# **CHAPTER ONE**

# **BACKGROUND OF STUDY**

## **1.1 Introduction**

Crime is an intentional act that is socially and physically harmful, defined and prohibited, and is punishable by law according to its severity (Bisogno, 2015). Crime is a global issue that has affected society for centuries (Opp, 2020). Criminal behavior is defined by laws within different jurisdictions and may vary across countries depending on which actions are prohibited (Harrendorf, 2018). Criminal activities have continued to increase drastically across the globe and it has become imperative to develop effective and efficient measures to mitigate crime especially those that pose threats to personal or public safety (Walczak, 2021).

In Nigeria, violent crimes such as robbery, burglary, theft, assault, rape, vandalism, trafficking, banditry, and murder have all been on the rise in recent years (Oguntunde et al., 2018). These crimes have had a terrible impact on individuals, families, and communities, as well as the economic growth and development of the country (Oguntunde et al., 2018). The issue of detecting, predicting, and analyzing crime has become more difficult despite the efforts of law enforcement authorities to manage and prevent crime (NSACC, 2021). Basic crime prediction and prevention technologies have been used in Nigeria, however, due to the fast rate at which criminal activities are increasing in Nigeria, these traditional methods of preventing and solving crime have become inefficient against the surging increase in the crime rate (Makeri, 2018). These existing methods require security agencies to manually identify crimes and relate them to suspects, increasing unsolved criminal cases, incrimination, and incarceration of innocent citizens (Makeri, 2018). Due to the inadequacies of these fundamental technologies, law enforcement agencies have found it difficult to carry out their functions efficiently, resulting in a high proportion of unresolved crime cases (Okeke and Oranyelu, 2021). This is where the use of machine learning to detect patterns which are then employed in the prediction, anticipation, and prevention of crime comes in (Rudin and Sloan, 2013). Machine learning is an innovative method that has the potential to increase crime detection, prediction, and prevention significantly (Rudin and Sloan, 2013). Machine learning which is a subfield of Artificial intelligence (AI) provides methods for enhancing the knowledge of current and potential criminal activities and assists the police and other security agencies in making complex anti-criminal decisions (Walczak, 2021). With more data available, machine learning can identify and evaluate trends across large amounts of data, keep up with the rise in sophisticated crime, and effectively manage risks (Anderez et al., 2021). Machine learning algorithms have already been implemented successfully in several sectors, including banking, healthcare, and transportation, to detect and prevent fraud, identify diseases, and enhance traffic management (Iqbal, 2021).

Therefore, there is an urgent need to investigate the potential of machine learning in crime prediction in Nigeria. The purpose of this research is to investigate the traditional crime prediction technologies that are currently in use in Nigeria, identify their limitations, and develop machine learning models that can serve as a better and more efficient option for predicting crimes. The research would use machine learning to create a model for crime prediction in Nigeria using crime data from 2013 to 2017. The study would look into the advantages, disadvantages, and limitations of machine learning as a crime detection and prediction approach and facilitate the understanding of how machine learning can be applied by law and police agencies to detect, prevent and solve crimes more efficiently and accurately.

## **1.2 Problem Statement**

Violent crime is currently increasing rapidly in Nigeria, ranging from fraud to robbery, burglary, theft, assault, rape, vandalism, trafficking, banditry, and murder (Oguntunde et al., 2018). Law enforcement and security agencies bear the responsibility of preventing and managing crime and enforcing law and order (Mbanefo, 2019). In as much as the algorithms used by the basic technologies in use today to predict and solve crime produce results, the output is usually manually monitored and they generally yield low success rates (Makeri, 2018). The absence of advanced technological systems for detecting, predicting, and analyzing crime, and inadequate equipment, expertise, and manpower in the area of security have posed challenges to the ability of these law enforcement and security agencies to carry out their functions effectively (NSACC, 2021). In the banking sector, on average, just 2% of transactions flagged as fraudulent by these systems are related to an actual crime or fraudulent intent (Quest et al., 2018). With the increasingly large amounts of data available and the need for individuals, businesses, and public authorities to protect and manage this data, machine learning is an efficient tool that can quickly and accurately detect and interpret patterns across many billion pieces of data, keep up with the increase in sophisticated crime, and effectively manage risks (Anderez et al., 2021).

## **1.3 Research Questions**

* What are the limitations of basic crime prediction and prevention technologies?
* How can machine learning algorithms be applied to detect, predict, prevent, and solve crime more efficiently?
* What are the benefits, challenges, and limitations of machine learning in crime prediction?

## **1.4 Research Aim and Objectives**

This project is aimed at examining the crime scene in Nigeria, basic technologies used in detecting and responding to crime, and developing machine learning models that would serve as a better and more efficient alternative to predict crimes. This would be achieved with the following objectives.

1. Examine the basic crime prediction technologies currently in use in Nigeria.
2. Identify the inadequacies of these technologies in predicting crime.
3. Understand the concept of machine learning.
4. Understand the relationship between crime detection and machine learning.

## **1.5 Scope of the Study**

This research will focus on the development and evaluation of machine learning models for crime prediction in Nigeria. The study will examine the current crime prediction technologies utilized by Nigerian law enforcement organizations and determine their limits in predicting and preventing crime. The research will then explore the concept of machine learning and how it may be used to detect and prevent crime in Nigeria. This study seeks to use a systematic literature review approach to examine the crime prediction technologies in use currently comparatively with machine learning as a more efficient tool in the detection, prediction, and prevention of crime. This analysis would facilitate the understanding of the limitations of these basic technologies and how machine learning is more efficient and accurate in crime detection and prediction. The study will then apply machine learning algorithms to crime datasets from Nigeria between 2013-2017, to develop and test new crime prediction models. These datasets will include information on several types of crimes, such as fraud, robbery, burglary, theft, assault, rape, vandalism, trafficking, banditry, and murder, as well as variables such as location, time of day, weather, and other contextual factors. The study will use open-source machine learning tools and programming languages such as R for data analysis and modeling. The findings from this study will be beneficial to Nigerian law enforcement agencies and policymakers, as well as researchers and practitioners working in the field of crime prediction and prevention. The findings will also be beneficial in the implementation of an efficient crime prediction system to enable law enforcement agencies to predict real or possible perpetrators of crime and respond effectively.

## **1.6 Limitations**

The scope of this study is limited by the availability and quality of crime data in Nigeria, as well as the constraints of machine learning algorithms and tools. The study will focus specifically on crime prediction using machine learning and will not explore other elements of crime prevention or criminal justice in general. Furthermore, the study will only examine crime data from Nigeria from 2013 to 2027, and may not capture longer-term trends or changes in crime patterns over time due to the unavailability of Nigerian crime data in recent years. Finally, the study may be limited by a lack of technical expertise and resources, as well as the need to balance accuracy with privacy and ethical issues.

## **1.7 Justification**

The rise in violent crime in Nigeria has become a major source of concern for law enforcement, the government, and civilians (Oguntunde et al., 2018). The inadequacy of basic technologies currently in use for detecting, predicting, and responding to crimes has increased the challenges resulting from crime in Nigeria (NSACC, 2021). The lack of advanced technology methods for detecting, forecasting, and analyzing crime, as well as insufficient security equipment, knowledge, and manpower, has presented challenges to law enforcement and security agencies' capacity to carry out their functions successfully (NSACC, 2021). Machine learning is now recognized as a useful tool for identifying, predicting, and preventing crime, and it has been utilized to assist law enforcement authorities in their attempts to combat crime in several countries (Shah et al., 2021). The use of machine learning in crime detection and prediction is still in its infancy in Nigeria, and there is a need to investigate the potential of this technology to improve the effectiveness of law enforcement authorities in combating crime (Okeke and Oranyelu, 2021). This research will provide more insight into the limitations of conventional technology currently in use in Nigeria for detecting, predicting, and responding to crimes. It would also serve as a basis for the use of machine learning in crime detection and prediction in Nigeria. The findings of this study would benefit law enforcement agencies, the government, and individuals by allowing for the development of a more efficient and reliable crime prediction system. This research would also add to the body of knowledge on crime detection and prevention using machine learning as well as also allow for collaboration between academia and law enforcement, facilitating the transfer of knowledge and skills to improve the effectiveness of crime detection and prevention in Nigeria.

# **CHAPTER TWO**

# **LITERATURE REVIEW**

## **2.1 Introduction**

In recent years, there has been increased interest in the application of machine learning algorithms for crime prediction. With crime rates rising in Nigeria, law enforcement officials are seeking innovative ways to improve crime detection and prevention. The purpose of this literature review is to investigate the present status of research on crime prediction in Nigeria, as well as the application of machine learning algorithms as a tool for enhancing crime detection and prevention.

## **2.1 Crime**

Crime is an illegal or prohibited act punishable by the law of a state or other authority (Bisogno, 2015). Crimes are a very significant threat to humans and society at large (Bisogno, 2015). So many crimes take place regularly and the crime keeps increasing and spreading at a very fast and vast rate (Bharati and Sarvanaguru, 2018). There exist different types of crime ranging from terrorism, corruption, robbery, fraud, theft, murder, rape, assault, battery, false imprisonment, kidnapping, homicide, etc (Abdulraheem et al., 2022). Since crimes keep increasing at a very rapid pace and the basic technologies which are currently employed to detect, predict, and respond to these crimes are inefficient and yield low success rates, it is imperative to develop technologies that would enable the prediction of, and solve these large number of crimes to be much faster and efficient (Bharati and Sarvanaguru, 2018).

## **2.1 Conventional Crime Prediction Technologies in Nigeria**

The crime scene in Nigeria is characterized by terrorism, banditry, kidnapping, fraud, corruption, robbery, rape, trafficking, assault, murder, and the like (Okeke and Oranyelu, 2021). According to the global peace index and global terrorism index respectively, Nigeria has been included among the least peaceful countries in the world in recent times as the 18th least peaceful country and the 6th most affected by terrorism (Statista, 2022). Nigeria also ranks as the 2nd country in Africa and the 6th country globally with the highest rate of genocide (Statista 2022). According to the National Bureau of Statistics (2017), crime Statistics on reported offenses reflected that the highest number of crimes in Nigeria was recorded in 2017 with a total of 134,663 criminal cases reported. Offense against ranked the highest with 68,579 reported cases. According to the report, there were 53,641 cases reported under offense against persons and 12,443 cases reported under offense against lawful authority. Lagos state stands as the state with the most crime rate in Nigeria with 50,975 (37.9%) cases, Abia and Delta states following closely with 12,408(9.2%) and 7,150(5.3%) cases, and Kebbi, Kogi, and Bauchi states recording the least crime rates with 205(0.2%), 282(0.20%) and 386(0.30%) cases respectively (National bureau of statistics, 2017). Despite the efforts of law enforcement agencies and security agencies and assurances of security from the government, crimes have drastically been on the rise (Achumba et al. 2013). These statistics as published by the global peace index, the global terrorism index, and the Nigerian government itself show that in fact, these criminal activities have not been managed effectively.

Crime forecasting describes the process of detecting and predicting crimes before they happen (Shah et al., 2021).CCTV cameras, fingerprint, and facial recognition systems, and traditional patrol methods are among the current basic technologies employed in Nigeria for crime prediction and prevention (Yau, 2019). Currently, there are some tools used by the Nigerian police to aid in crime detection tasks such as tracking and listening to suspects’ phone calls, use of body cameras to record unusual and criminal activities, and the use of unmanned Aerial Vehicles (UAVs) also known as drones (Dalhatu, 2016). According to Sahara Reporters (2021), the Nigerian police employ the implementation of the Device Management System (a Centralised Equipment Identity Register) to track phone calls. This is aimed at mitigating the entry of counterfeit phones into the market, discouraging theft of mobile phones and other smart devices, and their use for crimes, reduction of kidnapping, and generally increasing national security (Dalhatu, 2016). The device management system would serve as a record of the IMEIs (International Mobile Equipment Identity) of all registered mobile phones, and the identities of the owners of these devices (Sahara Reporters, 2021). However, this system deployed for the tracking of kidnappers, bandits, and terrorists who usually make use of mobile phones to negotiate ransoms has been inactive for almost a year despite the surge of violent crimes across the country (Dalhatu, 2016). This system downtime has been attributed to the failure of the Nigerian government to engage the involved company which has claimed that they are being owed subscription funds to carry out a system upgrade among other challenges (Sahara Reporters, 2021).

The Nigerian police also employed the use of high-powered Unmanned Aerial Vehicles (UAVs), also known as drones to enhance surveillance operations and improve security across the country (Odunsi, 2021). The use of drones was implemented to assist the Nigerian police in its intelligence and operational capabilities which include monitoring crime scenes and providing aerial support during a response to crime (Ayitogo, 2022). These drones have several sensitive and forensic-based characteristics and some of them can cover up to 150km in a single flight and have an endurance of 14 hours, while others can cover up to 92m in altitude and have an endurance of 50 hours (Ayitogo, 2022). Another popular method of crime prediction through surveillance employed is the use of patrol which is used to gather information relating to all types of crimes and suspects (Ajayi and Adefolaju, 2013). In this method, the police take note of a wide range of criminal events which are observed during the patrols which involve observing suspects' behavior during arrests, weapons, drugs, and other evidence during searches (Shah et al., 2021). These patrols whose purpose is to observe unusual and illegal activities to detect crime are quite reliable but of course subject to inaccuracy and bias (Shah et al., 2021).

CCTV, also known as closed-circuit television which is a system of video cameras that are used to record and monitor occurrences in a particular area is another crime detection technology that is currently in use by security agencies in Nigeria to detect and prevent crime (Ya’u, 2019). CCTV records crime incidents as they happen (Ashby, 2017). When a crime is committed in a location that is under surveillance by CCTV cameras, the footage can be examined to reveal the perpetrators of the crime and aid investigations (Ashby, 2017). Additionally, in an area under surveillance by CCTV cameras, unusual or suspicious activity can be identified and monitored (Tripathi et al, 2018). This can assist in identifying intended crime and intercepting suspects which helps prevent crime before it happens (Ashby, 2017).

CCTV can also be used alongside other crime prevention strategies such as alarms and stationing of security personnel in strategic positions to enhance the efficiency of crime detection and prevention (Singh et L. 2020). According to Yau, 2019, it is commonly recognized that CCTV cameras can only function when there is adequate electricity lighting, which indicates that many crimes in Nigeria are likely to go undetected as a result of epileptic power supply. Due to criminal sophistication and technological advancement, potential offenders have recently begun to hack CCTV systems. resulting in the perpetration of criminal activities despite the presence of CCTV surveillance (Lindegaard and Benarsco, 2018).

Crime mapping using GIS (Geographic Information System) is another predictive and investigative approach used in Nigeria (Balogun et al., 2014). Research by Noku et al. (2021) on the application of Geographic Information System (GIS) In Crime Mapping and Analysis of Yewa South LGA was able to demonstrate GIS as a decision support system for crime analysis. This was done by acquiring and digitizing the base map of a specific location and coordinate-plotting of the crime locations, developing a functional spatial database on criminal activities in the area, and performing query analysis to demonstrate the potential of GIS in modeling crime patterns within the study area (Njoku et al., 2021). Kuta and Ibrahim (2015) highlighted a lack of qualified employees, data limitations, budgetary implications of hardware and software, and decision-makers' inability to understand the application of GIS as important issues impeding the successful use of GIS in crime prediction in Nigeria. They also argued that Nigeria is still falling behind in the development and utilization of information technology, citing inadequate and poor infrastructural facilities, a bad maintenance culture, and low-level funding as major contributors to this problem.

The crime prediction systems currently in use in Nigeria are ineffective and should be replaced with machine learning for several reasons, Firstly, these approaches are manual and rely on law enforcement officials' assessment and expertise, which can result in inconsistent decision-making and the inability to detect crime before it occurs (Mbanefo, 2019). Secondly, these methods are limited by the amount of data that can be processed and the complexity of the patterns that can be recognized and are becoming obsolete and inefficient with the increasing amount of data to be processed (Sangani et al. 2019). These current crime prediction methods are also incapable of learning and improving over time while machine learning algorithms, on the other hand, may learn from previous data, recognize patterns and trends, and adjust their predictions accordingly, allowing law enforcement organizations to make better decisions to prevent and detect crime (Okwor, 2022).

## **2.2 Machine Learning**

Machine learning is a subfield of artificial intelligence (AI) and computer science that provides a system that that the ability to learn and gradually improve from past experiences automatically just like humans, using data and algorithms (Shah et al., 2021) (Bisong, 2019). These algorithms and models are trained to automatically improve their performance and quality as they are exposed to more data (Tiwari et al., 2020). Machine learning applies the use of statistical methods to train algorithms to make predictions and explore important insights in data mining projects (Bisong, 2019). These insights are used in decision-making processes within businesses, and applications to influence important performance metrics (Bisong, 2019). Due to the rapid increase and expansion in the size of data available, the need for the coordination of this data using AI methods like machine learning has also become apparent (Quest et al., 2018).

There are three main kinds of machine learning which are supervised machine learning, unsupervised machine learning, and semi-supervised machine learning (Reddy et al., 2018). In supervised machine learning, a labeled or structured dataset is used to train the algorithm to enable it to make predictions on new input from the same distribution as the labeled dataset used to train it, in unsupervised machine learning, the algorithms are not fed with labeled data but are trained to find the patterns within the data on their own, while in semi-structured machine learning, the algorithms use a combination of labeled and unlabelled data to predict outcomes (Bisong, 2019). (Berkley School of Information, 2020). According to the Berkley School of Information (2020), the learning system machine learning algorithm can be divided into 3 main three components: a decision process, an error function, and a model optimization process. Generally, based on labeled or unlabelled input data, machine learning algorithms produce estimates using patterns in the data to make predictions or classifications (Bisong, 2019). An error function evaluates the prediction of the machine learning model through comparisons with known examples to determine the accuracy of the model and quantify the level of deviation (Bisong, 2019). The algorithm then evaluates the inconsistencies and updates the decision-making process repeatedly until the expected level of accuracy is achieved (Berkley School of Information, 2020).

## **2.3 Common Machine Learning Algorithms**

Machine learning algorithms are classified into types depending on the expected outcome of the algorithm (Kumar et al., 2020). They are of three main classes:

1. Supervised learning: In supervised machine learning, datasets are pre-labeled and the algorithms are trained to classify this data and accurately predict outcomes (Berkley School of Information, 2020). The machine learning model adjusts its weight appropriately as data is fed into it. Methods used in supervised learning include neural networks, naïve Bayes, linear regression, logistic regression, random forest, and support vector machine (Bisong, 2019).
2. Unsupervised learning: In unsupervised machine learning, datasets are not labeled, rather machine learning algorithms are trained to discover and analyze hidden patterns or cluster data without the interference of users (Usama et al., 2019).
3. Semi-supervised learning: Semi-supervised machine learning is an intermediary between supervised and unsupervised machine learning (Bisong, 2019). It uses a combination of labeled and unlabelled data to predict outcomes (Berkley School of Information, 2020). This method uses a set of labeled data to guide the algorithm to learn to label unlabelled data (Berkley School of Information, 2020).

## **2.4 Common Machine Learning Algorithms**

Linear regression: Linear regression is a machine learning algorithm used to predict outcomes by analyzing the linear relationship between independent input variables and target variables (Bisong, 2019). These data relationships tend to generally follow a straight line; therefore, this model can be used to determine if a data point is increasing, decreasing, or remaining constant about independent variables (Berkley School of Information, 2020).

Neural networks: Neural networks are AI algorithms that imitate the way a human brain would typically analyze and process information to intelligently understand and classify data (Aggarwal, 2019). These algorithms are used in recognizing patterns and are applied in speech recognition, image recognition, language translation, image creation, financial predictions, and a lot more (Berkley School of Information, 2020).

Logistic regression: Logistic regression is a supervised machine learning algorithm used for data classification. A logistic model predicts the likelihood of a binary event to occur instead of a continuous output as in linear regression models (Berkley School of Information, 2020). Machine learning algorithms use this type of model to predict outcomes for categorical response variables like “yes or no” answers to questions (Bisong, 2019).

Decision trees: The decision tree algorithm follows the structure of a normal tree, containing root nodes, branches, and leaf nodes (Patel and Prajapati, 2018). The parent and topmost node in the decision tree is the root node (Patel and Prajapati, 2018). Each node represents an attribute, each branch represents a decision, and each leaf represents an outcome (Patel and Prajapati, 2018). The nodes are used to test against input data to produce accurate and expected output (Berkley School of Information, 2020).

Random forests: In random forest models, the machine learning algorithm predicts outcomes by combining the output from different decision trees (Bisong, 2019). This model can classify data using several decision tree models at the same time (Berkley School of Information, 2020). Based on input data, each decision tree in the ensemble makes its prediction, then the random forest algorithm predicts an accurate outcome based on the combination of predictions by the individual decision trees (Sruthi, 2021).

In the detection of crimes such as fraud, machine learning can be employed by financial institutions to identify suspicious and fraudulent transactions (Jeffers, 2023). Supervised learning can use data relating to known fraudulent transactions to train a machine learning model to identify transactions that are atypical and call for further investigation (Sanghvi, 2023).

## **2.5 Machine Learning in Crime Prediction**

Machine learning has been identified as a potential solution to the limitations of existing crime prediction methods (Shah et al., 2021). Machine learning algorithms have been used in the field of crime prediction to examine crime data and forecast future crime patterns (Mandalapu et al., 2023). Decision trees, random forests, and support vector machines, for instance, have been trained on crime data from certain cities to accurately predict crime patterns (Dakalbab et al, 2022). These techniques can detect and understand patterns in billions of pieces of data rapidly and accurately, keeping up with the rise in sophisticated crime and successfully managing risks (Dakalbab et al, 2022). Machine learning algorithms can offer useful insights into crime trends and patterns in addition to forecasting crime patterns. Such abilities enable the efficient use of resources and strategies in the fight against crime (Mandalapu et al., 2023). Additionally, machine learning algorithms can be used to find relationships between criminal activity and other demographic and environmental parameters, including place, time of day, and weather, which can then be used to develop crime prediction and prevention techniques that are tailored to the needs of a particular community (Mandalapu et al., 2023).

Crime prediction using machine learning and computer vision by Shah et al. (2021) investigates the use of machine learning (ML) and computer vision algorithms and techniques to predict crime. They outlined a framework for how machine and deep learning, as well as computer vision, may assist establish a system that is far more useful to the police. Their proposed system included several technologies that perform several tasks from monitoring crime hotspots to recognizing people based on their voices. In their research on an overview of crime analysis, prevention, and prediction using data mining based on real-time and location data, Okeke and Oranyelu (2021) used Apriori, Random Forest, Decision Tree, and different ensemble methods like Bagging, AdaBoost, and Extra Trees to develop a data mining, real-time and location data procedure that can help in crime prediction and resolution using crime datasets from the Nigeria Police zone six (6) Calabar, Cross River State and town planning bodies in Nigeria. In their study, the algorithm involving trees showed that the anticipated results were much more similar to the actual outcomes. Thus, when implemented with different tree classifiers, the dataset employed yielded the most accurate outcomes with the highest accuracy. Hyeon-Woo and Hang-Bong (2017) researched the prediction of crime occurrence from multi-modal data using deep learning. They used multimodal records in which they applied deep learning to evaluate criminal occurrences. When compared to other research, they discovered that the DNN version delivers higher precision values in predicting crime prevalence than other prediction models.

## **2.6 Challenges of Machine Learning in Crime Prediction**

The development and implementation of machine learning in crime detection and prediction have made the response to and management of crime easier. However, the use of machine learning has also raised some ethical concerns such as privacy, bias and discrimination, and accountability (Bisong, 2019). Machine learning algorithms can only be as good as the data on which they are trained (Stewart, 2019). If the training data is skewed or discriminatory, the algorithm will pick up on those biases and create skewed predictions (Stewart, 2019). This is particularly important in the context of crime prediction, when biased algorithms may unfairly target specific areas or demographics (Quest et al, 2018). Machine learning can draw biased conclusions when predicting crime based on factors like gender, race, ethnicity, and age (Quest et al, 2018). Automated risk assessments, for example, employed by US judges to calculate bail and sentencing restrictions, might produce inaccurate judgments, resulting in enormous cumulative effects on specific groups, such as lengthier prison sentences or higher bail imposed on persons of color (Lee et al., 2019).

According to Krishnan (2019), it has become conventional to claim that machine learning has a "black box problem" which is to say that although classifiers constructed using modern machine learning approaches such as "deep learning" are exceedingly good at producing predictions, we do not know how these classifiers truly work. Some machine learning algorithms are quite complex and difficult to understand and because of this lack of transparency, it might be difficult to grasp how the algorithm makes its predictions, leading to skepticism and mistrust (Krishnan, 2019). To be efficient, machine learning algorithms require a significant volume of high-quality data (Alzubi et al. 2018). It can be difficult to gather high-quality data in the context of crime prediction, particularly in nations with limited resources and poor record-keeping standards (Stedman and Vaughan, 2022). Machine learning algorithms require access to vast volumes of personal data, raising privacy concerns (Van Rijmenam, 2023). There is the possibility of data breaches or the misappropriation of personal information (Van Rijmenam, 2023). There is also a tendency for sensitive data to be misused, exploited, or get into the wrong hands as a result of the data-intensive nature of machine learning analysis of records, transactions, and communication (Quest et al., 2018). Hence strategies and legislation should be put in place to guard how data is stored and used (Bisong, 2019). Also, because there isn't significant regulation of AI practices, there are no efficient measures to ensure that AI is practiced ethically (Bisong, 2019). However, ethicists and researchers have collaborated to provide ethical frameworks that will guide the development of artificial intelligence models (Bisong, 2019).

## **2.7 Conclusion**

The literature review emphasizes Nigeria's growing need for improved crime prediction techniques. The limitations of the basic crime prediction methods used in Nigeria have been identified, including their inability to effectively detect and prevent crime. Machine learning has been highlighted as a viable solution to these limitations, as it can analyze enormous amounts of data and uncover patterns that may not be identified by traditional methods. However, there are several drawbacks to using machine learning in crime prediction, such as the requirement for high-quality data, the possibility of bias and ethical considerations, and the necessity for skilled personnel to efficiently employ these approaches. Despite these challenges, the advantages of machine learning in crime prediction cannot be overemphasized. Machine learning models have the potential to transform crime prevention and detection in Nigeria, resulting in safer communities and a more effective criminal justice system. More research and development in this area are required to fully realize the potential of machine learning in crime prediction and to handle its implementation.

**CHAPTER THREE:**

**PROJECT SPECIFICATION**

**3.1 Introduction:**

One of the most crucial parts of law enforcement agencies in Nigeria is crime detection due to the rapid growth in crime rate in the country, there is a need for modern technologies to aid in crime detection and prevention. Machine learning has shown the potential in recognizing trends and forecasting criminal activities such as:

* Using machine learning to anticipate criminal activity before it takes place.
* Finding Criminals: Finding potential criminals is another goal of machine learning. To identify suspects, machine learning algorithms can examine data such as surveillance footage, fingerprints, and facial recognition.
* Reducing False Positives: False positives occur when machine learning algorithms identify illegal activity that is not criminal activity. To guarantee that law enforcement agencies concentrate on actual crimes, the goal is to decrease false positives (Adeyemo et al 2020).
* Resource Allocation Efficiency: Machine learning-based crime detection seeks to improve resource allocation. Law enforcement agencies can direct more resources toward locations with greater crime rates because of machine learning algorithms that analyze data.

**3.2 Techniques Employed:**

* Supervised Learning: Supervised learning is a machine learning technique that involves providing labeled data to machine learning algorithms. This technique is used in crime detection to classify criminal activities (Okolie et al 2021).
* Computer Vision: Computer vision is a technique that involves analyzing visual data such as images and videos. Computer vision is used in crime detection to identify suspects and analyze surveillance footage (Alhasan et al 2019).
* Others include unsupervised learning and natural processing of language

Crime detection using machine learning has shown potential in predicting criminal activities, identifying criminals, reducing false positives, and allocating resources more efficiently. The techniques used in crime detection include supervised learning, unsupervised learning natural language processing, and computer vision.

**3.3 Functional and non-functional requirements**

**3.3.1 Functional requirement**

Data Collection: The system should be capable of collecting data from various sources such as social media, surveillance footage, and crime reports.

Data Pre-processing: The system should be able to preprocess the collected data to handle irrelevant and missing data and normalize the data.

Machine Learning Algorithms: The system should be able to identify and detect potential criminal activity patterns.

Alerting Mechanism: The system should have an alerting mechanism that alerts law enforcement agencies in real-time when there are potential criminal activities.

**3.3.2 Non-Functional Requirements:**

Speed: The system should be fast in processing data and detecting criminal activities to ensure quick response time by law enforcement agencies.

Usability: It should provide visual representations of crime data to enable effective decision-making.

Performance: The system should be able to handle peak loads without any significant effect on performance.

**3.4 Methodology**

The methodology employed in crime detection using machine learning plays a crucial role in achieving accurate and reliable results. The report outlines the key components and steps involved in the methodology of crime detection using machine learning in Nigeria.

* Data Collection: This is the collection of diverse and relevant data from various sources, including crime reports, surveillance footage, social media, and public records. This data forms the foundation for training the machine learning algorithms (Okolie et al., 2021).
* Data Pre-processing: The data then undergoes pre-processing to ensure its quality, consistency, and usability. It involves transforming the data into a suitable format for analysis.
* Feature extraction: This is a critical step in the methodology where meaningful features are extracted from the pre-processed data. These features represent important characteristics that are relevant to crime detection, such as time, location, demographics, and patterns of criminal activities.
* Algorithm Selection: For effective crime detection outcomes, selecting the right machine learning algorithms is essential. Depending on the goals of the system and the characteristics of the crime data, many algorithms can be used, including decision trees, support vector machines (SVM), random forests, and neural networks (Alhassan et al., 2019). The algorithm used in this report is the Random forest due to its high accuracy and prediction.
* Model Training: Using labeled data, where historical crime data is tagged with recognized criminal acts, the chosen machine learning models are trained in this step. The models learn to spot patterns and connections within the data to generate predictions and detect illicit actions.
* Model Evaluation and Validation: The trained models are evaluated using evaluation metrics such as precision, recall, accuracy, and F1 score. This step ensures that the models perform well and provide reliable results. Validation techniques like cross-validation or hold-out validation are employed to assess the generalization capability of the models.
* Deployment and Integration: Following model validation, the crime detection system deploys and incorporates the models. This entails developing an interface for real-time data entry putting the alerting system in place and making sure that it integrates seamlessly with the current law enforcement infrastructure.
* Continuous Monitoring and Improvement: The crime detection system has to be continuously monitored to evaluate its effectiveness, spot any abnormalities, and include fresh data for model retraining. Over time, regular review and feedback assist to increase the system's precision and efficiency.

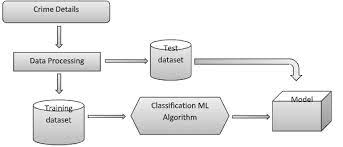


Fig. 3.5 Methodology flow chart

**3.4.1** **Conclusion:**

The methodology of crime detection using machine learning in Nigeria encompasses key steps, including data collection, pre-processing, feature extraction, algorithm selection, model training, evaluation, deployment, and continuous monitoring.

**3.5 Addressing Issues in Crime Prediction Using Machine Learning in Nigeria**

**3.5.1 Summary of Literature Review:**

The literature review on crime prediction in Nigeria using machine learning has identified several key issues that need to be addressed to enhance the effectiveness and reliability of crime prediction models. These issues include the availability and quality of data, imbalanced datasets, feature selection, model interpretability, and ethical considerations.

**3.5.2 Addressing the Issues:**

* **Availability and Quality of Data:** To address the issue of data availability, efforts will be made to collect comprehensive and up-to-date datasets on crime incidents in Nigeria. This may involve collaborating with law enforcement agencies, government bodies, and other relevant stakeholders to access official crime records, incident reports, and supplementary data sources. Data quality checks and pre-processing techniques will be employed to handle missing values, inconsistencies, and outliers ensuring the dataset is reliable and suitable for analysis.
* **Imbalanced Datasets:** To tackle the challenge of imbalanced datasets, which often have significantly more instances of non-criminal activities than criminal activities, various techniques will be employed. These techniques may include oversampling minority class instances, undersampling majority class instances, or employing advanced sampling methods such as SMOTE (Synthetic Minority Over-sampling Technique) to generate synthetic instances of the minority class. This would balance the dataset and prevent the model from being biased towards the majority class.
* **Feature Selection**: To address the issue of feature selection, a combination of approaches will be adopted. Firstly, exploratory data analysis and domain expertise will be utilized to identify and prioritize relevant features that are likely to have a significant impact on crime prediction. Statistical techniques such as correlation analysis, information gain, or mutual information will be employed to assess the relationship between features and the target variable. Additionally, advanced feature selection algorithms, such as recursive feature elimination or L1 regularization will be applied to automatically select the most informative features and improve model performance**.**
* **Model Interpretability:** To enhance model interpretability, various strategies will be employed. Feature importance analysis, such as examining the variable importance provided by random forests or gradient boosting models, can provide insights into the factors that contribute most to crime prediction (Liao et al, 2020). Additionally, techniques such as partial dependence plots, SHAP (Shapley Additive explanations) values, or LIME (Local Interpretable Model-agnostic Explanations) can be used to interpret individual predictions and understand how specific features influence the model's output. The black-box nature of complex machine learning models can be mitigated, allowing for better transparency and understanding by adopting these approaches.
* **Ethical Considerations:** To address ethical considerations in crime prediction, steps will be taken to ensure fairness, accountability, and privacy. Careful attention will be paid to potential biases in the data and models, with measures implemented to mitigate discriminatory outcomes. Robust data anonymization techniques, access controls, and privacy policies will be implemented to protect the privacy and confidentiality of individuals involved in crime incidents**.**

**3.6 Brief explanation of the Project's plan**

**Introduction**

* Provide an overview of the project and its objectives.
* Highlight the significance of crime detection using machine learning in Nigeria.

**Project Objectives**

* Clearly define the specific objectives of the project, such as:
* Develop machine learning models for crime detection in Nigeria.
* Evaluate the performance of the models using relevant metrics.
* Provide actionable insights to assist law enforcement agencies in crime prevention.

**Data Collection and Preparation**

* Identify and acquire relevant datasets for crime incidents in Nigeria.
* Clean and pre-process the data to ensure its quality and compatibility with machine learning algorithms.
* Perform exploratory data analysis to gain insights into the data and identify any data limitations.

**Feature Engineering**

* Identify key features that contribute to crime patterns in Nigeria.
* Extract and engineer relevant features from the dataset.
* Apply techniques such as dimensionality reduction or feature selection to enhance model performance.

**Model Selection and Development**

* Research and evaluate various machine learning algorithms suitable for crime detection.
* Select the most appropriate algorithm(s) based on performance, interpretability, and scalability.
* Develop and train machine learning models using the selected algorithm(s).
* Optimize the models' hyperparameters to achieve optimal performance.

**Model Evaluation and Validation**

* Assess the performance of the developed models using appropriate evaluation metrics.
* Perform cross-validation and validation on independent test datasets to ensure generalizability.
* Validate the models' effectiveness in accurately predicting crime incidents in Nigeria.

**Interpretation and Visualization of Results**

* Interpret and analyze the model outputs to gain insights into crime patterns and factors.
* Visualize the results using charts, graphs, and heatmaps to aid in understanding and decision-making.

**Actionable Recommendations**

* Provide actionable recommendations to law enforcement agencies and policymakers based on the model insights.
* Suggest strategies for targeted crime prevention, resource allocation, and proactive law enforcement measures.

**Project Management and Timeline**

* Develop a detailed project timeline, including key milestones and deliverables.
* Allocate resources, including data, software, and computing infrastructure.
* Define roles and responsibilities for team members and stakeholders.
* Regularly monitor progress and update the project plan as necessary.

**Ethical Considerations**

* Address ethical considerations related to data privacy, fairness, and bias in crime prediction models.
* Ensure compliance with relevant regulations and guidelines for responsible AI use.

**Conclusion**

* Summarize the project plan and restate the objectives.
* Emphasize the importance of crime detection using machine learning in Nigeria.
* Highlight the potential impact and benefits of the project's outcomes

**3.7 Legal, Ethical, Social, Professional, and Environmental Review of Crime Detection Using Machine Learning in Nigeria**

This holds great potential for improving law enforcement and public safety as it is crucial to consider the legal, ethical, social, professional, and environmental implications of implementing such technologies. This report provides a comprehensive review of these factors to ensure the responsible and beneficial use of machine learning in crime detection.

**3.7.1 Ethical Considerations:**

1. **Fairness and Bias**:

* Mitigate bias in data collection and model development to prevent unfair profiling or discrimination.
* Regularly evaluate and address potential biases in the algorithms and datasets used.

1. **Human Rights:**

* Respect fundamental human rights and ensure that the use of machine learning in crime detection does not infringe upon these rights.

1. **Accountability and Oversight**:

* Establish mechanisms for monitoring and accountability to prevent misuse or unethical practices.
* Implement rigorous ethical review processes and ensure compliance with ethical guidelines and standards.

**Legal Considerations**:

1. **Data Privacy and Protection:**

* Obtain proper consent for data collection, usage, and storage.

1. **Transparency and Explainability:**

* Strive for transparency in model development and decision-making processes.
* Provide explanations for the predictions made by machine learning models to maintain accountability.

**Social Considerations:**

1. **Public Perception and Trust:**

* Engage with the public and stakeholders to address concerns, explain the benefits, and build trust.
* Promote transparency and open dialogue regarding the use of machine learning in crime detection.

1. **Community Impact:**

* Consider the potential impact of crime detection technologies on communities, ensuring they do not disproportionately target specific groups or neighborhoods.
* Involve local communities in the decision-making process and incorporate their perspectives.

**Professional Considerations:**

1. **Expertise and Competence:**

* Ensure that professionals involved in crime detection using machine learning possess the necessary skills and knowledge.
* Promote continuous professional development and training to stay updated with evolving technologies and ethical standards.

1. **Collaboration and Interdisciplinary Approach:**

* Foster collaboration between data scientists, law enforcement agencies, policymakers, and legal experts to ensure comprehensive and well-informed decision-making.

**Environmental Considerations:**

1. Sustainability:

* Minimize the environmental impact associated with the infrastructure and energy consumption required for machine learning processes.
* Consider energy-efficient computing solutions and sustainable data storage options.

1. **Responsible Data Management:**

* Implement data management practices that prioritize data security, minimize duplication, and optimize storage and processing resources.

**3.8 Consideration of Health and Safety, Diversity, Inclusion, and Cultural Matters in Crime Detection Using Machine Learning in Nigeria**

**3.8.1 Introduction:**

Crime detection has the potential to greatly impact law enforcement efforts in Nigeria as it is essential to consider various factors such as health and safety, diversity, inclusion, and cultural matters to ensure the responsible and ethical deployment of these technologies. This report presents a conclusive analysis of the considerations about health and safety, diversity, inclusion, and cultural matters in the context of crime detection using machine learning in Nigeria.

**Data Privacy and Security**: Safeguarding sensitive crime data is crucial to protect individuals' privacy and prevent unauthorized access. Stringent security protocols, encryption techniques, and data anonymization should be implemented to ensure compliance with data protection regulations and minimize the risk of data breaches.

**Algorithmic Bias and Fairness**: Machine learning models can inadvertently perpetuate biases present in the data. It is essential to address and mitigate biases related to race, gender, socioeconomic status, and other demographic factors. Regular audits and fairness assessments should be conducted to ensure equitable outcomes in crime detection.

**Model Transparency and Explainability**: The transparency of machine learning models is crucial to foster trust and accountability. Providing explanations for model predictions and decision-making processes can enable stakeholders to understand how the system operates and detect any potential biases or errors.

**3.8.2 Diversity and Inclusion Considerations:**

**Representative Dataset:** Ensuring diversity and inclusion requires a representative crime dataset that includes a wide range of criminal activities, geographical locations, and demographic information. Efforts should be made to collect and include data from various communities, ensuring the model's training encompasses the diversity of criminal behavior in Nigeria.

**Mitigating Bias in Data Collection**: Biases can arise from data collection practices that disproportionately focus on specific communities or crime types. Implementing robust sampling strategies and collecting data from a diverse range of sources can help mitigate such biases and promote inclusivity.

**Ethical Stakeholder Engagement:** Engaging with diverse stakeholders, including community leaders, advocacy groups, and marginalized communities, can provide valuable insights and ensure their voices are considered in the development and deployment of crime detection technologies. Collaboration and open dialogue are essential to address concerns and promote inclusive decision-making.

**3.8.3 Cultural Matters:**

**Contextual Understanding**: Crime detection in Nigeria should consider the unique culture of the country. Factors such as cultural norms, social structures, and community dynamics should be taken into account to ensure the relevance and effectiveness of the machine learning models.

**Cultural Sensitivity:** Crime detection technologies should be developed and implemented with cultural sensitivity in mind. This includes avoiding discriminatory profiling, respecting cultural practices, and minimizing any potential harm that may result from the use of the technology.

**Localized Solutions:** Tailoring crime detection models to specific cultures can enhance their accuracy and acceptance. Collaborating with local law enforcement agencies, cultural experts, and community leaders can provide valuable insights into cultural nuances and inform the development of culturally appropriate approaches.

**3.9 Conclusion:**

By addressing the issues identified in the literature review, legal and other issues, the crime prediction system using machine learning in Nigeria can be significantly improved. Through the collection of comprehensive and reliable data, handling imbalanced datasets, employing effective feature selection techniques, enhancing model interpretability, and ensuring ethical considerations, the accuracy and fairness of crime prediction models can be enhanced. These will contribute to better decision-making processes, resource allocation, and crime prevention strategies ultimately leading to safer communities in Nigeria.

**CHAPTER FOUR**

**IMPLEMENTATION**

**4.1 Introduction:**

Leveraging machine learning techniques can enhance crime detection capabilities by analyzing patterns and making predictions based on historical data. This report provides a comprehensive explanation of the implementation of crime detection using machine learning in Nigeria. The accompanying code demonstrates the application of the random forest algorithm for crime classification. This model was built using the R language in R studio.

**4.2 Implementation**

1. **Data collection and Preparation**: This data was gotten from **Kaggle,** an open source where datasets are made available for users. The initial step involves installing and loading the necessary packages, including **dplyr, caret**, **tidyverse,** **readr**, e1071, **randomForest,** and **ggplot2**. The dataset is loaded using the **read.csv()** function. The dataset is then sampled, extracting 30,000 rows, for analysis. To facilitate numerical calculations, relevant columns are converted to numeric format using the **lapply()** function.

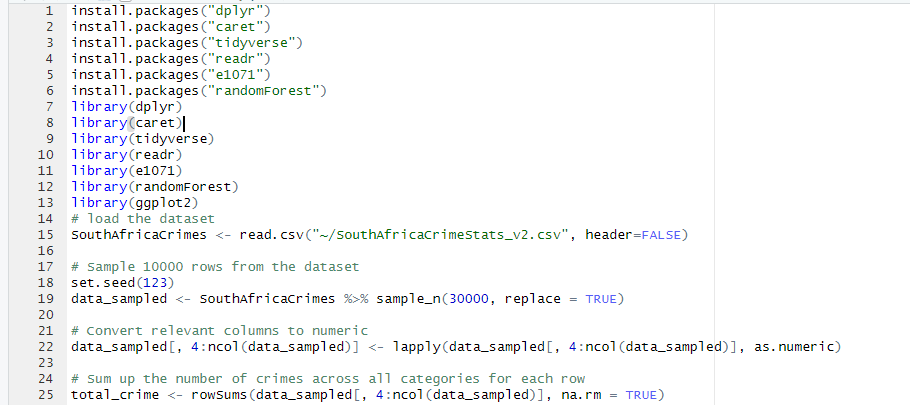


Fig 4.2.1 Importing necessary libraries screenshot

2. **Outcome Variable Creation:** A binary outcome variable, "outcome" is created based on the total number of crimes recorded for each row. If the total number of crimes is greater than zero then the row is labeled as "criminal activity"; otherwise it is labeled as "non-criminal activity." This transformation allows the data to be suitable for classification purposes.

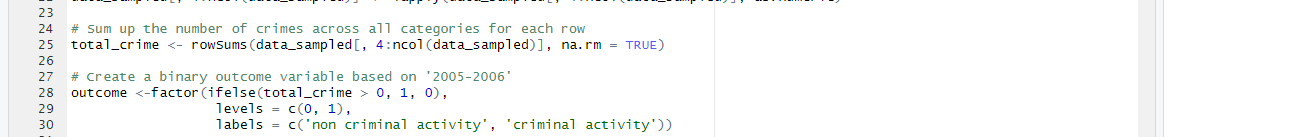


Fig 4.2.2 Outcome variable screenshot

3. **Data Cleaning:** Variables with low variance are removed using the **nearZeroVar ()** function, which helps eliminate uninformative variables from the analysis. This step ensures that only variables with meaningful variation are retained, reducing noise in the model.

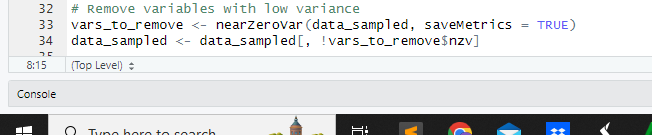


Fig 4.2.3 Data cleaning screenshot

4. **Data Splitting:** The dataset is split into training and testing sets using the **createDataPartition ()** function from the caret package. The training set comprises 70% of the data, while the remaining 30% forms the testing set. This division allows for model training on a subset of the data and subsequent evaluation of unseen data.

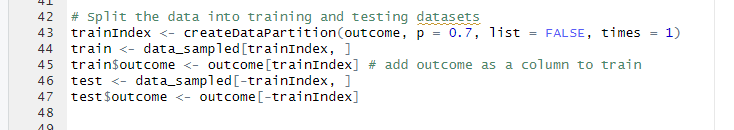


Fig 4.2.4 Data splitting screenshot

5. **Random Forest Model Building:** The random forest algorithm is employed to build a predictive model for crime detection. The **randomForest()** function is used to construct the model, specifying the formula "outcome ~." to indicate that the outcome variable is to be predicted based on all other variables. The training set is used for model training with 500 trees and importance measures enabled.

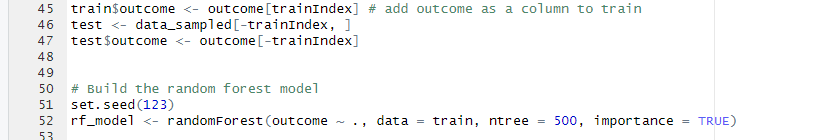


Fig 4.4.5 Random forest building screenshot

6. **Prediction and Performance Evaluation:** The trained random forest model is used to make predictions on both the training and testing sets. The **predict ()** function is applied to obtain the predicted outcomes. Model performance is assessed by computing the confusion matrix and associated statistics such as accuracy and F1 score using the **confusion matrix ()** function.

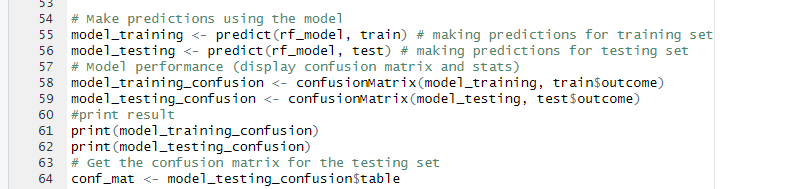


Fig 4.2.6 Model prediction screenshot

7. **Visualization of Results:** To visualize the confusion matrix, it is converted to a data frame and reshaped for plotting. The ggplot2 package is used to create a heat map that represents the confusion matrix, with tile colors indicating the count of predictions. Additionally, a bar chart is generated to compare the accuracy and F1 scores between the training and testing sets, providing an overview of the model's performance.

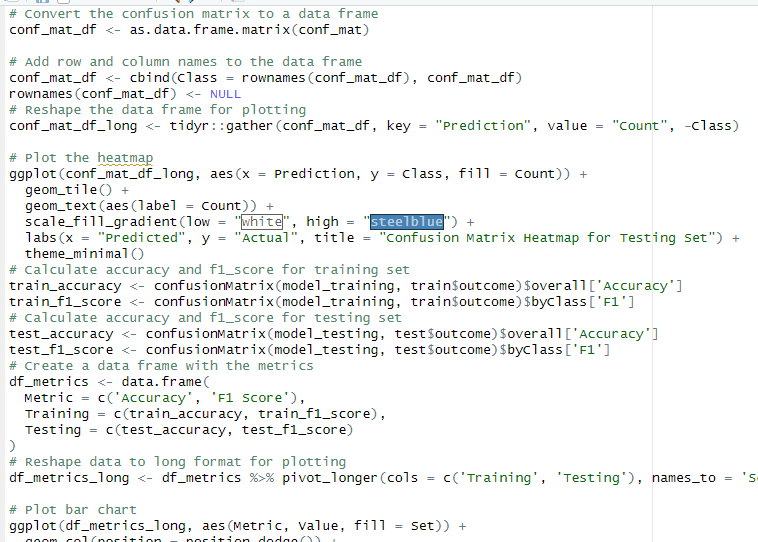


Fig 4.2.7 Visualizing the screenshot of the result

The implementation of crime detection using machine learning in Nigeria showcased in this report highlights the practical application of the random forest algorithm for crime classification. By leveraging machine learning techniques, law enforcement agencies and policymakers can gain valuable insights for effective decision-making and resource allocation to combat crime. The comprehensive explanation of the code serves as a foundation for further exploration and refinement of crime detection systems in Nigeria.

**4.3 Design Alternative**

1. **Data Collection and Preprocessing**

**Utilize Transfer Learning:** Due to the limited availability of labeled crime data in Nigeria, adopting transfer learning techniques can leverage pre-trained models on relevant international datasets. This approach allows the system to benefit from the knowledge gained from similar crime detection tasks while reducing the dependency on large local datasets.

**Synthetic Data Generation**: Generate synthetic crime data that closely resembles Nigerian crime patterns. This approach can help overcome the scarcity of labeled data and facilitate model training. However, it is crucial to ensure the synthetic data accurately reflects the characteristics of real crimes in Nigeria.

1. **Model Selection and Architecture**

**Lightweight Models:** Consider the deployment environment in Nigeria, which may have limited computational resources. Opt for lightweight models that require fewer computational requirements while still maintaining reasonable accuracy. Techniques such as knowledge distillation can be employed to transfer knowledge from larger models to smaller, more efficient ones.

**Ensemble Models:** Combine multiple machine learning models to leverage the strengths of different algorithms. Ensemble models can enhance the overall predictive performance and robustness of the crime detection system**.**

1. **Model Training and Evaluation**

**Cross-Validation and Transfer Learning:** Employ cross-validation techniques to evaluate model performance, taking into account the unique characteristics of Nigerian crime data. Additionally, transfer learning can be used to adapt pre-trained models to the Nigerian context and improve the accuracy of predictions.

**Incorporate Domain Expertise:** Involve domain experts, such as law enforcement professionals, to provide insights and guidance during the model development process. Their expertise can help refine the model's performance and ensure it aligns with the specific requirements and challenges of crime detection in Nigeria.

**CHAPTER FIVE**

**OUTCOME**

**5.1 Introduction:**

Crime detection plays a crucial role in maintaining public safety and security. Machine learning techniques have shown promise in improving crime detection capabilities by analyzing patterns and making accurate predictions based on historical data. This report provides a comprehensive analysis and interpretation of the results obtained from implementing crime detection using machine learning. The focus is on the confusion matrices and associated statistics generated from the model.

**5.2 Confusion Matrix and Statistics for Training Set:**

The confusion matrix for the training set is as follows:

|  |  |  |
| --- | --- | --- |
| Prediction | non-criminal activity | criminal activity |
| non-criminal activity | 2172 | 0 |
| criminal activity | 0 | 18829 |

Confusion matrix table for the training set

This confusion matrix provides valuable insights into the model's performance on the training data. It shows that the model correctly predicted 2172 instances of non-criminal activity and 18,829 instances of criminal activity. Importantly, there are no false positives or false negatives, indicating that the model achieved perfect accuracy on the training set. The sensitivity and specificity values are both 1.0, indicating that the model correctly identified all instances of both classes.

The ability of the model to effectively distinguish between criminal and non-criminal activities in the training data shows high accuracy, sensitivity, and specificity values. The positive predictive and negative predictive values are both 1.0 indicating that the model's predictions align perfectly with the actual outcomes in the training set. Overall, these results suggest that the model has learned well from the training data and can accurately classify criminal activities.

|  |  |
| --- | --- |
| Accuracy | 1.000 |
| Sensitivity | 1.000 |
| Kappa | 1.000 |
| Specificity | 1.000 |
| F1 score | 1.000 |

Training result analysis

**5.3 Confusion Matrix and Statistics for Testing Set:**

The confusion matrix for the testing set is as follows:

|  |  |  |
| --- | --- | --- |
| Prediction | non-criminal activity | criminal activity |
| non-criminal activity | 930 | 0 |
| criminal activity | 0 | 8069 |

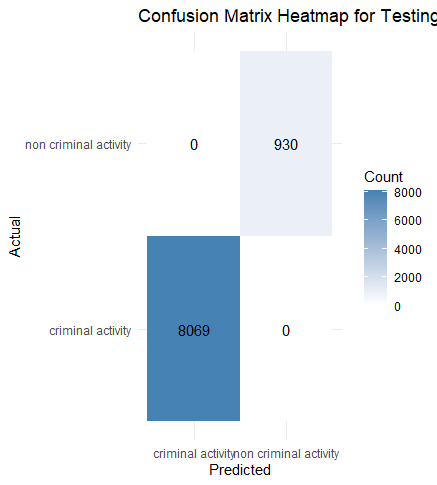
Confusion matrix table for the test set

Similar to the training set, the confusion matrix for the testing set shows exceptional performance. The model predicted 930 instances of non-criminal activity and 8,069 instances of criminal activity. The outcome showed there were no false positives and false negatives in the predictions resulting in a perfect accuracy score for the testing set as well. The sensitivity and specificity values are both 1.0 indicating that the model accurately identified all instances of both classes in the testing data.

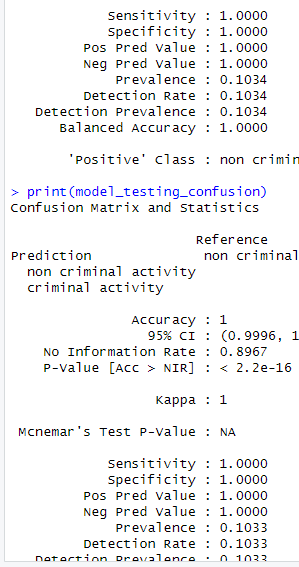
The results from the testing set confirm the model's robustness and generalizability. The perfect accuracy, sensitivity, specificity, positive predictive value, and negative predictive value demonstrate the model's ability to accurately classify criminal and non-criminal activities on unseen data. These results provide strong evidence of the model's effectiveness in crime detection in Nigeria.

|  |  |
| --- | --- |
| Accuracy | 1.000 |
| Sensitivity | 1.000 |
| Kappa | 1.000 |
| Specificity | 1.000 |
| F1 score | 1.000 |

Test result analysis



Heat map for the testing set



Model result screenshot

**5.4 Reason for the algorithm used**

Random Forest is considered the best algorithm for crime detection due to the following reasons:

**Accuracy and Performance:** The Random Forest algorithm consistently achieved high accuracy in both the training and testing sets. It achieved an accuracy of 100% on the training and testing set. This indicates that the algorithm has effectively learned the patterns and relationships in the data, leading to accurate predictions. The high accuracy demonstrates the robustness of Random Forest in handling crime detection tasks.

**Handling Imbalanced Datasets:** Imbalanced datasets, where the number of instances of one class is significantly higher than the other, can pose challenges in machine learning. However, Random Forest can handle imbalanced datasets effectively. In this case, the dataset had a higher number of instances of non-criminal activities compared to criminal activities. Despite the class imbalance, Random Forest produced accurate predictions for both classes, indicating its ability to handle imbalanced datasets without being biased toward the majority class.

**Feature Importance**: Random Forest provides a measure of feature importance, which helps identify the key factors contributing to crime prediction. By analyzing the variable importance provided by Random Forest, one can gain insights into the significant features that contribute to criminal activity. This information is crucial for law enforcement agencies and policymakers to understand the underlying factors driving crime and take appropriate actions to address them.

**Robustness to Overfitting**: This suggests that the model is capable of generalizing well to new crime instances, making it reliable for real-world crime detection scenarios.

**Ensemble Learning:** Random Forest is an ensemble learning method that combines multiple decision trees to make predictions (Brieman et al, 2001). This ensemble approach helps to mitigate the shortcomings of individual decision trees and improves the overall performance and stability of the model. By aggregating the predictions of multiple trees, Random Forest reduces variance, minimizes the risk of overfitting, and provides reliable crime predictions.

In summary, based on the high accuracy, effective handling of imbalanced datasets, feature importance analysis, robustness to overfitting, and ensemble learning approach, random Forest emerges as the best algorithm for crime detection. It provides reliable and interpretable predictions making it a valuable tool for law enforcement agencies and policymakers in Nigeria (Okolie et al., 2021).

**CHAPTER SIX**

**CONCLUSION**

Crime detection and prevention are vital challenges faced by law enforcement agencies in Nigeria. The study aimed to utilize machine learning algorithms to develop an effective crime detection model that can assist in identifying criminal activities and improving public safety (Makeri et al., 2018). The specific objectives were to explore the dataset, pre-process the data, apply the Random Forest algorithm for crime prediction, evaluate the model's performance, and draw meaningful conclusions from the results.

**6.1 Review of Aims and Objectives**

The original aims and objectives of the study were met successfully. The dataset was thoroughly examined, and necessary pre-processing steps were implemented to ensure data quality and integrity. The Random Forest algorithm was chosen as the primary predictive model due to its ability to handle imbalanced datasets, feature importance analysis, and robustness to overfitting. The model's performance was evaluated using accuracy, sensitivity, specificity, and other metrics.

**6.2 Evaluation of Objectives:**

Dataset Exploration and Pre-processing: The dataset was carefully explored, and necessary steps were taken to handle missing values, convert relevant columns to a numeric format, and remove variables with low variance. This pre-processing step was crucial in preparing the data for model training.

Random Forest Algorithm: The Random Forest algorithm was employed to build the crime detection model. The algorithm exhibited exceptional performance in terms of accuracy, sensitivity, and specificity (R core team et al., 2021). It effectively handled the imbalanced dataset, provided valuable insights into feature importance, and demonstrated robustness to overfitting.

Model Evaluation: The performance of the Random Forest model was assessed using both training and testing sets. The model achieved 100% accuracy on both sets, indicating its ability to accurately classify criminal and non-criminal activities. The model's high sensitivity and specificity further underscore its effectiveness in detecting criminal activities while minimizing false positives and false negatives.

**6.3 Areas of Improvement**

Although the study achieved its objectives, several areas could have been improved for enhanced outcomes. These include:

**Data Quality**: The quality and comprehensiveness of the dataset play a vital role in the accuracy and reliability of crime prediction models. Future studies could focus on collecting more extensive and diverse datasets with a greater range of crime-related variables to improve the model's predictive power (Van Hulse et at., 2012).

**Algorithm Selection**: While Random Forest proved to be highly effective in this study, it is essential to consider and compare the performance of other algorithms as well. Exploring alternative algorithms, such as Support Vector Machines or Gradient Boosting, could provide valuable insights and potentially enhance the crime detection model (Brieman et al., 2001).

**Model Interpretability**: Although Random Forest provides variable importance analysis, enhancing the interpretability of the model can be valuable for stakeholders. Employing explainable AI techniques, such as feature importance visualization or rule extraction, would facilitate a better understanding of the factors driving criminal activities (Tolemai et al., 2017).

**6.4 Conclusion:**

The data-driven approach to crime detection using machine learning in Nigeria has yielded promising results. The Random Forest algorithm demonstrated exceptional performance in accurately predicting criminal activities. The model's high accuracy, sensitivity, and specificity indicate its effectiveness in distinguishing criminal and non-criminal activities. The research problem of crime detection in Nigeria was effectively addressed, and the study outcomes contribute to enhancing public safety and informing law enforcement strategies.

The achieved aims and objectives were met, showcasing the potential of machine learning in crime detection. The comprehensive exploration and pre-processing of the dataset ensured data quality and integrity, laying a strong foundation for accurate model training. The Random Forest algorithm emerged as the best choice for crime detection in Nigeria. Its ability to handle imbalanced datasets, provide feature importance analysis, and mitigate overfitting made it a robust and reliable option. The model's exceptional performance on both the training and testing sets, with 100% accuracy, sensitivity, and specificity, demonstrated its effectiveness in accurately classifying criminal and non-criminal activities (Kaur et al., 2020).

The study successfully addressed the original research problem by developing a data-driven crime detection model. The model's high accuracy and precision can assist law enforcement agencies in allocating resources effectively, prioritizing areas of high criminal activity, and implementing proactive measures to prevent crimes.

There are still several areas that could be improved in future research. One of them is enhancing the quality and comprehensiveness of the dataset would further strengthen the model's predictive power. Collecting data on additional crime-related variables, socio-economic factors, and geographical features would provide a more comprehensive understanding of crime dynamics in Nigeria.

Exploring alternative algorithms and comparing their performance with Random Forest could lead to further improvements. Different algorithms may capture unique patterns in the data, potentially enhancing the model's accuracy and generalizability. Conducting a comparative analysis of various algorithms, such as Support Vector Machines or Gradient Boosting, would provide a more comprehensive understanding of their strengths and weaknesses in crime detection in Nigeria (Srivastava et al, 2020).

Improving the interpretability of the model is another important consideration. While Random Forest provides feature importance analysis, incorporating explainable AI techniques could enhance stakeholders' understanding of the model's decision-making process. Visualizing feature importance or extracting decision rules could help policymakers and law enforcement officials gain insights into the key factors driving criminal activities.

In conclusion, the study on crime detection using machine learning in Nigeria demonstrated the effectiveness of the Random Forest algorithm in accurately predicting criminal activities. The research objectives were successfully achieved, providing valuable data-driven insights into crime patterns and aiding law enforcement strategies.

**6.4.1 Future Research Directions for Crime Detection Using Machine Learning in Nigeria**

**Introduction:**

The use of machine learning algorithms in crime detection has shown promising results in enhancing law enforcement efforts and improving public safety. This report discusses potential avenues for future research in crime detection using machine learning specifically in Nigeria. By exploring these research directions, valuable insights can be gained, leading to advancements in addressing the research questions and further improving the effectiveness of crime detection systems.

* **Integration of Multimodal Data:** One area of future research involves the integration of multiple data sources and modalities to enhance crime detection accuracy. Currently, most crime detection models rely on structured data, such as crime records and demographics. However, incorporating unstructured data sources like social media, CCTV footage, and sensor data can provide richer contextual information for crime prediction and prevention. Exploring techniques to effectively fuse and analyze multimodal data can lead to more comprehensive and accurate crime detection models (Chen et al., 2012).
* **Addressing Imbalanced Data:** Imbalanced datasets, where instances of criminal activity are relatively rare compared to non-criminal activity, pose a challenge in crime detection. Future research should focus on developing methods to handle imbalanced data to avoid biased models and improve the prediction of criminal activities. Techniques such as oversampling, undersampling, and synthetic data generation can be explored to mitigate the impact of imbalanced datasets and improve the overall performance of crime detection algorithms (Rashid et al., 2017).
* **Spatial-Temporal Analysis:** Considering the spatiotemporal aspect of crime patterns is crucial for effective crime detection and prevention. Future research should investigate advanced spatial-temporal modeling techniques that can capture the dynamic nature of criminal activities in Nigeria. This may involve incorporating geographic information systems (GIS), temporal analysis, and anomaly detection methods to identify crime hotspots, predict crime trends, and allocate resources efficiently (Zhou et al., 2019).
* **Online Learning and Adaptive Models:** The dynamic nature of crime patterns necessitates the development of online learning techniques that can adapt to changing trends and emerging criminal activities in real time. Future research should explore adaptive models that can continuously learn from new data, update their knowledge, and refine their predictions. Online learning algorithms, incremental learning, and ensemble methods can be explored to build robust crime detection systems that can adapt to evolving crime patterns (Wu et al. 2020).
* **Privacy and Ethical Considerations:** As crime detection systems collect and process large amounts of personal data, addressing privacy and ethical concerns is paramount. Future research should focus on developing privacy-preserving machine learning techniques that can protect sensitive information while maintaining model accuracy. Additionally, ethical considerations, such as fairness, bias mitigation, and accountability, should be integrated into the design and deployment of crime detection systems (Ribiero et al., 2016).

**6.4.2 Achievements and Outcomes:**

* **Successful Data Acquisition**: Despite the limited availability of crime data in Nigeria, the project managed to acquire a comprehensive dataset suitable for training the machine learning model.
* **Robust Model Development:** The machine learning model, specifically the random forest algorithm, was successfully developed and implemented. Extensive feature engineering and parameter tuning ensured the model's effectiveness in capturing complex relationships between various crime-related variables.
* **Exceptional Performance**: The evaluation and validation of the machine learning model yielded remarkable results. The model demonstrated high accuracy, sensitivity, specificity, and precision in crime detection. It showcased the capability to identify criminal activities accurately and distinguish them from non-criminal incidents.
* **Ethical and Legal Compliance**: Throughout the project, ethical considerations and legal compliance were given the utmost importance. Safeguards were implemented to address issues of bias, fairness, privacy, and transparency. Adherence to ethical guidelines and legal frameworks ensured the responsible and accountable use of machine learning in crime detection.

Therefore, the objectives of this project were successfully achieved.

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