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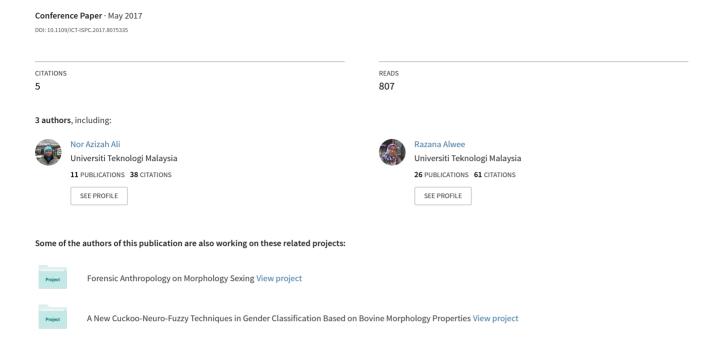A New Cuckoo-Neuro-Fuzzy Techniques in Gender Classification Based on Bovine Morphology Properties View project

# An Overview on Crime Prediction Methods

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*Abstract— In the recent past, crime analyses are required to reveal the complexities in the crime dataset. This process will help the parties that involve in law enforcement in arresting offenders and directing the crime prevention strategies. The ability to predict the future crimes based on the location, pattern and time can serve as a valuable source of knowledge for them either from strategic or tactical perspectives. Nevertheless, to predict future crime accurately with a better performance, it is a challenging task because of the increasing numbers of crime in present days. Therefore, crime prediction method is important to identify the future crime and reduces the numbers of crime. Currently, some researchers have been conducted a study to predict crime based on particular inputs. The performance of prediction models can be evaluated using a variety of different prediction methods such as support vector machine, multivariate time series and artificial neural network. However, there are still some limitations on their findings to provide an accurate prediction for the location of crimes. A large number of research papers on this topic have already been published previously. Thus, in this paper, we thoroughly review each of them and summarized the outcomes. Our objective is to identify current implementations of crime prediction method and the possibility to enhance it for future needs.*

*Keywords—crime analysis; crime prediction; prediction methods*

## I. INTRODUCTION

Crime is one of the major issues is continuing to grow in intensity and complexity [1]. In the recent years, crime is one of the social problems influencing the nature of life and economic development in a community [1]. Crime can be divided into a few types such as crime against properties (theft, burglary, and robbery) and crime of aggression (homicides, assaults and rape) [2]. The availability of information technologies has enabled law enforcement to collect detailed information of crime data [3]. With the increasing numbers of crimes nowadays, crime analysis is needed which comprises measure and procedure that intend to reduce the risk of crime [4]. Crime analysis can be done through both quantitative and qualitative methods [5, 6]. Qualitative approaches in predicting crime such as scenario writing or environmental scanning are valuable in identifying the future of criminal activity [7]. Meanwhile, quantitative method is used to predict the crime rates in future specifically. Moreover, crime analysis is a practical approach to analyze and identify the pattern of crimes [8]. The study by [9] stated that crime analysis is part of crime prevention which has the

tasks of discovering and detection of crimes and their relation with criminals.

However, a considerable challenge faced by law enforcements is to analyze the increasing numbers of crime data accurately and efficiently [10]. The ability to analyze amount of crime data without using computational support will put strain on human because human mechanism is incapable of comprehending with millions of data [11]. Since the high dimensional of crime data, traditional crime analysis methods cannot be applied for identifying the future crimes. The powerful system in predicting crime is required when the more data and the complex queries are being processed [10, 11]. Therefore, developing a systematic crime analysis tool to identify the crime patterns effectively and promptly for future crime patterns detection is needed. This includes the capability of the system to analyze or evaluate a large amount of data and information from variety sources.

Hence, this study was conducted to review and examine the current methods used in crime prediction analysis. The organizations of this paper are as follows. Section I describes the introduction of the study. Section II discusses the overview of crime prediction methods. In Section III, we thoroughly review the previous study related to crime prediction and summarized the important outcomes. The discussions of this paper are written in Section IV and the conclusions are given in Section V.

## II. CRIME PREDICTION METHODS

### A. Support Vector Machine (SVM)

Recently, support vector machine (SVM) is a nonlinear model and it has been performed well for time series prediction, classification tasks and regression [12]. The performance of the SVM is compared with the performance of both recurrent neural network model (RNN) and autoregressive moving average (ARMA) in time series prediction [13]. ARMA model is a linear behavior but it is easy and fast in use while RNN can be in principle model linear but they are usually difficult to train and does not lead to one unique or global solution due to differences in their initial weight set [13]. Besides that, SVM has been performed well in prediction of time series because they can model nonlinear relations in a stable and efficient way [14]. Furthermore, the SVM is educated as a convex optimization problem resulting in a global solution which in many cases

output unique solutions [15]. Thus, SVM was applied in predicting of crime hot-spots [16] and predict the common diseases (diabetes and pre-diabetes) [17].

### B. Fuzzy Theory

Furthermore, to build the prediction system using fuzzy modeling mentioned in [18] requires numerical inputs. The IF-THEN regulations formed have vague predicates in their antecedent part and a linear or quadratic combination of the antecedent variables for consequent part [19]. There is no need to defuzzify the output for the consequent parts since their rules are crisp value rather than vague and fuzzy [19]. Meanwhile, fuzzy modeling requires less computational efforts and excellent learning capabilities. It provides similar degree of robustness and accuracy together with lesser computational complexity as compared with various other methods [20]. The prediction system can be affected by increasing the number of inputs [21]. The characteristic of the fuzzy modeling is used to improve the prediction efficiency. Thus, fuzzy was applied for forecasting crime [22], predict the quality of software [23] and predict the price of stock [24].

### C. Artificial Neural Network (ANN)

According to [25], artificial neural network (ANN) is a model inspired by biological neuron and act as the human brain in decision making. It consists of a large number of processing components that work together to solve problems [25]. Meanwhile, ANN model is based on the prediction by smartly analyzing the trend from an already existing voluminous historical set of data [26]. ANN has more flexible and general functional forms can effectively deal with than the traditional statistical methods [27]. Frequently, traditional statistical prediction models have limitations functions to estimate the relationship between the inputs (the past values of the time series or other relevant variables) and the outputs (the future values) due to the complexity of the real system but ANN can be used as an alternative method to resolve these limitation functions [28]. Thus, ANN was applied in predicting of groundwater level [29], predict the geo-temporal variations of crime and disorder [30] and predict osteoporosis in the elderly [31].

### D. Multivariate Time Series

The study conducted by [32] mentioned that multivariate time series is one of the statistical tools to study the behavior of time-dependent data and predict the future values based on history of variations in the data. According to [33], multivariate time series can be significantly used better than using univariate time series in prediction. This method is not essential for recovering dynamics but only one time series should be needed according to the embedding theorem. Multivariate time series data are available in many practical situations such as economic data and physiological data are usually multi-dimensional [34]. Thus, this method was applied in predicting of model for cash-flow data, testing the statistical significance of multivariate time series analysis technique for epileptic seizure prediction and predicts the business failures [34].

### III. RELATED WORKS

Many different methods for crime prediction have been proposed by researchers. However, there are still has some limitations in these methods.

According to [16], Support Vector Machine method can be used in hot-spots prediction to predefine a level of crime rate and given the percentage of data. A subset of the crime datasets are selected (percentage or number of data crimes) and classify each of selected data point based on the predefined level of crime rate. The data point which has above than predefined rate are positive or classified as hotspot class and the data point which have below than predefined rate are negative or non-hotspot class. The parameter selected will be used as the training in SVM classification. As a result, linear, polynomial and gaussian kernel function has been chosen to compare the performance of one-class SVM for predicting the hotspot crime of location. The datasets are from the Internet public datasets (2 datasets, Columbus and ST. Louis). However, using this method is still slow and computationally expensive even though it has been modified.

Fuzzy time series was applied by [22], in orders to discover a crime pattern in community. To reduce the computational overhead in this method, the simplified process and model that include simple arithmetic operations has been used. This method utilized seventeen years historic data of crime incidents (cases of murder in Delhi City). Hence, the parameters used are actual registered cases and years. The three different sets of data obtained by partitioning it into five intervals (Scheme-I), ten intervals (Scheme-II) and twenty intervals (Scheme-III) implemented. The prediction of results obtained from Scheme-II and Scheme-III are quite acceptable while the result of scheme-I incline to slightly over forecast with an average absolute error (-0.323). However, this method works on binary transaction data only for example 0 or 1.

Prediction crime using artificial neural network (ANN) as one of proposed method mentioned in [30]. This method introduced by focusing on geographical areas that outperform traditional policing boundaries for crime prediction. Therefore, ANN can be educated using geographical clusters of crime data to ease predictive modeling. Hence, the scanning algorithm based on geographical crime incidents used to identify clusters with relatively high level of crime hotspots. Generally, ANN reveals a capacity to model the trends with each cluster. In this study, the dataset used are 18,498 violent incidents (criminal damages, violence against the person) included a number of variables related to time, day, month, location and weather. The result shows that the comparison of mean standard error (MSE) between ANN (9.94) and random walk (22.50). Thus, ANN predicts accurately more than random walk. Nevertheless, this method takes a long time in training phases.

For analyzing a large number of crime data in different time points, an unsupervised method by using multivariate time series is introduced by [32]. This method usually is based on parametric Minkowski model and dynamic time wrapping (DTW). It has been proposed to find similar crime trends among various crimes cases and used the obtained information

for future crime trends prediction. The effectiveness of this method has been proved using Indian crime dataset provided by the Indian National Crime Records Bureau (29 districts). The parameter of this model is the different of dimensions data weights. Their results showed the comparison between DTW with Euclidean (equal weight age) and DWT with parametric Minkowski model (different weight age). This method proposed for finding similar crime trends and predict crime trends efficiently where the dimensions of data do not have equal weight age. However, this method is difficult to handle a missing value in order to get more accurate results.

In addition, [35] introduced Bayesian Network based on bayesian learning theory as one of crime prediction model. This method can be used to build effective mathematical models to understand the behaviors of serial crimes. There are many potential factors affecting the selective of criminals for the future crime location. The model has been testing using serial crime dataset found in Gansu, China. Hence, the parameters used are characteristics of the victims (age, gender, jobs and race) and characteristics of crime areas (residence, school, bus stop, hotel and hospital). Furthermore, the given predicted areas (yellow, green and red color) will help police to arrest criminals but it is depends on geographical factors selected. Nevertheless, this method is totally depending on selection of parameter. Therefore, it is may lead to some deviation during conducted the experiment so the more factors unrelated to the geography should be considered to improve the accuracy of the model.

As discussed in [36], decision tree is one of the supervised methods used to handle the complex classification and produce reasonable classification tree. It provides the tree structure of classification and divides a dataset into smaller subsets. The decision tree helps police to discover the crime pattern and predict the future trends. The final result represented as a tree with decision nodes and leaf nodes which decision nodes have two or more branches and leaf nodes represent a decision or classification. The dataset used in their testing and training phases were extracted from the Internet. The parameters used in dataset are heartbeat rate, facial emotion, state and voice tone. The result of crime cases has been classified into two classes such as neutral and danger. However, this method does not work well on all type of datasets.

The study by [37] applied a logistic regression model to examine the relationship between the predicting factors of crimes and burglary occurrence probability. The factors used including time of day (category data), day of the week (discrete), barriers (physical structures that will interfere an individual's egress from a targeted residence), connectors (the amount of access bridges, streets and pathways relative to the targeted residence) and repeat victimization (the occurrence of the offense at the same residence following the initial offense over the calendar year, same category data). The datasets for testing were collected in burglary incidents in 2010 from a local police report of Florida City. The model has been shown the various degrees of significance in terms of predicting the occurrence within different ranges. However, the limitation of this approach is difficult to identify the probability of burglary activity and specific locations.

## IV. DISCUSSION

Solving a crime problem is a complex task that requires human experience and intelligence and also methods that can help them with crime detection problems [38]. Besides that, the prediction of future crime patterns or trends involves the changes of crime rate from one year to another year and used the prediction methods to find out those changes into the future [39]. As discussed in [40], the current problem is to identify methods that can efficiently and accurately analyze this growing volume of crime dataset. The proposed study by [41] proved that prediction crime using neural network method is generally high in accuracy and fast in evaluation of the learned target function.

The dataset for crime prediction which has been used is usually found in official records. There is an important part for experimentation to develop a more scientific and exact procedure for obtaining information in future [42-44]. The study conducted by [12], to get a satisfactory model for crime prediction analysis and to get accurate results of analyzing crime dataset, it requires huge historical data that can be used for training and testing the model. Hence, [25] mentioned that ANN can provide a better accuracy because of larger volumes in data crimes.

According to [19], the accuracy of crime prediction is depending on dataset. If dataset used is a huge number, the model training is achieved the high level in accuracy while if the dataset used is a small number, the low level of model training is achieved. Moreover, the accuracy of prediction is depending on the level of training data based on their amount or dimension data. The accuracy will be more accurate if the model is highly trained while if the model is not highly trained, the result of accuracy will be low [44].

For future works involving crime prediction algorithm in crime analysis field, it is hoped that researchers can propose more hybrid methods between crime prediction algorithm in order to get best finding data and results. As mentioned by [30], to produce better result, the hybrid methods are highly recommended compared to the filter methods.

## V. CONCLUSION

The crime analysis is sensitive domain where efficient for prediction and classification to analyze the increasing numbers of crime data. Hence, the crime prediction methods will be evaluated and analyzed by the systematic tool in crime analysis. The biggest challenge facing by many law enforcement is how to efficiently and accurately analyzing the increasing volumes of crime data. This research work focuses on reviewing a crime prediction analysis tool for many scenarios using particulars crime prediction methods that can help law enforcement to efficiently handle crime incidents. Therefore, a crime analysis should be able to identify the crime patterns as fast as possible and in an effective manner for future crime detection. Using a wide range of methods such as artificial neural network, fuzzy or support vector

machine, it is possible to find helpful information to help in crime prediction problems. To our knowledge, there is no standard method that can solve the problems in different datasets of crime. In this paper, we report on result of an extensive comparison of crime prediction methods. Furthermore, for future research, we propose to expand this study to enhance the crime prediction methods in order to resolve the limitation of current methods to obtain more accurate result and good performance.

## ACKNOWLEDGMENT

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