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CREDIT CARD APPROVAL PREDICTION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Credit cards have become an everyday payment choice, leading to a surge in applications and posing challenges for swift approval processes. This study aims to find the best machine learning algorithms for credit card approval by searching 208 papers from various sources then through inclusion and exclusion, are narrowed into 23 most relevant papers. The highlighted issues include time-consuming manual approval, high use of human resources, and possible human errors in the process. The manual method's inefficiencies can lead to wrong approvals, which could cause financial losses and harm the banks' reputation, especially if it happens in large scales. In this situation, machine learning can offer a solution for faster approval procedures and fewer errors. To address these concerns, this research evaluates different machine learning algorithms, including decision trees, random forests, logistic regression, support vector machines, and artificial neural networks. The evaluation considers algorithm ranking, statistical measures, and the nature of the algorithms to understand their effectiveness and potential for overfitting. The author's findings emphasize that adopting machine learning algorithms like random forests, logistic regression, and support vector machine can significantly enhance credit card approval processes. These algorithms exhibit higher accuracy and a reduced risk of overfitting, contributing to overall bank performance improvement. Furthermore, recommendations are provided for a more effective model development process, including choosing suitable methodologies, exploring data, reducing complexity, tuning parameters, and validating results. By following these suggestions, banks can enhance model performance while minimizing overfitting concerns.This systematic review not only underscores the importance of embracing machine learning for credit card approval but also offers practical insights into selecting algorithms and refining model development strategies. By embracing advanced algorithms and improved model building techniques, banks can navigate challenges posed by increasing credit card applications and establish more efficient, accurate, and dependable credit approval systems.

Keywords: *Credit Card, Credit Card Approval, Manual, Machine Learning*

1. INTRODUCTION

Credit card is a credit facility given to a customer by banks and finance companies [1]. It's one of a substitute for cash as a payment method in the form of a plastic card that can be used by consumers to exchange for the goods and services they want at places that accept payment by credit card [2]. The procedure for applying for a credit card begins with making an agreement that offers installments to users to pay off consumer goods or services within a certain period of time.

Nowadays, credit cards have been increasing exponentially, the manual credit card approval process takes a long time plus a large number of applicants can make this process take longer [4], [5], [8], [10], [12]. In addition to the long approval process, this also requires banks to increase the number of special workers for the credit card approval process [4], [7]. Besides being inefficient, manual credit card approval can cause a human error in the approval process so that people who should not be approved are actually approved and vice versa [4], [5], [8], [10], [12]. Furthermore, there are several banks that have

implemented machine learning but the model they used is still inefficient so the performance of the approval is also not optimal [3]. These mistakes can impact negatively on bank loan management and can cause losses to the bank in terms of finance which negatively affect the bank's reputation [9], [13], [14].

In several developing countries, it is difficult for banks to approve their customers' credit card applications if they only rely on a manual approval system. While some of the reason is due to people in developing countries rarely using credit cards, it's also caused by the difficulty in determining the customers with good credit risk. Because of these reasons, it is hard for banks to actually provide credit cards to their customers in these developing countries [5], [6]. [16], [17].

Looking at the issue of credit card approval, the credit card approval process can be done faster if the processes are automated. This automation can be achieved by implementing machine learning models [8], [10] [17]. An optimal machine learning model can be obtained by choosing the right algorithm, the right pre-processing method, and training model with large amounts of historical data [10], [12], [17].

The motivation of the author doing this research is to help banks improve their credit card approval process by suggesting algorithms widely used for the credit card approval as well as some recommendations for improving the accuracy as well as reducing cases of overfitting. The author hopes that this research can provide insight on which algorithms are more effective for credit card approval as seeing there are so many machine learning algorithms such as decision tree, random forest, logistic regression, k-nearest neighbor, naive bayes, support vector machine, and many others machine learning algorithms. Besides speeding up the credit card approval process, the machine learning model can also help banks in reducing human error in the approval process, saving costs as well as minimizing efforts or human resources needed for credit card approval.

The purpose of this paper is to recommend some algorithms that are suitable to be applied on credit card approval and general methods for improving accuracy and reducing overfitting. As there are so many machine learning algorithms, people might find it hard to choose among the algorithms, this applied even more on the less known algorithms. The author conducts this research by searching the papers related to credit card approval machine learning, then the author explores, summarizes, analyzes, and synthesizes the information found in these papers.

2. THEORETICAL FOUNDATION

Machine learning is the fastest growing artificial intelligence application today. Machine learning uses a computer system that can perform very large computational tasks using text data sets, or numbers. Thus it can reduce one's workload and help work processes that can save time and expenses. Machine learning algorithms work by recognizing patterns in data. This pattern recognition process is divided into 2 ways: supervised learning and unsupervised learning. In supervised learning, labeled data is processed by machine learning algorithms to generate trained models. After that, the new data is used in the model to obtain the results. Because the results are obtained from original data that has been labeled, this method can be used to solve real world problems. In unsupervised learning, data that has no labels are processed using machine learning algorithms to create trained models. Since there are no labels, this trained model identifies patterns in the data by grouping salient attributes [17].

There are several machine learning algorithms that can be used:

2.1. Logistic Regression

Logistic regression is a development of the linear regression method where logistic regression will only produce 2 categorical outputs. This algorithm can represent well the probability of a class having binary outcomes [7], [9], [18]. Logistic regression is one of the classification algorithms in the supervised learning approach. This algorithm classifies data using a logistic function. Logistic regression is good to use when a graph is completely inappropriate and does not match the data points. Logistic regression can create a curve on the existing graph to match the existing data points because it uses a sigmoid function in logistic regression. The sigmoid function is useful for creating curvature in the graph [19].

2.2. Decision tree

Decision tree algorithm is one of the algorithms in the supervised learning approach. This algorithm can be used to solve classification and regression problems. The purpose of this model is to create a trained model that will later be used to predict groups or classes of existing variables with the rules of the trained data [20].

Decision trees are similar to flowcharts that can describe the flow of the trained model. Decision Tree is suitable for both numerical data and categorical data [16]. Decision tree serves to explore the data, finding the relationship between several candidate input variables and the target variable [11].

2.3. Random forest

Random forest is simply a collection of several decision trees [16]. This method runs decision trees in parallel so that there is no relationship between one tree and another. The main objective of this algorithm is to determine the final output by combining multiple decision trees [15]. Random forest classifier works by doing row sampling and feature sampling then coupled with replacement [16]. Random Forest has the advantage that it can handle a large number of input variables without having to delete the variables and produces little variation because changes in data will not affect the accuracy of the model [10], [19]. Similar to other supervised learning, the variables that are recommended to be used are variables that are important to be classified [19].

2.4. Artificial neural network

Artificial Neural Networks (ANN) are information processing structures evolved from the biological neural network of the human brain, working in parallel and capable of storing knowledge gained from experience. They model complex relationships between input features and target outputs, with performance measured using loss functions such as cross-entropy. ANNs are suitable for various tasks including classification and data mining, and they consist of interconnected processing elements with local processing capabilities based on input values and stored memory. The pattern of relationships between neurons, weight determination, and activation functions are key characteristics of ANN models [1] [8] [13].

2.5. Support Vector Machine

Support Vector Machines (SVM) is a supervised machine learning algorithm used for classification and regression problems. It operates by plotting data items as points in an n-dimensional space, and its effectiveness is particularly notable in supervised learning scenarios involving linearly categorized data [1] [6]. SVM's core objective is to discover the optimal hyperplane that divides two classes in the input space through Structural Risk Minimization (SRM) principles. This hyperplane is positioned between the class sets, with the margin calculated as the distance between the hyperplane and the nearest pattern of each class (support vectors), making SVM effective for binary classification tasks [13]. This classification algorithm excels in producing reliable results, even with limited data, by iteratively constructing a hyperplane in an n-dimensional space and minimizing errors through support vectors. Once the best-fit hyperplane is obtained, the classifier is equipped to categorize data points and provide predictions [16].

3. RESEARCH METHOD

In this section, the author will discuss how the author collected the relevant papers. The author uses journal websites to search for relevant papers and the use of keywords followed by the selection of the output of the journals obtained.

3.1. Search process

After determining the topic to be discussed, the author begins to search for papers that are relevant to the paper the author is researching ranging from the year 2017 to 2023. Papers were collected from various sources, such as the Institute of Electrical and Electronics Engineers (IEEE), IOS Press, Springer, Sage Journals, AIP Publishing, International Journal of Machine Learning (IJMLC), International Journal of Soft Computing and Engineering (IJSCE), International Journal for Research in Applied Science and Engineering Technology (IJRASET), Journal of Intelligence Studies in Business (JISIB), and so on.

Through existing sources, the author searched for papers using several keywords to obtain relevant papers. The keywords used by the author include 'Credit Card Approval', 'Machine Learning', 'Data Mining', and 'Prediction'. The author used ‘Data Mining’ as key words because ‘Data Mining’ algorithms are also related to ‘Machine Learning’ algorithms. Specifically, the author used the following keywords:

- "Credit Card Approval" AND ("Machine Learning" OR "Data Mining" OR “Prediction”)
- “Credit Card” AND ("Machine Learning" OR "Data Mining" OR “Prediction”)
- “Credit Card” AND ("Machine Learning" OR "Data Mining" OR “Prediction”)
- “Credit Card Approval”

- "Credit Card"

The author uses specific to general keywords to get the most relevant papers. While the author mostly uses the first three keywords in most of the search process, the author also uses the last two keywords due to special cases. As there are many algorithms in machine learning and data mining, some authors use the name of these algorithms and not machine learning and data mining.

3.2. Inclusion and exclusion

After the search results were collected, the author browsed, read and understood each paper through their title, abstracts, and the content to determine which papers were suitable for research. The author includes studies of machine learning, data mining, credit card approval within the past 6 years. Finally, through this inclusion and exclusion the author finds that 23 out of 208 papers are interesting and suitable for research. The author looks at and compares the selected papers. The author compares in terms of objectives, preprocessing used, algorithms used, and accuracy of each algorithm.

3.3. Data extraction

Table 1.Number Of Papers In Sources That Have Been Collected And Selected

Source	Studies Found	Candidate Studies	Selected Studies
IEEE	8	5	2
IOS Press	3	3	1
Springer	73	2	1
Sage Journals	1	1	1
AIP Publishing	1	1	1
IJMLC	1	1	1
IJSCE	1	1	1
IJRASET	1	1	1
IJRAR	1	1	1
IJSRD	1	1	1
IJAIDM	1	1	1
IRJET	1	1	1
JAICT	1	1	1
IJEAT	1	1	1
JISIB	1	1	1
Sinkron Journal Publications & Informatics Engineering Research	1	1	1
University of Colombo School of Computing	1	1	1
Indian Institute of Technology Kharagpur	1	1	1
California State University San Marcos	1	1	1
Other publication	108	22	3
Total	208	48	23

In this section, the author collects all data like the type of algorithms and the number of each algorithm used in these 23 papers. By comparing the algorithms in each paper, the author can see which algorithm is the most suitable to be used in developing the credit card approval machine learning model.

4. RESULT AND DISCUSSION

From the results of a review of researchers, the author found that some of the most widely used algorithms in credit card approval are Logistic Regression, Decision Tree, and Random Forest. Where logistic regression is very suitable to be used for supervised learning datasets and can represent well the possibility of classes that have binary outcomes [7], [9], [18], [19]. Decision trees can classify numerical and categorical data and display trained models in a form similar to a flowchart [11], [16], [20]. The random forest can handle a lot of input variables without deleting the variables and produces a small variation without affecting the accuracy of the model [10], [15], [16], [19]. Table 2 is the count of algorithms found used in each paper.

Table 2.Paper Count By Machine Learning Algorithm

Algorithm	References	Total Papers
Logistic Regression	[6]–[10], [13], [14], [16]–[18], [20]–[22]	13
Decision Tree	[7], [9], [11], [16], [18], [20]–[24]	10
Random Forest	[10], [15]–[18], [25]	6
Artificial Neural Network	[1], [7], [8], [13], [16], [21]	6
Support Vector Machine	[1], [5], [6], [13], [16]	5
K-Nearest Neighbor	[7], [18], [20], [21]	4
XGboost	[15], [16], [18]	3
Gradient Boosting	[5], [18]	2
Adaboost Classifier	[5], [18]	2
Random Wheel	[3]	1
Quadratic Discriminant Analysis	[21]	1
Parallel Factor PARAFAC	[4]	1
Naive Bayes	[11]	1
Linear Discriminant Analysis	[21]	1
Deep Neural Network	[12]	1
Bayesian Network	[23]	1
Total		58

The author found that these papers mainly have their datasets from these three sources while the rest are not mentioned. The three sources are University of California Irvine (UCI), Kaggle, and Bank. The author needs to identify the dataset source as the author would not only compare the data to the whole 23 papers, but to also get the fair evaluation within the same source, the author also compares the papers according to the most used dataset, that is the UCI dataset. Table III shows

Table 3.Paper Count By Dataset Source

Dataset Source	References	Total Paper
UCI Credit Approval Dataset	[1], [3], [6], [8], [11]–[13], [16], [17], [20]–[23], [25]	14
Kaggle Credit Card Approval Prediction	[4], [5], [14], [15], [18]	5
Real Bank Dataset	[7], [24]	2
Undefined source	[9], [10]	2

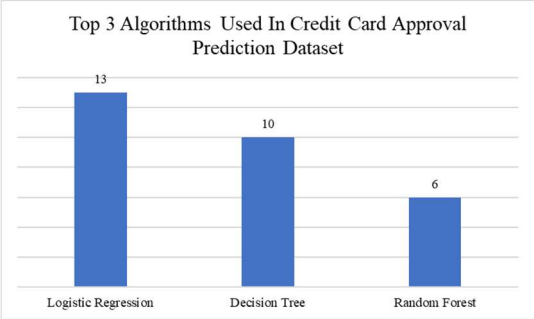

Figure 1. Top 3 Models Used In Credit Card Approval Prediction Dataset

Figure 1 shows the three most widely used algorithms for credit card approval prediction datasets which are logistic regression (LR), decision tree (DT), and random forest (RF). Out of the three most widely used algorithms, logistic regression comes on top which appears on 13 out of 23 papers, while decision tree and random forest comes at second and third with 10 and 6 papers respectively. According to the data collected, logistic regression, decision tree, and random forest can be considered as algorithms that are fairly popular to be used, which means that these algorithms would be easier to be studied and are less complicated than other less known algorithms.

Although not as much heard as the three previous algorithms, algorithms such as artificial neural network (ANN) and support vector machine (SVM), are also fairly good algorithms to be recommended. As to why they are considered as fairly good algorithms, beside the count of

papers by each algorithm that's used to validate the accuracy of the information and the accuracy to see how accurate the prediction of the model, in this study, the author also ranks the models of algorithm in each paper. Table IV shows the average rank of each algorithm according to whole papers and papers that use UCI dataset.

Table 4.Paper Count By Dataset Source

Algorithm	Average Rank	
	Whole Dataset	UCI Dataset
RF	1.83	1.5
LR	2.69	2.41
DT	2.89	2.75
ANN	2.75	3
SVM	3.14	3.8

From Table 4, it can be seen that random forest has a fairly good rank among all the algorithms whether in the UCI dataset or in all dataset followed by logistic regression, decision tree, artificial neural network and support vector machine. Through this rank, it can be seen that random forest, logistic regression, and decision tree perform consistently, whether using all dataset and in UCI dataset, the average rank is higher than 3. So according to this study, these three algorithms can be said to be quite suitable for credit card approval, especially using UCI dataset.

Although according to the algorithm's average rank on the UCI dataset, the author got random forest, logistic regression, and decision tree as a suitable algorithm for credit card approval, the author wants to explore more regarding these algorithms potential . Below is the statistical data of the 5 algorithms performance collected from UCI dataset.

Table 5.Data Collected Regarding Five Algorithms Performance Using Uci Dataset

Algorithm	Paper Count	Accuracy				
		avg	median	min	max	stdev
ANN	3	85.73	82.9	80.3	94	5.94
DT	7	84.16	84.71	73.3	99.7	7.43
LR	11	83.61	85.48	75	91.4	4.59
RF	4	87.41	87.1	86.7	88.75	0.8
SVM	5	83.95	84.9	78.2	86.23	2.92

From Table 5, the author can notice some different results than the average algorithm rank of the UCI dataset. From the data, the author notes that random forest has lower standard deviation of accuracy, followed by support vector machine and logistic regression. These data along with the nature of algorithms can sometimes be used to see whether these algorithms have potential to overfit. According to the standard deviation, these three algorithms are less likely to be overfit, especially on UCI dataset. But beside the three algorithms, decision tree algorithm and artificial neural network algorithm also have potential as their highest accuracy is higher than the three algorithms. Although these two are more prone to overfit than the three algorithms, but as long as the algorithm is carefully controlled, pruned, and regularized properly, then these overfit cases would be less likely to happen. Below is the review of the algorithm

Table 6.Five Algorithm's Review Along With Nature Of Algorithm And Uci Performance Data

Algorithm	Algorithm Nature	Review
RF	Strong ensemble approach	Very low standard deviation (stdev) and a small range suggest a low likelihood of overfitting. Ensemble nature and robustness contribute to this.
LR	Simple and stable	Low standard deviation (stdev) and consistent behavior show a low likelihood of overfitting. Simplicity and stability contribute to this.

SVM	Flexible and balanced	Moderate standard deviation (stdev) and a balanced range indicate a low likelihood of overfitting. SVM's balanced nature and adaptability help prevent overfitting.
DT	Versatile and easy to understand	The wide range between minimum and maximum indicates a moderate likelihood of overfitting. While versatile, decision trees can fit noise if not pruned properly.
ANN	Complex and sensitive to data pattern	The higher standard deviation (stdev) and variation suggest a moderate likelihood of overfitting. Complex nature might make it sensitive to overfitting, especially if not carefully controlled.

After reviewing the algorithm, the author also reviewed some methods based on papers on how some researchers increase their performance. It's important to know which methodology or process is used to build the machine learning model according to the needs such as KDD, CRISP-DM, and SEMMA. In this study related to credit card approval, most researchers use CRISP-DM and KDD for credit card approval. Most of the researchers perform Exploratory Data Analysis (EDA) to better understand the characteristic of the data then pay attention to implement dimensionality reduction, hyperparameter tuning, and cross-validation. Dimensionality reduction enhances the model efficiency and reduces noise, hyperparameter tuning optimizes model behavior for best performance, while cross-Validation validates model performance on diverse data subsets, these three have major impact in the increase of model performance and reducing overfit.

While knowing these methods' usefulness, the author also found several examples from the papers. The methods of dimensional reduction found are Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Non-negative Matrix Factorization (NMF). The examples of hyperparameter optimization that could be done are Grid Search, Particle Swarm Optimization (PSO), and Bayesian Optimization. Below is the algorithm and the example of their parameters that could be optimized.

Table 7.Five Algorithm's Parameter That Could Be Optimized

Algorithm	Parameter
LR	Regularization Strength (C)
DT	Maximum Depth, Minimum Samples per Leaf, Minimum Samples per Split
RFt	Number of Trees (n_estimators)]
ANN	Number of Hidden Units, Learning Rate, Batch Size, Number of Layers
SVM	Kernel Type, Kernel Parameters, Regularization Parameter (C)

For evaluation, the author recommends using k-fold cross validation. From this study, the author found that most researchers use k-fold cross validation with 5 or 10 folds instead of the holdout cross validation method. This method of evaluation is less prone to show overfit accuracy since all the folds are given the chance to be part of the model evaluation instead of only one of the folds like on holdout cross validation.

V. CONCLUSION

In this study, it can be seen that the bank faced several issues in approving credit card requests. The problems the bank faced include human errors, time consumption as needing more labor force in this area, and so on. The problems are mostly caused by the bank still using manual methods in approving credit card requests. With models from machine learning, these problems can be minimized and can improve effectiveness and efficiency in credit card approval hence improving bank performance.

The algorithm for implementing credit card approval prediction can differ depending on the data, nature of the algorithm, and the pre-processing technique. The author has reviewed 23 papers from different sources which have several different types of algorithms, and for the credit card approval mostly use supervised learning algorithms. The author, through this study,

recommends five algorithms that can be a start to be used for building their machine learning model for credit card approval. The five algorithms are random forest, logistic regression, support vector machine, decision tree, and artificial neural network. The author starts with screening the most widely used algorithms as these algorithms have richer information to compare as well as higher confidence than the algorithm that is used on one paper only. The author then defines the algorithm rank according to the research they are in, average the rank in the same algorithm category, then compares the averaged rank with the averaged rank of other algorithms, in which the random forest, logistic regression, and decision tree got higher rank among the five algorithms.

Beside using rank, the author also uses statistical mean like average, min, max, median, and standard deviation along with the nature of algorithms in order to have a better understanding of the potential of the algorithms. Using these methods, the author can classify among these five algorithms on which algorithm is less prone to overfit and more likely to have better accuracy if carefully maneuvered. From this method, the author found that random forest, logistic regression, and support vector machine are less likely to overfit, but decision tree algorithm and artificial neural network algorithm are more likely to have better accuracy if regularized appropriately.

Through this study, there are several recommendations that could be done to improve model performance. The author recommends choosing the suitable methodology/process before building machine learning, understanding the characteristics of the data by EDA, then performing dimensionality reduction, hyperparameter tuning, and cross-validation. The last three processes have a significant impact in the increase of model performance and reducing overfit.

REFERENCE

[1] M. P. C. Peiris, "Credit Card Approval Prediction by Using Machine Learning Techniques," University of Colombo, 2022. Accessed: Mar. 07, 2023. [Online]. Available: https://dl.ucsc.cmb.ac.lk/jspui/handle/123456789/4593

[2] R. Marginingsih and I. Sari, "Nilai Transaksi Non Tunai Terhadap Pertumbuhan Ekonomi Di Indonesia Periode 2014-2018," *Inovator*, vol. 8, no. 2, p. 24, Sep. 2019, doi: 10.32832/INOVATOR.V8I1.2504.

[3] A. Khan and S. K. Ghosh, "Machine assistance for credit approval? Random wheel can recommend and explain," *Expert Syst Appl*, vol. 215, p. 119231, Apr. 2023, doi: 10.1016/J.ESWA.2022.119231.

[4] Z. Zarnaz, D. Biswas, and K. M. A. Hasan, "Credit Card Approval Prediction by Non-negative Tensor Factorization," *International Conference on Robotics, Electrical and Signal Processing Techniques*, pp. 319–323, 2021, doi: 10.1109/ICREST51555.2021.9331172.

[5] N. Dalsania, D. Punatar, and D. Kothari, "Credit Card Approval Prediction using Classification Algorithms," vol. 10, 2022, doi: 10.22214/ijraset.2022.47369.

[6] Md. G. Kibria and M. Sevkli, "Application of Deep Learning for Credit Card Approval: A Comparison with Two Machine Learning Techniques," *Int J Mach Learn Comput*, vol. 11, no. 4, pp. 286–290, Aug. 2021, doi: 10.18178/IJMLC.2021.11.4.1049.

[7] L. Duan, "Performance evaluation and practical use of supervised data mining algorithms for credit card approval," *Proceedings - 2020 International Conference on Computing and Data Science, CDS 2020*, pp. 251–254, Aug. 2020, doi: 10.1109/CDS49703.2020.00057.

[8] S. Hemkiran, G. Sudha Sadasivam, A. Prasanna Rahavendra, and A. K. Anjhanna, "Design of Automatic Credit Card Approval System Using Machine Learning," *Lecture Notes in Electrical Engineering*, vol. 806, pp. 1–9, 2022, doi: 10.1007/978-981-16-6448-9_1.

[9] J. Chongwatpol, "Credit Card Applications Pending – Who are Our Best Prospect Cardholders? Improved Decisions through Business Analytics and Business Intelligence," *https://doi.org/10.1057/s41266-016-0009-8*, vol. 8, no. 1, pp. 29–44, May 2018, doi: 10.1057/S41266-016-0009-8.

[10] H. V. Peela, T. Gupta, N. Rathod, T. Bose, and N. Sharma, "Prediction of Credit Card Approval," *International Journal of Soft Computing and Engineering*, vol. 11, no. 2, pp. 1–6, Jan. 2022, doi: 10.35940/IJSCE.B3535.0111222.

[11] A. A. Agustian and A. Bisri, "Data Mining Optimization Using Sample Bootstrapping and Particle Swarm Optimization in the

Credit Approval Classification," *Indonesian Journal of Artificial Intelligence and Data Mining*, vol. 2, no. 1, Mar. 2019, doi: 10.24014/ijaidm.v2i1.6299.

[12] M. Markova, "Credit card approval model: An application of deep neural networks," *AIP Conf Proc*, vol. 2321, no. 1, p. 030023, Feb. 2021, doi: 10.1063/5.0040744.

[13] I. Sugiyarto, B. Sudarsono, and U. Faddillah, "Performance Comparison of Data Mining Algorithm to Predict Approval of Credit Card," *Sinkron : jurnal dan penelitian teknik informatika*, vol. 4, no. 1, pp. 149–157, Oct. 2019, doi: 10.33395/SINKRON.V4I1.10181.

[14] A. Husejinovic, N. Durmić, and S. Jukić, "Application of Business Intelligence in Decision Making for Credit Card Approval," *Journal of Intelligence Studies in Business*, vol. 12, no. 2, pp. 54–64, Feb. 2022, doi: 10.37380/JISIB.V12I2.956.

[15] P. Yasasvi and S. Magesh Kumar, "Improve Accuracy in Prediction of Credit Card Approval Using Novel XGboost Compared with Random Forest," *Advances in Parallel Computing*, no. 41, pp. 582–588, 2022, doi: 10.3233/APC220083.

[16] Siddhi Bansal and Tushar Punjabi, "IRJET-Comparison of Different Supervised Machine Learning Classifiers to Predict Credit Card Approvals," *IRJET*, vol. 8, no. 3, pp. 1339–1348, Mar. 2021, Accessed: Mar. 06, 2023. [Online]. Available: https://www.academia.edu/51027669/IRJET_Comparison_of_Different_Supervised_Machine_Learning_Classifiers_to_Predict_Credit_Card_Approvals

[17] U. Tanikella, "Credit Card Approval Verification Model," Sep. 2020, Accessed: Mar. 07, 2023. [Online]. Available: https://scholarworks.calstate.edu/downloads/cn69m841j

[18] O. Kazeem, "ALGORITHM UNFAIRNESS. A case of study of Credit Card Approval process.," University of Stirling, 2022. Accessed: Mar. 07, 2023. [Online]. Available: https://www.researchgate.net/publication/362826792_ALGORITHM_UNFAIRNESS_A_case_of_study_of_Credit_Card_Approval_process

[19] K. Shah, H. Patel, D. Sanghvi, and M. Shah, "A Comparative Analysis of Logistic Regression, Random Forest and KNN Models for the Text Classification," *Augmented Human Research 2020 5:1*, vol. 5, no. 1, pp. 1–16, Mar. 2020, doi: 10.1007/S41133-020-00032-0.

[20] A. C. S. Hubert, R. Vimalesh, M. Ranjith, and S. A. Raj, "Predicting Credit Card Approval of Customers Through Customer Profiling using Machine Learning," vol. 9, no. 6, pp. 552–557, 2020, doi: 10.35940/ijeat.D7293.049420.

[21] A. Smith, B. Mahe, and D. Khaneja, "Credit Approval Analysis using R," Nov. 2017. Accessed: Mar. 14, 2023. [Online]. Available: https://www.researchgate.net/publication/321002603_Credit_Approval_Analysis_using_R

[22] D. Jayanthi, "CREDIT APPROVAL DATA ANALYSIS USING CLASSIFICATION AND REGRESSION MODELS," vol. 5, no. 3, pp. 162–169, Sep. 2018, Accessed: Mar. 13, 2023. [Online]. Available: www.ijrar.org

[23] W. Musyoka, "Comparison of Data Mining Algorithms in Credit Card Approval," vol. 5, no. 11, pp. 432–438, 2018, Accessed: Mar. 06, 2023. [Online]. Available: https://www.academia.edu/35884113/Comparison_of_Data_Mining_Algorithms_in_Credit_Card_Approval

[24] I. Ivandari, M. Karomi, and M. Maulana, "Improved C45 performance with gain ratio for credit approval dataset," *JAICT*, vol. 7, p. 135, Nov. 2022, doi: 10.32497/jaict.v7i2.3978.

[25] N. Widjiyati, "Implementation of Random Forest Algorithm in The Classification of Credit Approval Dataset," *Jurnal Janitra Informatika dan Sistem Informasi*, vol. 1, no. 1, pp. 1–7, Apr. 2021, doi: 10.25008/JANITRA.V1I1.118.