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A Review on Machine Learning Models for Crime Predictions in Nigeria

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ABSTRACT

Crime is a general phenomenon that integrates into every society which cannot be eradicated completely. It hinders all forms of developments. This informs the reason why government of every society mandates security agencies, such as, police and other forces to serve as agents of crime fighters within its domain. Again, for the police force to effectively carry out their constitutional rights there is need to have an efficient solution that will aid them in forecasting where and when the next crime is likely to occur so that police officers will be deployed to the location before criminals commit such crime. The crime predictions can only be achieved through the application of an efficient machine learning model. The goal of this paper is focused on systematic review of criminal activities in Nigeria and machine learning models. Conducting this review provides adequate in-depth knowledge on the best models that can be effectively applied to crime predictions. Therefore, the paper x-rays the concept of crime, criminal categories and crime situational reports in Nigeria. Some evidence-based existing empirical works were reviewed to shed more lights on these models and recommendations were proffered on way-forward to have a predictive policing system in Nigeria.

Keywords: Crime, Predictions, Machine Learning, Models, Nigeria Police Force, Predictive Reasoning, Policing.

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1. BACKGROUND OF THE STUDY

The act of committing crime on earth is old as man. This is evident in the history of descendant of Adam and Eve as rightly observed by (Gillani, Mahmood, Rehman & Rashid, 2008; Jalil & Iqbal, 2010) that the first offence was committed on earth by Cain, the first offspring of Adam and Eve when he killed Abel (his blood brother) as a result of jealousy. This act of criminality has continuously expanding till present time across the world. No society is totally free from crimes, except that the level of perpetration may differ from one society to another.



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This implies that what is considered as a punishable crime in a particular society may differ in another society (Usman, Yakubu & Bello, 2012; Adebayo, 2013; Ghani, 2017). For instance, in Nigeria, termination of unwanted pregnancy (abortion) openly is illegal whereas it is legalized by South Africa government (Morrioni, Myer & Tibazarwa, 2006). In Nigeria context, Nigeria Police Force (NPF) is mandated to control, monitor, apprehend and prosecute criminals after being convicted at the competent court of law (Nigeria Constitution, 1999). Therefore, more efforts need to be taken in both reactive and proactive measures by Nigeria Police to nib the crimes in the bud before it occurs. Reactive within the context of this article implies taking action on a crime after the perpetrator might have committed it, while proactive is the situation whereby a crime is being curtailed before it happens. To actualize the latter, there is need to explore machine learning models that can be employed in future crime prediction by analyzing the trends or patterns of previous crime datasets.

Machine learning as a soft-computing is an integral part of artificial intelligence that employs supervised, unsupervised or hybridized learning approach for prediction. In essence, machine learning is the application of different algorithms that make computers learn (using training datasets) and make predictions based on available known data – testing datasets (Javed, 2016). Within the context of this paper, an algorithm is the finite steps by steps procedures applied in solving a problem. Therefore, to use an efficient algorithm in solving a problem, Kundu (2008) explained that heuristic approach should be adopted to select an algorithm that can give appropriate solution and save computational time. Kundu's submission is expressed in figure 1. Machine Learning today is among the growing computing specialized field of study (Srivastava, Hinton, Krizhevsky, Sutskever & Salakhutdinov, 2014) and its applications cover wide range of areas, such as, pattern and speech recognition, fraud detection, image analysis, computer vision, crime prediction, to mention but a few (Nguyen, Hatua & Sung, 2017; Internet Society, 2017; Carreira-Perpiñan, 2016; Dey, 2016; Macdonald, 2016; Alpaydin, 2014 & Schmidhuber, 2014).

2. STATEMENT OF PROBLEM

It is obvious today that with the emergency of Information and Communication Technology (ICT) tools, criminal activities are committed in all nook and crannies of all six geo-political zones of Nigeria ranging from corruption, rape, terrorist, banditry, kidnapping, murder/assassination, car theft, human trafficking, assault, bombing, terrorism, impersonation, forgery, unlawful possession of firearms, to mention but a few (Tenibiaje, 2010 & Tretter, 2013). These acts are escalating daily which need urgent attention of Federal Government through its well established security agencies such as NPF. To curtail criminals' activities, there is need to a viable system that can aid police in the aspect of predictive policing. Therefore, this article explores some of the available supervised machine learning models that would be implemented in the aspect of crime predictions thereby providing opportunity for NPF in adopting predictive policing to minimize crimes in our various societies before it happens.



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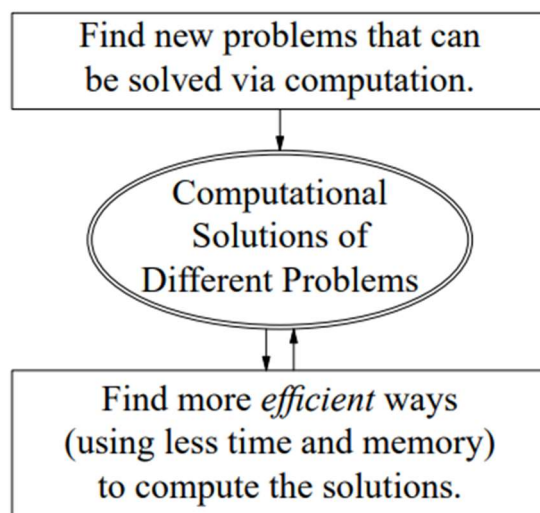


Figure 1: Procedures of selecting an appropriate algorithm in solving a problem.

Source: Kundu (2008)

3. OBJECTIVE OF THE STUDY

The objective of this article is to conduct a systematic review of criminal activities in Nigeria and machine learning models that can be best effectively applied to crime predictions.

4. METHODOLOGY

To achieve the stated objective, secondary data and information were sourced from printed and online materials, such as, conference papers, journal articles and books. These materials were reviewed and authors were as well acknowledged.

5. RESULTS

The following concepts were meticulously reviewed as follows:

5.1 Classifications of Criminals

In an attempt to classify criminals, Akers and Sellers (2013) come up with three major classifications, namely; born criminal, criminaloid and insane criminal. These are briefly explained as follows:

- (i) **Born Criminal:** This category of criminal was identified by Lombroso as reported in Akers and Sellers (2013) and opined that the act is very dangerous and hardened criminal which is very difficult to desist from if one engages in it.
- (ii) **Criminaloid:** In this category, committing crimes are motivated by lust and criminal is ready to perpetrate any illicit act under the influence of peers coupled with intention to satisfy his/her needs in any circumstances or opportunity. In this category, Oni (2016) expressed that crime is committed on two factors, that is, motivation and opportunity.



- (iii) **Insane Criminal:** in this category, crimes are committed due to the fact that one is suffering from psychological disorders. This implies that crimes are perpetrated when one is mentally unstable.

The above three classifications of criminals are illustrated in criminal triangle as shown in figure 2

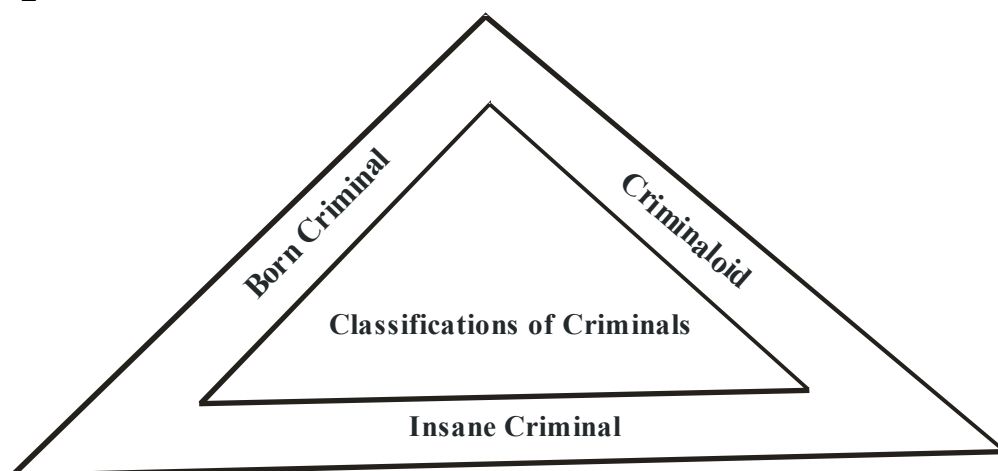


Figure 2: Schematic representation of three classifications of criminals

5.2 Nigeria Crime Situational Report

In line with the report of crime statistics issued by National Bureau of Statistics (NBS) in 2016 where top ten list of states with high number of crimes were Lagos; Abuja; Delta; Kano; Plateau; Ondo; Oyo; Bauchi; Adamawa and Gombe States (Oguntunde, Ojo, Okagbue & Oguntunde, 2018). However, Ukoji, Ayodokun and Eze (2018) extracted fatalities crime dataset from Nigeria Watch Database and used descriptive statistics for the analysis and in a sum of 8,516 deaths that was recorded between June 2006 and September, 2015, armed robbery contributed 2,468 crimes, which is about 50% of the total crime fatalities, cultism with 2,363 deaths equivalent to 28%, thuggery/assassination/ hooliganism with 676 amounted to 8%, domestic violence with 605 deaths accounted for 7%, kidnapping with 467(6%) and rape with 147 (2%).

Presently, the insecurity in Nigeria is worsened with the emergency of banditry in the northwest and Boko Haram insurgency in the northeast while the armed robbery as well as cultism rocked the southwest and south-south. In the trying period, many lives were lost to these different forms of criminal activities. States like Sokoto, Niger, Kaduna, Katsina and Zamfara were more affected by the banditry (Olaniyan & Yahaya, 2016). On several occasions, bandits were seen displaying weapons to terrorize good citizens resulting to killings and kidnappings people from their homes to bush demanding for ransom (Olaniyan, 2018). It was reported by Abdullahi (2019) that in about 330 attacks made by banditry from January to July, 2019, 1,460 people lost their lives, while others sustained varying degrees of injuries.



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5.3 Crime Prediction

Literally, crime prediction can be seen as the use of analytical techniques to assume when, where and who will commit crime in future. Describing crime prediction, Walter, Brian, Carter, Susan and John (2013) stressed that the theory which says crime is predictable can easily be supported with a strong body of evidence because criminals tend to operate at their comfort zone. This implies that offenders usually engage themselves in the type of crimes they have been committing successfully in the past and such crimes are committed close to the same vicinity and time. Therefore, predicting where and when the crime will occur in future can help police officers to have pre-knowledge on when and where criminal(s) will likely strike.

In turn, the police officers can be deployed to the location ahead of perpetration. In this 21st century where there is pervasive use of ICT devices, tendency to commit crimes daily in the society is very rampant, therefore, ability to detect and apprehend criminals by police officers proactively cannot be as well underestimated. Thus, planning effective and efficient crime prevention strategy would not only prevent crimes and victimization in the societies, but also promote community safety and contribute to the sustainable development of countries (Adeola, Falaki & Olabode, 2014) and in turn improve the quality of life of citizens as well as daily economic transactions (Ahishakiye, Omulo, Wario & Niyonzima, 2017).

5.4 Application of Machine Learning Models for Crime Predictions

The advancement in information technology coupled with artificial intelligence has paved ways for the application of machine learning models for predictions in many fields of human endeavours and machine learning models employ the use of algorithms to learn from the existing datasets and make future predictions from such previous datasets in order to make decisions (Bengio, Courville & Vincent, 2013).

Similarly, Huapaya, Rodriguez and Esenarro (2020) pointed out that machine learning has ability to perform automatic detection of patterns in the input data. Therefore, while using machine learning models for prediction, some processes must be followed (Diwan, Nigam, Tiwari & Bhati, 2017) and these are depicted in figure 3. Machine learning models can be basically grouped into three, as enumerated by (Internet Society, 2017; Chawla, Singh & Jijja, 2016; McClendon & Meghanathan, 2015 and Sathya & Abraham, 2013) as follows.

In this article, emphasis is made on supervised machine learning models.

- (1) Supervised Learning,
- (2) Unsupervised Learning, and
- (3) Reinforcement learning.

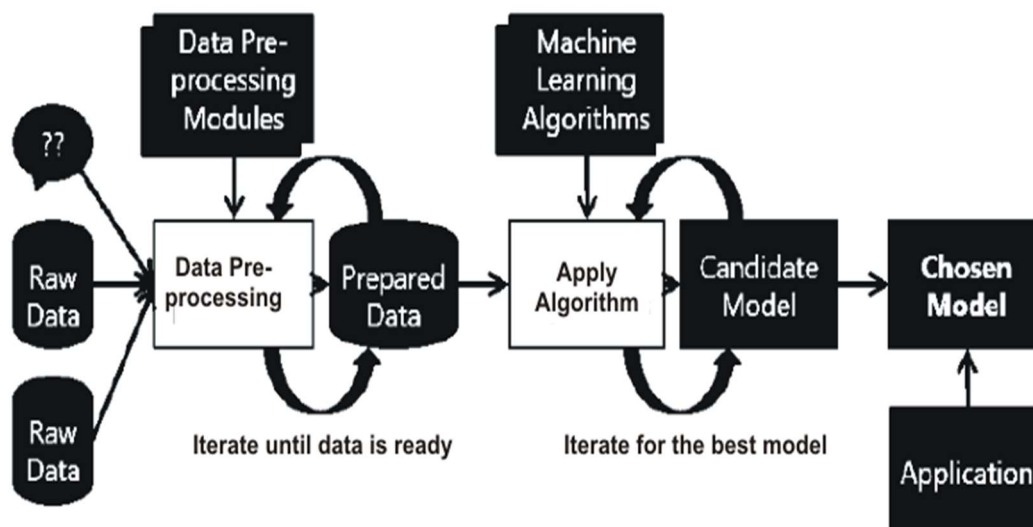


Figure 4: Machine Learning Processes. Source: Diwan, Nigam, Tiwari & Bhati (2017)

Supervised machine learning models are widely used by the researchers (Welling, 2010). In supervised learning model, there is need for collection of existing datasets which can be further sub-divided into training and testing sets by following a particular ratio (for instance, 70:30/80:20). Training datasets with high percentage of datasets are used to train the model. By training previously datasets, the model can then predict outcome that are more accurate from testing datasets (with low percentage). Supervised machine learning can thus be expressed mathematically as having an input variable (X) and an output variable (Y). That is to say, machine learning algorithm can learn mapping functions from the input to the output (Brownlee, 2020). There are many models/algorithms in supervised machine learning models, according to Huapaya, Rodriguez and Esenarro (2020) and include the following, but not limited to Logistic Regression, Linear Regression, Linear Classifiers, Time series, Support Vector Machine, Artificial Neural networks, Bayesian networks, K-Means grouping, Naive Bayes Classifier, Quadratic classifiers, Decision Tree, Random Forest, to mention but a few.

5.5 Empirical Research works using supervised machine learning models

Researchers have conducted researches on supervised machine learning, such as, linear regression, logistic regression, autoregressive integrated moving average (ARIMA), Support Vector Machine, Naive Bayes Classifier and Artificial Neural Network for various types of predictions. These models can also be implemented to predict rate of crimes, when and where future crime will likely occur to forestall its occurrence. For instances, ARIMA model was investigated on crime forecasting by (Payne & Morgan, 2020); Jiang & Barricarte, 2011; Chen, Yuan & Shu, 2008; Catlett, Cesario & Talia, 2016 and Talib, Sallehuddin & AbHassan, 2006). ARIMA model and fuzzy alpha-cut method was proposed by Noor & Retnowardhanib (2013) for effective crime predictions. Lins and Rocha (2012) developed SARIMA model for estimation rate of homicides in Pernambuco during the period of January 2007 to March 2012.



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A similar research was carried out by Zhuo & Libed (2020) which was focused mainly on the crime rates prediction in Philippines and dimensionalities using simplex linear programming and regression analysis. K-means algorithm was implemented in a research conducted by Delima (2019) to cluster cities and determine identical traits, trends and values of major cities with low, moderate, and high number of recorded violent and non-violent crimes from 2013 to 2017 in Surigao del Norte. Besides, an experiment with three models; exponential smoothing methods, auto-regressive integrated moving average (ARIMA), and neural network auto-regressive (NNAR) models were compared by Zhang, Lee & Wang (2016) on spam predictions in USA. Similarly, accuracy of two algorithms; ARIMA and Holt-Winters additive exponential smoothing were juxtaposed by Donnelly and Wan (2016) in predicting the size of the total adult prison population in New South Wales Australia.

Furthermore, ARIMA and Exponential Smoothing models were used to forecast numbers of male and female prisoners by Athanasopoulos and Weatherburn (2018). Autoregression technique was adopted by Yadav and Sheoran (2018) for crime prediction. Islam and Raza (2020) also made use of ARIMA model to forecast crime in London using five previous year datasets. Besides, Agyemang (2012) employed ARIMA model to predicts major crime rates in Ghana. In addition to the above experiments, hybrid ARIMA and Artificial Neural Network (ANN) models were used for time series forecasting by Zhang (2003).

Also, Butt, Letchmunan, Hassan, Ali, Baqir, Koh and Sherazi (2021) investigated spatio-temporal crime prediction by using artificial intelligence for citizen's security in smart cities. Seasonal Autoregressive Integrated Moving Average (SARIMA) was exploited in each densely crime region to predict the crimes rates in future with spatial and temporal information. The results of the works indicated that the applied models produced accurate predictions on crimes as evaluated performance metric accuracy, such as, Mean Absolute Error (MAE), Absolute Percentage Errors (APEs), Mean Square Error (MSE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE) were within the acceptable values. From the above literature review, it implies that these models can fit in crime datasets in Nigeria to predict future crime so as to make decisions on number of police officers to be employed and deployed to appropriate locations where criminal activities can likely take place.

6. SUMMARY AND CONCLUSION

Attempts have been made in this article to describe the concept of crime, categorization of criminals and crime situational reports in Nigeria. In the paper, reviews were made on machine learning models with a goal of getting insights on the models that can be adopted in predicting crimes in Nigeria. Hence, the best machine learning models that can be suitable for crime predictions are Bayesian theory, Artificial Neural Network (ANN), Support Vector Machine (SVM), linear regression, Auto-regression Integrated Moving Average (ARIMA), Markov Chain and Random Forest models. Besides, reviews were made on existing evidence-based researches on machine learning models.



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7. CONTRIBUTION TO KNOWLEDGE

Based on reviews on the existing literature on supervised machine learning models, the paper recommends that Federal Government of Nigeria, through its well-established security agency (Nigeria Police Force) should liaise with researchers in the tertiary institutions and in turn link with security based industries to develop an efficient working crime prediction model to assist police officers in discharge their constitutional rights by protecting lives and properties of its citizens through effective and efficient proactive policing.

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