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Performance Analysis of QoS Parameters and Churn Prediction Model Development for MNOS in Nigeria

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Abstract

This paper presents the results and analysis of research about subscriber satisfaction and their propensity to churn in the Nigerian GSM Telecommunication Industry. The research built a model using three different algorithms, viz: Principal Component Analysis (PCA), KMeans Clustering for unsupervised learning of dataset, and the Logistic Regression (LR) Model. The datasets used were performance metrics of the Quality of Service (QoS) of four major Mobile Network Operators (MNOs) in Nigeria; Airtel, 9mobile, Globacom, and MTN. The QoS were analysed using a built model. The parameters of the QoS analysed and from which a model was built were the Call Set-up Success Rate (CSSR), the Drop Call Rate (DCR), the Standalone Dedicated Channel Congestion Control Rate (SDCCH), and the Traffic Congestion Control Rate (TCCH). The PCA helped to simplify the datasets such that the trends and patterns are retained and thereafter, the KMeans Clustering was applied on the simplified dataset and was tagged with segregating the Network Predictors which indicated the MNOs with satisfactory results and those likely to lose subscribers. The LR model was used in a supervised learning mode for unlabeled datasets using clusters as labels which finally resulted in a prediction model with a predicting accuracy of 95%.

Keywords: Churn, Principal Component Analysis, KMeans Clustering, Logistic Regression, Quality of Service, Model, CSSR, DCR, SDCCH, TCCH.

Introduction

The Nigerian telecommunication industry is one of the country's most dynamic and competitive sectors, with many service providers. The industry has witnessed tremendous growth over the years, fueled by the increasing demand for telecommunication services, such as voice, data, and internet.

Despite the growth, the industry faces significant challenges, including the issue of subscriber churn. Subscriber churn refers to the rate at which customers terminate their subscriptions with a particular service provider. Churn is a significant concern for telecommunication operators in Nigeria, leading to revenue loss, decreased market share, and increased competition.

Additionally, low customer satisfaction is a significant challenge for telecommunication operators in Nigeria. Dissatisfied customers are more likely to switch to other service providers, resulting in subscriber churn. Hence, telecommunication operators need to evaluate customer satisfaction levels continually.

A satisfied customer is a potential latent marketer of a company. They proudly advertise and discuss casually the offers and services they enjoy from a particular brand to friends and family at no cost to the company, and this can have a very positive effect in promoting the company's brand. This assertion is also true for customers dissatisfied with a brand's offers and services. The complaints of such kinds of customers if not promptly resolved have the potential of affecting negatively the brand of the company and also, the company might lose not only the customer but other customers that might have been nursing dissatisfaction from services provided.

There is a dearth of empirical research in churn analysis (Bhattacharyya, 2022). This can be attributable to the confidentiality in closely guarding customers' data in the telecommunication industry (Maki, 2019). However, there have been a couple of researches conducted over the years that can be a good foundation upon which further studies can be built.

The Nigerian Communications Commission (NCC) in March 2016, recorded on its website that the active GSM mobile subscription in Nigeria stood at 148,745,464. Fast forward to August 2023, this figure has improved by 32.5% (71,615,722 additional subscribers) and it is now about 220,361,186.

In 2016, MTN led other Mobile Network Operators (MNOs) with about 39% amounting to 58.5 million subscribers, followed by Globacom with 23% amounting to about 27.3 million subscribers, Airtel was next with 23% representing 27.1 million subscribers, and finally Etisalat (now 9mobile) with 15 % amounting to about 19.3 million subscribers. As of February 2023, MTN still led other MNOs with 40.87%

amounting to 92.7 million subscribers, Airtel with 26.78% amounting to 60.7 million subscribers, Globacom with 26.58% amounting to 60.3 million subscribers, and finally 9mobile with 5.76% amounting to 13 million subscribers.

The most recent statistics as of August 2023, shows that MTN now has 38.98% (85,005,917) of the total GSM subscribers while Globacom, Airtel, and Etisalat have 27.86% (69,315,108), 27.30% (60,169,082) and 6.26% (13,791,079) respectively.

This research, therefore, intends to analyse the quality of service (QoS) parameters of the mobile network operators vis-à-vis the quality of experience (QoE) of subscribers and their propensity to churn.

Related Works

Several researchers have investigated customer satisfaction and churn prediction in the telecommunication industry, and the various factors that influence these variables. Research by Abjal (2021) and Alzoubi et al, (2020), established that service quality, value for money, and perceived network quality significantly impact customer satisfaction in the telecommunication industry. The study identified that customer satisfaction leads to loyalty and reduces customer churn. The study's findings highlighted the importance of customer satisfaction in the telecommunication industry, and the need for telecommunication companies to ensure that customers are satisfied with their services to retain them.

Research by Almuhanna et al. (2023) and Moses et al, (2019) highlighted that social media presence has a significant impact on customer satisfaction in the telecommunication industry. The study revealed that social media presence positively affects customer satisfaction and can lead to increased customer loyalty. The study also found that negative comments on social media platforms can lead to customer dissatisfaction and churn. The findings highlighted the importance of telecommunication companies' online presence and the need for effective social media management to enhance customer satisfaction.

Also, Zhao et al. (2023) and Hangarge et al, (2023) explored machine learning algorithms for churn prediction in the telecommunication industry. The study established that machine learning algorithms such as decision trees and random forests were effective in predicting customer churn. The findings highlighted the importance of machine learning algorithms in customer churn prediction and the need for telecommunication companies to invest in these technologies to predict and prevent customer churn.

Another research by Meghyasi et al. (2020) and Wu, (2023) examined customer churn prediction in the telecommunication industry using the neural network algorithm. The study found that neural network algorithms were effective in predicting customer churn, and the model achieved a high accuracy rate.

A study by Akhigbe and Olokoyo, (2019) focused on the impact of service quality, customer relationship management, and corporate social responsibility on customer satisfaction and loyalty in the Nigerian telecommunication industry. The study found that service quality, customer relationship management, and corporate social responsibility significantly influence customer satisfaction and loyalty.

Furthermore, Olatokun and Ojo, (2016) conducted a study on the impact of customer experience and service quality on customer satisfaction and loyalty in the Nigerian telecommunication industry. The study found that customer experience and service quality significantly influence customer satisfaction and loyalty.

Overall, these studies highlight the importance of customer satisfaction and churn prediction in the Nigerian telecommunication industry and the need for effective strategies to improve customer satisfaction and reduce churn rates.

Considering the high churn rate in the telecommunication industry (Mobile telephony segment) which ranges from 20 to 30% annually (Onwuka et al, 2017) churn prediction becomes an important area of focus for data analysis for mobile telephony providers.

Methodology

Research on Churn generally in Nigeria has always met the challenge of getting objective data. Most researchers resort to questionnaires, asking subscribers directly about their QoE and the QoS offered by MNOs. The setback of this kind of method is that it is subjective and researchers find it difficult to properly scrutinize responses that might have been emotionally influenced or sentimental.

To address the above challenge, this research sourced and mined data from the Nigerian Communications Commission (NCC), a regulatory body in charge of ensuring standards in the communication industry. The QoS performance metrics used for this research were four (4), viz: Call Set-up Success Rate (CSSR), Drop Call Rate (DCR), Standalone Dedicated Channel Congestion Control (SDCCH), and Traffic Congestion Control Rate (TCCH).

QoS Parameters

The QoS parameters were chosen because it is common to all users. The research hypothesis is that the Quality of Experience of users is directly influenced by the Quality of Service provided by the MNOs. Poor QoS will imply poor QoE. The CSSR and DCR show the success rate of different MNOs in establishing a call and sustaining the call. The SDCCH and the TCCH show the efficiency of MNOs in terms of congestion control and traffic management that leads to call establishment, access to internet service, and other services dependent on the quality of channel control. A brief

definition of the QoS parameters chosen as provided by the NCC is given below to further explain the parameters.

a. **Call Set-up Success Rate (CSSR):** The **Call Setup Success Rate** (CSSR) is calculated by taking the number of unblocked call attempts divided by the total number of call attempts. A call setup is an exchange of signaling information in the call process that leads to a Traffic Channel (TCH) seizure.

Performance Threshold: The CSSR should be equal to or greater than 98%.

$$\text{CSSR}(\%) = \frac{\textit{Number of Unblocked Call Attempts}}{\textit{Total Number of Call Attempts}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots 2.1$$

b. **Drop Call Rate (DCR):** The **Dropped Call Rate** (DCR) - also called *Call Drop Rate* - is the number of dropped calls divided by the total number of call attempts. A dropped call is a call that is prematurely terminated before being released normally by either the caller or called party (i.e., the call is dropped before the exchange of Released Message "RL_M" and Released Complete Message "RLC_M" in the signaling flow).

Performance Threshold: The DCR should be equal to or less than 1%.

$$\text{DCR}(\%) = \frac{\textit{Number of Prematurely Terminated Calls}}{\textit{Total Number of Call Attempts}} \times 100 \ldots\ldots\ldots\ldots\ldots 2.2$$

c. **Standalone Dedicated Channel Congestion Control (SDCCH):** The Standalone Dedicated Control Channel Congestion Rate is defined as the probability of failure of accessing a Standalone Dedicated Control Channel (SDCCH) during call setup. The SDCCH is used in the GSM system to provide a reliable connection for signaling and SMS (Short Message Service) messages.

Performance Threshold: The SDCCH Congestion Rate should equal or less than 0.2%.

$$\text{SDCCH}(\%) = \frac{\textit{Number of Assignment Related Connect Fails}}{\textit{Mobile Originating Call Attempts}} \times 100 \ldots\ldots\ldots\ldots 2.3$$

d. **Traffic Control Channel Rate (TCCH):** The Traffic Control Channel Rate is the probability of failure in accessing a traffic channel during call setup. Traffic Control Channels (TCCH) are responsible for transferring control information between mobiles and the BTS.

Performance Threshold: The TCCH Congestion Rate should be equal to or less than 2%.

$$\text{TCCH}(\%) = \frac{\textit{Number of Call Connect Fails}}{\textit{Total Number of Call Attempts}} \times 100 \ldots\ldots\ldots\ldots\ldots 2.4$$

Choice of Sample States

Six states and the Federal Capital Territory (FCT), Abuja were selected as sample states for this research. The QoS of each of these states and the FCT, between July 2022 and June 2023 (12-month period), was mined, refined, grouped, and analyzed to show how the various MNOs performed within the period under review. A state was selected from each of the six geopolitical regions of the country to represent the region. Population was a major determinant of the states chosen. The Geopolitical regions in Nigeria are the North-West (NW), the North-East (NE), the South-West (SW), the South-East (SE), the South-South (SS), and the North Central (NC).

The chosen states were Kano (NW), Bauchi (NE), Lagos (SW), Anambra (SE), Rivers (SS) and Niger (NC). The National Bureau of Statistics (NBS) was the reference point in getting the population data of these states. Each of the chosen states is the most populous in their respective region. The FCT, Abuja was added to the list because of its strategic importance in the country.

The research also assumes that the average performance of the chosen QoS metrics of all sample states and the FCT can reflect fairly, the performance of MNOs across the country.

Churn Rates

The churn rate is the rate at which subscribers switch from one MNO to another. It usually costs little or nothing for this to happen and that is why it is very common and poses a danger for MNOs with poor QoS.

The incoming and outgoing churning activities of subscribers from July 2022 to June 2023 were also mined and analysed to know the Net Churn (Nech) of each of the MNOs for the period under review.

Research Flow Chart

The flow chart of this research was done using draw.io and it is presented below:

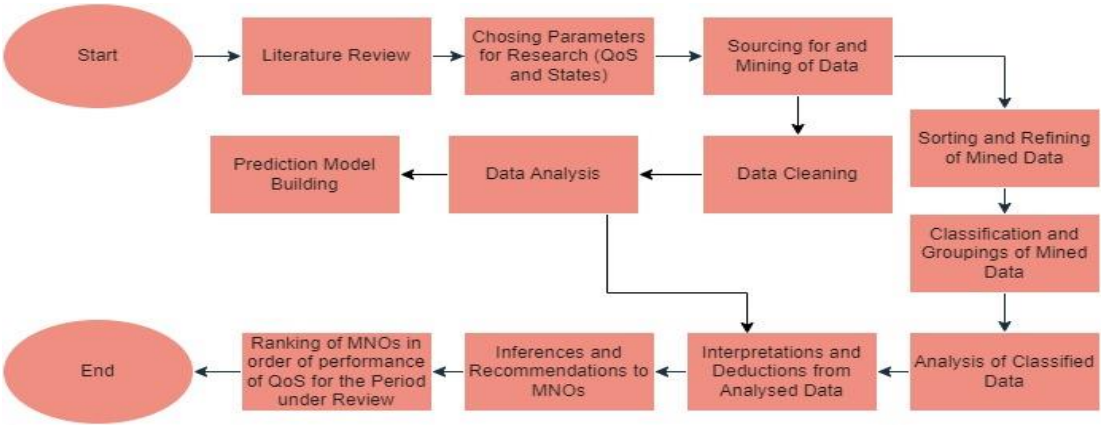


Fig 2.1: A flow chart of the research process and procedures

The flow chart in Fig 2.1 above shows the complete process and procedures followed in the course of this research.

The research started with a comprehensive review of works of literature for the problem definition of the research problem. Once this is done, it proceeds to choose its parameters and sample states. The data for the chosen parameters were sourced. The data underwent different stages of analysis, using machine learning.

While using the Python tool, the data was cleaned, the necessary libraries imported and then the data was analysed.

A prediction model (using Logistic Regression) was thereafter developed from the data. The prediction model was developed to predict the success and/or failure rate of MNOs if they fail to keep up with the Quality of Service benchmark. The model had an accuracy of 0.95 (95%).

Results and Analysis

In the first stage of analysis of the research work using machine learning, the gathered dataset of the QoS performance metrics (CSSR, DCR, SDCCH, and TCCH), was uploaded to the Python environment and thereafter, data cleaning was carried out for the data to make building of models for analysis, machine learning and adoption of a prediction model possible.

The model for analysis was built and the machine was allowed to study the uploaded data to allow for a prediction model.

The results are presented below.

Density Output of CSSR Performances of MNOs across all Sampled States

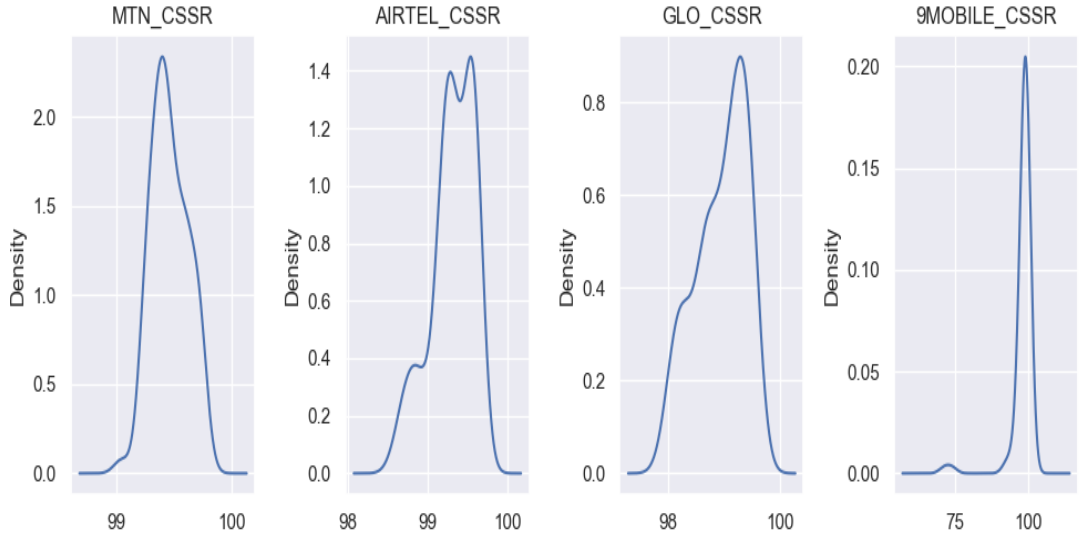


Fig 3.1 Density Output of CSSR Performances of MNOs across all Sampled States

Figure 3.1 above presents the analysis result of the density of the CSSR of MNOs across all sampled states. It can be seen from the figure above that MTN has the best CSSR performance because it has a CSSR above 99% average across all sampled states. The graph also shows that Airtel is second to MTN in terms of CSSR performance, followed by Glo, and then lastly, 9mobile.

Violin Plot Output for DCR across all Sampled States

A violin plot for the Drop Call Rate of the MNOs was also done and the result is presented below:

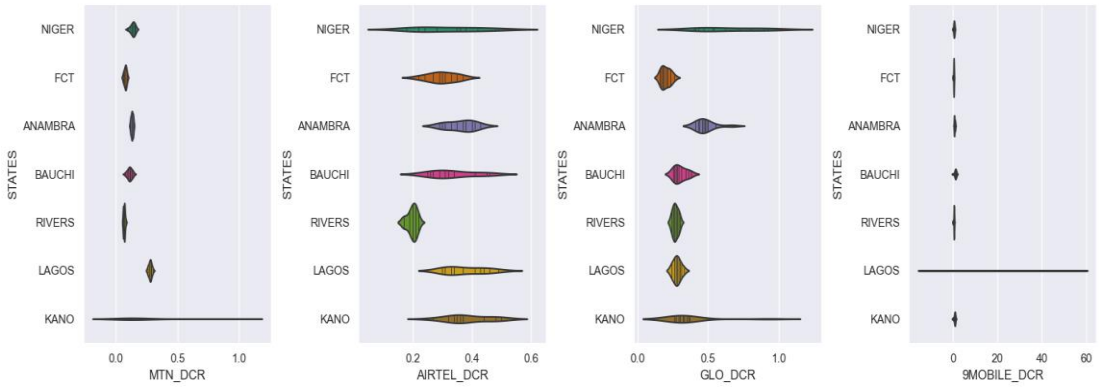


Fig 3.2 Violin plot of DCR of MNOs

It can be seen from the plot above, that MTN performed better than other networks in terms of DCR. This will imply that their subscribers will experience lower drop call rates whenever a call is established thereby leading to better quality of experience. MTN is followed by Airtel then close to Airtel in terms of performance is Glo and then you have 9mobile coming last in this regard. Poor DCR will mean bad quality of experience for subscribers which over time can frustrate the subscribers and lead to churning.

Frequency Output of SDCCH Performance of MNOs across all Sampled States

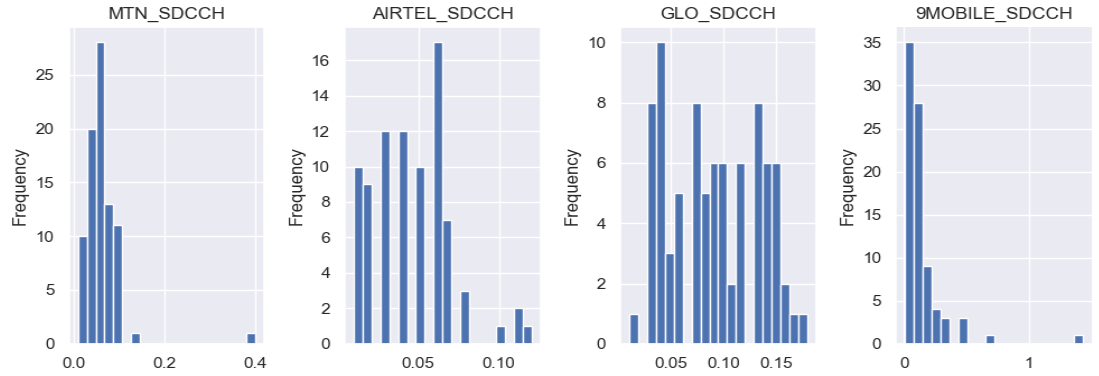


Fig 3.3 Frequency Output of SDCCH Performance of MNOs across all Sampled States

Fig 3.3 above shows the standalone channel congestion control rate (SDCCH) frequency plot for all MNOs. The channel control rate of MTN and Airtel is better off than that of Glo and then you have 9mobile having a not-so-good performance when compared to the other MNOs. The SDCCH like the TCCH plays a crucial role in setting up calls and allowing access to the internet and a poor SDCCH will imply poor quality of experience (QoE) for subscribers and this can lead to a high churn rate for affected MNOs. In this instance, it is necessary that 9mobile steps up its effort to ensure a better SDCCH performance.

TCCH Performance of MNOs across all Sampled States

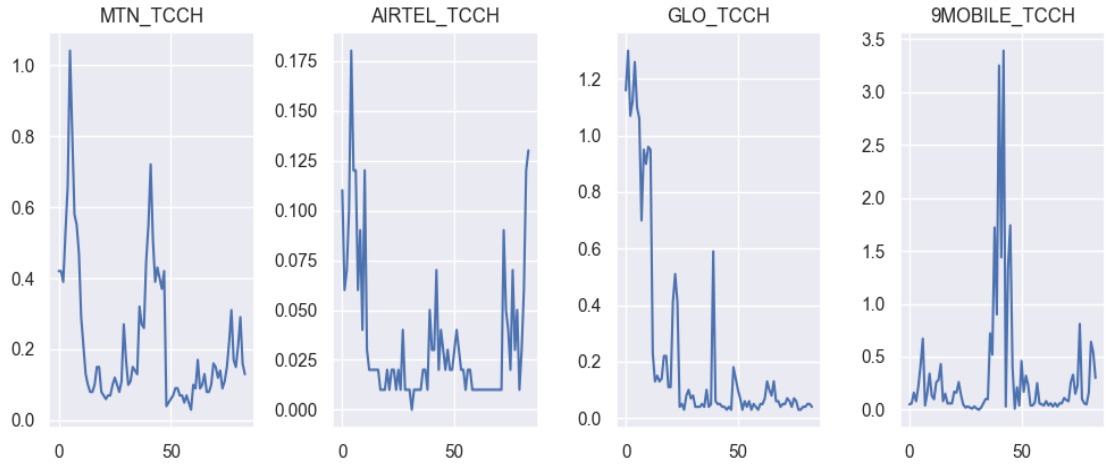


Fig 3.4 TCCH Performance of MNOs across all Sampled States

Fig 3.4 is a representation of the Traffic Congestion Control Rate (TCCH) of all mobile networks. The analysis of the plot shows that AIRTEL slightly edged MTN in terms of traffic control. This implies that subscribers on this network are likely to have a better experience when it comes to surfing the internet. However, a closer examination will show that MTN and Glo are not too far behind. If the subscriber share is put into perspective, it will be discovered that in relation to subscribers and the current TCCH analysis, MTN seems to be performing better than the other MNOs. Again, 9mobile is last on this analysis, and even worse is that they have the lowest subscriber share in the GSM section of the industry.

The poor TCCH performance of 9mobile will affect the overall quality of experience of subscribers on this network. They tend to have a lesser call setup success rate, a high rate of drop calls, difficulty in quickly accessing and seamlessly surfing the internet in many locations and a host of other network hitches here and there. This unpleasant experience for subscribers can be a reason for churning and can also be a reason why the market share of 9mobile has not improved over the years.

BUILDING AND TESTING THE PREDICTION MODEL

A Logistic Regression Model was adopted for the building of a prediction model for this research.

The data set was split into two, 80% was used for training and the remaining 20% was used for testing of the model.

The model accuracy of prediction during the testing phase (after the dataset had been trained) was 95% and a confusion matrix was also done to check for the metrics of prediction.

Table 3.1: Summary of QoS of MNOs vis-à-vis QoE and Propensity to Churn

MNOs	QoS	QoE	Propensity to Churn	Retention Rate	Rank Based on QoS Performance
MTN	Best	Very Satisfactory	Low	High	1st
Airtel	Better	Satisfactory	Medium	Medium	2nd
Globacom	Better	Satisfactory	Medium	Medium	3rd
9mobile	Fair	Not Satisfactory	High	Low	4th

Table 3.1 above shows the overall performance of MNOs after analyzing their QoS parameters. The table also shows the propensity of subscribers to churn, the quality of experience, and the retention rate of MNOs. This research can serve as a guide to underperforming MNOs to step up their efforts if they want to compete comfortably and still be in business.

Conclusion and Recommendation

At the end of this research work, the quality of service performance metrics of the four major mobile network operators in Nigeria was analysed and the MNOs were ranked based on their performances. Also, a prediction model using the Logistic Regression method was built to help predict the propensity of subscriber churn as a result of poor quality of service offered by an MNO. The prediction accuracy of the model was 95%. MNOs with poor network performance are therefore strongly advised to improve upon their network quality or risk losing their subscribers to competing MNOs. Losing subscribers is something that is detested by business organisations as it costs more to acquire subscribers than to retain them.

Future research can be carried out on this niche by sourcing much data and using other machine learning techniques to improve the prediction accuracy achieved by this research.

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