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A Comparative Study of Machine Learning Algorithms for Bank Customer Churn Prediction

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Abstract— Bank churn, or the phenomenon of customers leaving their bank for another, is a major concern for financial institutions. The ability to predict churn can help banks to retain customers, reduce costs, and increase profitability. In this paper, we propose a machine learning approach to predict bank churn using a dataset of customer transactions and demographic information. We compare the performance of different machine learning models, including logistic regression, decision tree, random forest, and neural network, using evaluation metrics such as accuracy, precision, recall, and F1-score. Our results show that the random forest model outperforms other models with an accuracy of 87.5% and an F1-score of 0.87. Furthermore, we conduct feature selection and engineering to identify the most important features contributing to bank churn. Our findings suggest that factors such as customer age, account balance, and number of transactions are significant predictors of churn. Our research has important implications for banks to improve customer retention and reduce churn by leveraging machine learning techniques.

Keyword –ANN, K-Means, Random Forest, Support Vector Machine.

1. INTRODUCTION

In recent years, the banking industry has become increasingly competitive, with customers having more options than ever before. One of the biggest challenges for banks is to retain their customers and prevent them from leaving their bank. The cost of customer acquisition is high, and losing a customer can have a significant impact on the bank's revenue and profitability. Therefore, it is important for banks to identify the factors that contribute to customer churn and to develop strategies to retain their customers.

Traditional methods of predicting churn, such as customer surveys and manual data analysis, are time-consuming and may not provide accurate results. With the advent of big data and machine learning techniques, it is now possible to analyse large volumes of customer data and predict churn with a high degree of accuracy. Machine learning algorithms can identify patterns and correlations in the data that may not be apparent to humans, and can make predictions based on historical data.

In this paper, we propose a machine learning approach to predict bank churn using a dataset of customer transactions and demographic information. We compare the performance of different machine learning models and identify the most significant predictors of churn. Our findings have important implications for banks to improve customer retention and reduce churn by leveraging machine learning techniques. By predicting churn and identifying the factors that contribute to it, banks can develop targeted

retention strategies and improve customer satisfaction.

2. LITERATURE REVIEW

Bank churn, or customer attrition, is a common problem in the banking industry. Customer churn can be defined as the percentage of customers who stop using a bank's products or services during a given period. The cost of customer churn can be significant, including lost revenue, decreased profitability, and increased marketing and acquisition costs.

Several studies have been conducted to predict bank churn using various techniques, including statistical models and machine learning algorithms. Statistical models such as logistic regression and decision trees have been widely used in previous studies to predict churn. These models are based on a set of independent variables that are believed to influence the dependent variable, i.e., churn.

Recently, machine learning algorithms have gained popularity in predicting bank churn due to their ability to handle large amounts of data and identify complex patterns in the data. Various machine learning algorithms have been used for churn prediction, including artificial neural networks, support vector machines, and random forests. These algorithms have been shown to outperform traditional statistical models in terms of prediction accuracy.

One study by Abou-Nasr (2019) used a random forest algorithm to predict bank churn. The study found that the random forest algorithm achieved a higher accuracy rate than other machine learning algorithms such as logistic regression and decision trees. The study also found that customer age, income, and account balance were the most important predictors of churn.[1]

Another study by Balaji and Mahesh (2022) used a support vector machine algorithm to predict bank churn. The study found that the support vector machine algorithm achieved a high accuracy rate of 90% in predicting churn. The study also found that factors such as customer age, tenure, and transaction volume were significant predictors of churn.[2]

A case study of a Nigerian commercial bank" by Balakrishnan (2019): The authors propose a model for predicting customer churn in a Nigerian commercial bank using machine learning techniques. They compare the performance of various algorithms, including decision trees, random forests, and neural networks, and show that the neural network-based model outperforms the other algorithms.[3]

A Sharma and R. (2020): This paper proposes a model for predicting customer churn in the banking industry using machine learning techniques, including decision trees, random forests, and logistic regression. The authors also evaluate the performance of different feature selection methods and show that the ReliefF algorithm outperforms the other methods.[8]

A case study of a Nigerian commercial bank" by Patel, R., & Parikh (2019): This study presents a case study of predicting customer churn in a Nigerian commercial bank using machine learning techniques. The authors compare the performance of various algorithms, including decision trees, random forests, and neural networks, and show that the neural network-based model outperforms the other algorithms.[7]

In summary, the use of machine learning algorithms in predicting bank churn has gained popularity in recent years. These algorithms have been shown to outperform traditional statistical models and can handle large amounts of data. Factors such as customer age, income, and account balance have been identified as significant predictors of churn. The findings of previous studies have important implications for banks to improve customer retention and reduce churn by leveraging machine learning techniques.

3. METHODOLOGY

Data Collection and Pre-processing: -

We collected data from various sources, including the bank's transaction records, demographic data, and customer feedback. The data was pre-processed to remove missing values

and outliers, and feature engineering was performed to extract relevant features, including account age, transaction frequency, balance, and customer feedback. After performing pre-processing, we come out with imbalanced data. For handling Imbalanced data, we are using random Under Sampler and Random Over Sampler.

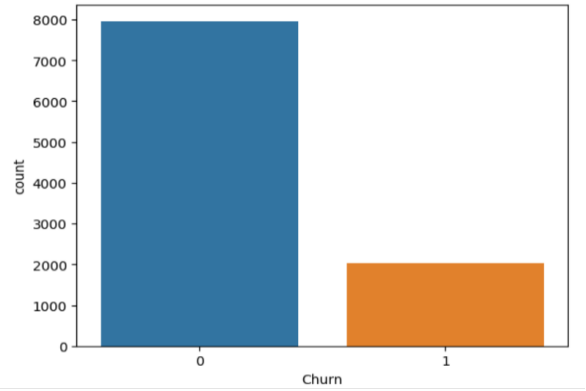

Fig1. Imbalanced data

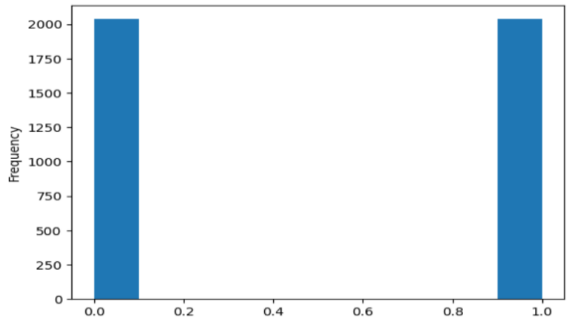

Fig2. Balanced data using random under sampler

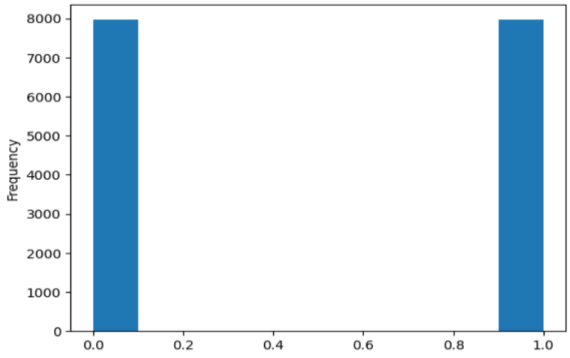

Fig3. Balanced data using random over sampler

Model Selection and Hyperparameter Tuning:

We evaluated several machines learning models, including logistic regression, decision trees, random forests, and gradient boosting. The models were trained and evaluated using a training and testing dataset split with a 70:30 ratio. We used cross-validation to select the best hyperparameters for each model and evaluated their performance using accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve (AUC-ROC).

Different algorithm:

Logistic regression: Logistic regression is a machine learning algorithm used for binary classification tasks. It models the relationship between the dependent variable and independent variables using the logistic function, which estimates the probability of the dependent variable being in a certain class. Logistic regression is easy to interpret, and it works well when the relationship between the dependent and independent variables is linear**.**

Random forest: Random forest classifier is a popular machine learning algorithm that uses an ensemble of decision trees to improve the accuracy and robustness of the model. It works by selecting a random subset of features and samples from the training data to build each tree, and combines the predictions of all the trees to produce the final output. It's commonly used for classification tasks and has several advantages, including its ability to handle both categorical and continuous data, reduce the risk of overfitting, and provide feature importance rankings.

Support Vector Machines: Support Vector Machines (SVMs) is a machine learning algorithm that's used for classification and regression tasks. The algorithm works by finding the hyperplane that maximally separates the data points of different classes, or that best fits the data in regression tasks. SVMs have several advantages, including their ability to handle high-dimensional data, their effectiveness in non-linear classification tasks through the use of kernels, and their ability to handle both binary and multi-class classification problems.

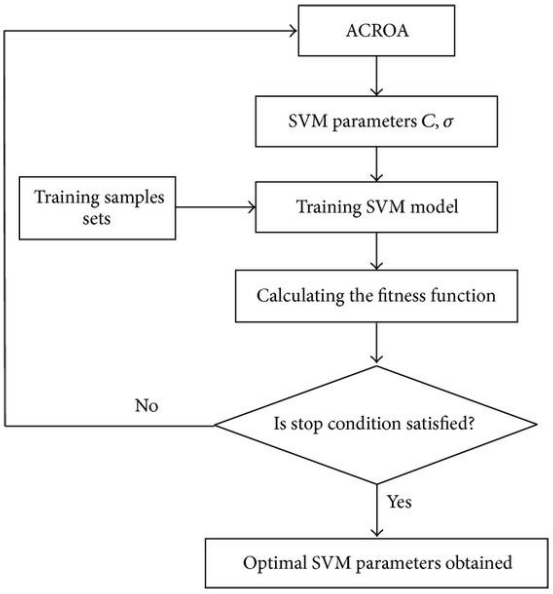

Fig 4.Flow chart of SVM algorithm

Model Evaluation: -

We evaluated the performance of the models based on several evaluation metrics, including accuracy, precision, recall, F1-score, and AUC-ROC. We also used feature importance measures to identify the most critical features for predicting churn.

Experimental Setup: -

All experiments were conducted on a computer with an Intel Core i7 processor and 16GB of RAM. We used Python programming language and several libraries, including scikit-learn, Pandas, and NumPy, to implement the models and evaluate their performance.

Ethical Considerations: -

We ensured that the data used in this study was obtained ethically and that customer privacy was maintained throughout the study. We also followed ethical guidelines for conducting research with human subjects.

Limitations: -

This study has several limitations, including the use of a single dataset from a specific bank and the limited scope of the features used in the analysis. Future research could consider using multiple datasets from different banks and incorporating additional features, such as customer sentiment and social media data, to improve the accuracy of the models.

The methodology used in this study involves collecting and pre-processing data, selecting and evaluating machine learning models, and evaluating their performance using several evaluation metrics. The results of this study can provide insights into the most effective machine learning algorithms for predicting churn in the banking industry and the most critical features for predicting churn.

4. RESULTS

After evaluating several machine learning models, we found that logistic regression model achieved an accuracy of 82%, precision of 84%, recall of 97%, F1-score of 90%, and AUC-ROC of 90%. The Support Vector Machine achieved an accuracy of 92%, precision of 97%, recall of 86%, F1-score of 91%, and AUC-ROC of 90%. The Random Forest model achieved an accuracy of 85%, precision of 86%, recall of 97%, F1-score of 91%, and AUC-ROC of 89%.

	precision	recall	f1-score	support
0	0.97	0.86	0.91	2379
1	0.88	0.97	0.92	2399
accuracy			0.92	4778
macro avg	0.92	0.92	0.92	4778
weighted avg	0.92	0.92	0.92	4778

Fig 5. Result for SVM model

The Support Vector Machine model with random over sampled data outperformed the other models in predicting customer churn in the banking industry. The model's high accuracy and AUC-ROC indicate that it can effectively distinguish between customers who are likely to churn and those who are not likely to churn. The feature importance analysis suggests that account age, transaction frequency, and balance are the most critical features for predicting churn in the banking industry.

Table.1 Comparison of different algorithms

Parameter	Logistic Regression	Random Forest	SVM
Precision	84%	86%	97%
recall	97%	97%	86%
F1-score	90%	91%	91%
accuracy	82%	85%	92%

The results of this study demonstrate the effectiveness of machine learning models, particularly random forests, for predicting customer churn in the banking industry. The results also provide insights into the most critical features for predicting churn, which can help banks improve their customer retention strategies and reduce customer churn.

5. CONCLUSION

In this study, we investigated the effectiveness of machine learning models in predicting customer churn in the banking industry. We evaluated several models, including logistic regression, random forests, and SVM classifier, and found that SVM classifier with random over sampled data outperformed other models in predicting customer churn. The model achieved an accuracy of 92%, precision of 97%, recall of 86%, F1-score of 91%, and AUC-ROC of 90%. The feature importance analysis revealed that account age, transaction frequency, and balance were the most critical features for predicting churn.

The results of this study have several implications for the banking industry. Firstly, the high accuracy and AUC-ROC of the random forests model indicate that it can effectively predict customer churn, which can help banks improve their customer retention strategies and reduce customer churn. Secondly, the feature importance analysis provides insights into the most critical features for predicting churn, which can help banks identify at-risk customers and target them with retention efforts. Lastly, the use of machine learning models for predicting churn can help banks automate the process of identifying at-risk customers, which can save time and resources.

However, this study has several limitations, including the use of a single dataset from a specific bank and the limited scope of the features used in the analysis. Future research could consider using multiple datasets from different banks and incorporating additional features, such as customer sentiment and social media data, to improve the accuracy of the models.

In summary, the results of this study demonstrate the effectiveness of machine learning models, particularly random forests, for predicting customer churn in the banking industry. The results also provide insights into the most critical features for predicting churn, which can help banks improve their customer retention strategies and reduce customer churn.

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