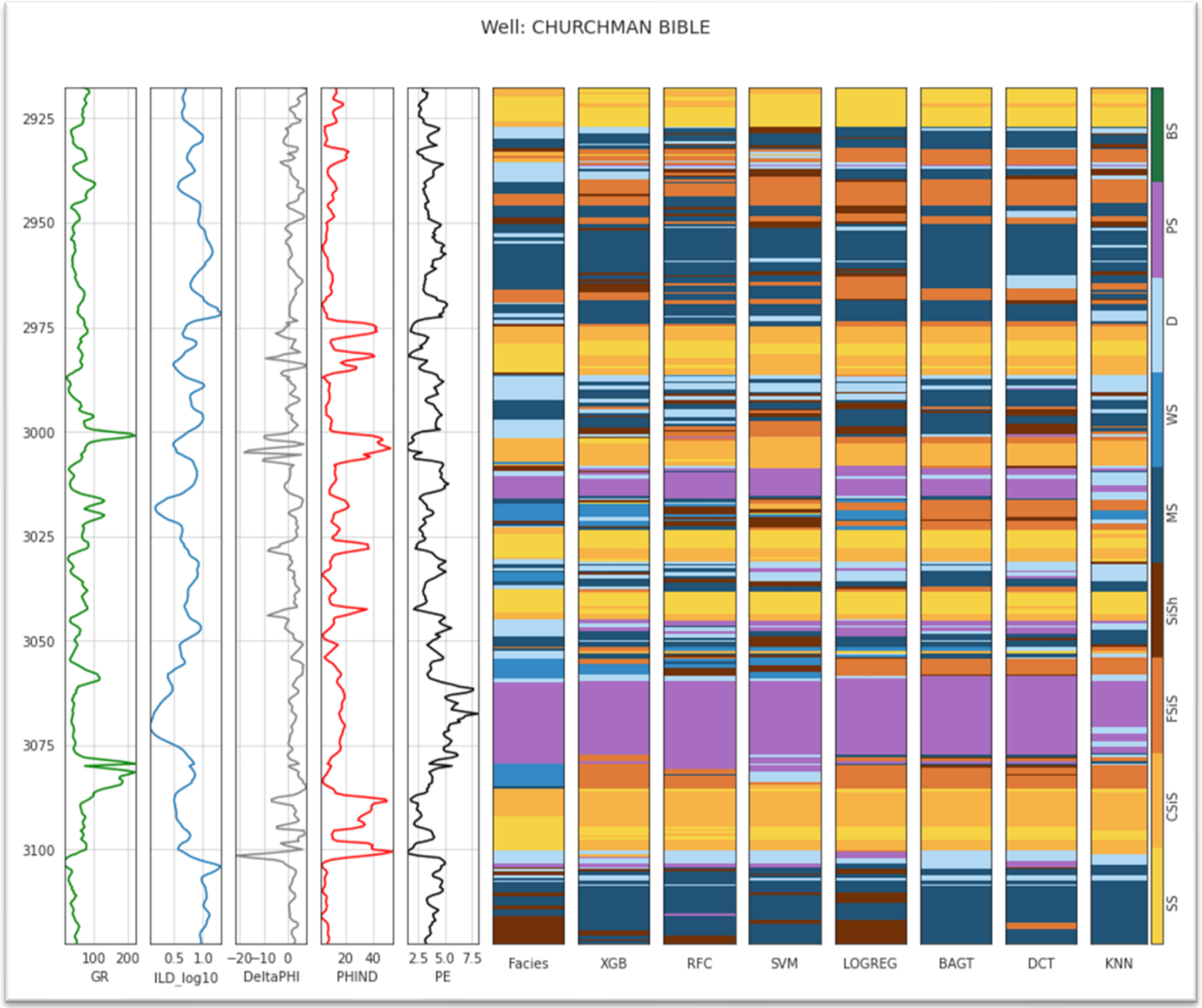

- every model could **predict the majority of facies** when the layer doesn't variate much, like at the depth around **3075 and 2960**
- But when it comes to variative layer like in the depth around **3050 and 3100** the predicted lithofacies become **clearly different** with actual facies.
- **XGB Classifier** with the **best performance evaluated from accuracy, adjacent accuracy, cv-score, and ROC-AUC** curve could predict the lithofacies layer better than any other model.

Conclusion

Conclusion

This research found that for facies classification case by comparing the performance of the models, the best supervised machine learning algorithm is XGBoost Classifier with an accuracy of 52.7%, adjacent accuracy of 86.6%, cv-score of 60.8%, and ROC-AUC score of 86.5%. One concern about this XGBoost classifier is although the performance score is good compare to others model the training time is longer than other simple supervised machine learning model like K-Neighborh or Decision Tree, this training time could be the consideration for design the facies classifier for production purpose.

Reference

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