

**Introduction:** In order to better organize machine learning workflows, pipelines can be used to make work quicker. In this exercise, two different data sets (Red Wine Quality Data Set and Brain Stroke Data Set) were used to compare performance of an ML pipeline. Within the pipeline, a scaling, feature selection, and Random Forest Classifier algorithm were combined. Following pipeline setup, a Bayesian Optimization was performed. The mean accuracy score of the train and test data was then collected. Here, the mean accuracy score describes the mean accuracy of the given data across all subsets (cv).

**Dataset Description:** The first data set worked with was the Red Wine Quality data set. In this data set, red wine quality is measured by twelve features including fixed acidity, volatile acidity, citric acid, residual sugar, chlorides, free sulfur dioxide, total sulfur dioxide, density, pH, sulphates, alcohol, and quality. For each of these features, the number of observations was 1599. Regarding preprocessing, I checked for null values using a `isnull().values.any()` function. There were not any null values. In this exercise, hyperparameter optimization was performed to improve the predicting model. The feature chosen to predict was quality.

The second data set worked with was the Brain Stroke data set. In this data set, occurrence of a stroke is measured by eleven features including gender, age, heart disease, ever married, work type, residence type, average glucose level, BMI, smoking status, and presence of stroke. For each of these features, the number of observations was 4981. Regarding preprocessing, I checked for null values by observing the table produced by `.describe` and also by checking with `isnull().values.any()` function. There were not any null values, however five features were listed as objects for data type. To change these to int, I used one hot encoding. The features changed from object to int using one hot encoding were gender, ever married, work type, residence type, and smoking status.

**Experimental Setup:** For this exercise, I used the Python programming language via Google Colab. For packages, pandas was used for data manipulation. The sklearn package was used for further data processing such as `train_test_split`, `StandardScaler`, `RandomForestClassifier`, `Pipeline`, `VarianceThreshold`, `make_classification`, `model_selection`, and `cross_val_score` .

As seen in the Auto Sklearn Fail exercise and the Hyperparameter Optimization exercise, the Wine Quality dataset is very imbalanced. Because of this, the same techniques used in those two exercises were used here. To account for imbalanced data and underrepresented data groups, Synthetic Minority Oversampling Technique (SMOTE) and `train_test_split` stratification were used before running Random Forest Classifier. To gain reproducible results across multiple executions, the random state was set to 42.

Beginning with Red Wine Quality Data Set, the pipeline was built to include `StandardScaler`, `VarianceThreshold`, and `RandomForestClassifier`. This pipeline was fit and the mean accuracy train and test score generated before a Bayesian Optimization was conducted. For Bayesian Optimization, `init_points` was set to 5, and `n_iter` was set to 50. Hyperparameters tuned here included `max_depth` (range of (1,500)), `max_leaf_nodes` (range of (10,100)), `max_samples` (range of (0.1, 0.8)), `min_samples_leaf` (range of (1,6)), `min_samples_split` (range of (1,6)), `n_estimators` (range of (50,700)), and `n_jobs` (range of (-1,400)). Regarding hyperparameter function, `max_depth` describes the depth of the tree, `max_leaf_nodes` describes the number of leaf nodes used, `max_samples` describes

the number of samples taken from X for training, `min_samples_leaf` describes the minimum number of samples needed to form a leaf node, `min_samples_split` describes the minimum sample requirement for a split, `n_estimators` describes the number of trees, `n_jobs` describes the number of jobs that run in parallel. After the Bayesian Optimization, the new mean accuracy test score was generated.

For the second data set, Brain Stroke Data Set, the same pipeline was tested as was generated for the Red Wine Quality Data Set. Additionally, the Brain Stroke dataset was imbalanced, so Synthetic Minority Oversampling Technique (SMOTE) and `train_test_split` stratification were used before running Random Forest Classifier.

**Results:** Beginning with the Red Wine Quality dataset, before the Bayesian Optimization, the test mean accuracy score was 0.88 (Table 1). After Bayesian Optimization the test score was 0.92 (Table 1). As a result of using Bayesian Optimization, the mean accuracy test score improved by 4.55%.

Next for the Brain Stroke dataset, before the Bayesian Optimization, the test mean accuracy score was 0.9478(Table 2). After Bayesian Optimization test score was 0.9502 (Table 2). As a result of using Bayesian Optimization, the mean accuracy test score improved by 0.25%.

Table 1: Red Wine Quality Pipeline	
Mean Accuracy Score Before Bayesian Optimization	0.88
Mean Accuracy Score After Bayesian Optimization	0.92

Table 2: Brain Stroke Pipeline	
Mean Accuracy Score Before Bayesian Optimization	0.9478
Mean Accuracy Score After Bayesian Optimization	0.9502

**References:**

1. Saeed, Mehreen. “Modeling Pipeline Optimization with Scikit-Learn.” MachineLearningMastery.Com, 21 Oct. 2021, [machinelearningmastery.com/modeling-pipeline-optimization-with-scikit-learn/](https://machinelearningmastery.com/modeling-pipeline-optimization-with-scikit-learn/).
2. “Sklearn.Pipeline.Pipeline.” Scikit, [scikit-learn.org/stable/modules/generated/sklearn.pipeline.Pipeline.html](https://scikit-learn.org/stable/modules/generated/sklearn.pipeline.Pipeline.html). Accessed 3 Apr. 2024.
3. “Sklearn.Ensemble.Randomforestclassifier.” Scikit, [scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html](https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html). Accessed 15 Apr.
4. Auto-sklearn Fail Exercise wrote in overleaf. <https://www.overleaf.com/project/66194f82a4874abfed54600f>
5. GfG. “One Hot Encoding in Machine Learning.” GeeksforGeeks, GeeksforGeeks, 21 Mar. 2024, [www.geeksforgeeks.org/ml-one-hot-encoding/](https://www.geeksforgeeks.org/ml-one-hot-encoding/).