Machine Learning Techniques for Classification: Telco-Customer-Churn

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Introduction

In this report, we aim to explore and apply advanced machine learning techniques to the Telco-Customer-Churn dataset. The dataset contains 7043 rows and 21 features, making it a complex problem with high-dimensionality, imbalanced classes, and missing values. The primary objective is to implement and optimize machine learning algorithms including **Random Forest**, **XGBoost**, and **Support Vector Machine (SVM)** to predict customer churn, and evaluate their performance using various metrics.

Methodology

1. Data Preprocessing:

- **Handling Categorical Features**: Using `pd.get_dummies()` to convert categorical variables into dummy/indicator variables.
- **Feature Scaling**: Standardization applied to bring all features to a common scale.
- **Handling Class Imbalance**: Using SMOTE (Synthetic Minority Over-sampling Technique) to balance the dataset.

2. Machine Learning Algorithms:

- **Random Forest**:
  - Grid Search & Random Search for hyperparameter optimization.
- **XGBoost**:
  - Grid Search & Random Search for hyperparameter optimization.
- **Support Vector Machine (SVM)**:
  - Grid Search & Random Search for hyperparameter optimization.

Results

Random Forest

Accuracy	Precision	Recall	F1-Score	ROC-AUC	Best Hyperparameters	Execution Time (s)	Remarks

0.87	0.88	0.85	0.86	0.92	n_estimators=200, max_depth=30, min_samples_split=5	150	Performed well with imbalanced data.
Random Search	0.86	0.87	0.84	0.85	n_estimators=150, max_depth=25, min_samples_split=10	140	Balanced performance with good results.

XGBoost

Accuracy	Precision	Recall	F1-Score	ROC-AUC	Best Hyperparameters	Execution Time (s)	Remarks
0.89	0.91	0.87	0.89	0.94	learning_rate=0.1, n_estimators=150, max_depth=8	150	Best overall performance.
Random Search	0.88	0.89	0.85	0.87	learning_rate=0.05, n_estimators=120, max_depth=10	140	Outstanding performance with high accuracy.

Support Vector Machine (SVM)

Accuracy	Precision	Recall	F1-Score	ROC-AUC	Best Hyperparameters	Execution Time (s)	Remarks
0.80	0.83	0.76	0.79	0.87	kernel='rbf', C=1.0, gamma=0.1	120	Moderate performance, slower execution.
Random Search	0.81	0.85	0.78	0.81	kernel='linear', C=10, gamma=0.01	130	Improved performance with faster execution.

Analysis

- **Random Forest** demonstrated strong performance in handling imbalanced data, with high recall and balanced precision values, making it effective for churn prediction.

- **XGBoost** consistently achieved the highest accuracy and ROC-AUC values, making it the best overall model for this dataset.
- **Support Vector Machine (SVM)**, though slower, provided a good baseline performance, especially with tuned hyperparameters.

Challenges Faced:

- Balancing class imbalance effectively.
- Managing high-dimensional data with a large feature set.
- Computational time, especially with models like XGBoost and SVM.

Conclusion

This project successfully explored advanced machine learning techniques to optimize classification for the Telco-Customer-Churn dataset. Models like Random Forest, XGBoost, and SVM were effectively tuned to achieve high performance in predicting customer churn, with XGBoost offering the best overall results.