



Original article

Local government unit common felony classification: A text mining and natural language processing approach

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ABSTRACT

The main objective of this research paper was to develop a model for crime classification in local government units like barangay in the Philippines. The study included natural language processing. Text mining process was applied in this research to test and evaluate the accuracy of three (3) different machine learning algorithms which are all famous for text classification such as naïve bayes, support vector machine (SVM) and neural networks. The blotter or complaint records of barangay Mayondon in Los Baños, Laguna, Philippines was used as a dataset for model development. Upon developing the model, it is found out that among the three algorithms, the neural network got the highest accuracy in terms of classifying crime in a blotter or crime report. It is also found in this paper that the males have the most probability to commit crime than the females. Hence, it is shown that physical injury is the most common crime committed in a barangay.

KEYWORDS: *Machine Learning, Model Development, NLP, Text Mining*

1 INTRODUCTION

Crime is one of the most rampant inhumane activities and problems of this generation. Majority of studies have indicated that machine learning plays a big part in solving this persistent problem. It can identify a criminal activity by making use of the basic details of a crime which took place in an area with time and location specified (Hossain, Abtahee, Kashem, Hoque, & Sarker, 2020). However, obtaining accurate information is a key factor affecting decision-making processes. Crime data is included among the application areas of data mining, being one of the data stacks which are rapidly growing with each passing day. Crime events constitute unwanted

behavior in every society. For this reason, it is important to extract meaningful information from crime data (Ates, Bostanci, & Guzel, 2020). Having to provide a data mining approach to distinguish the most criminal hotspots and locate the type, place, and time of committed crimes, it is certainly in parallel to hope to raise people's awareness regarding the dangerous locations in specific time periods. Furthermore, having this kind of knowledge would help people to improve their living place choices (Kumari, Uma, Rameshkumar, & Khaja, 2020) (de Blasio, D'Ignazio, & Letta, 2020).

The usage of machine learning algorithms for prediction and classification was found effective and accurate. These algorithms were already utilized in different field such as education, health, business, environmental modeling, accidents and even in crime (Lerios & Niguidula, 2018) (Asor, Catedrilla, & Lerios, 2020) (Lerios & Villarica, Pattern Extraction of Water Quality Prediction Using Machine Learning Algorithms of Water Reservoir, 2019) (Asor, Catedrilla, & Estrada, 2018). Currently, the data mining and machine learning approach are widely used for different strategies that can be applied in real-life in different fields (Prabakaran & Mitra, 2018). In the application of machine learning in crime classification, supervised learning algorithms such as xgboost, support vector machine (SVM), neural network, decision tree and multinomial regression was utilized to find which among of these algorithms will give an accurate result (Asor & Sapin, 2020) (Balahadia, Asor, Catedrilla, Villarica, & Cabiente, 2020) (Edoka, 2020). Neural network, Bayesian network and vector machine are found to be the most utilized and gives high accuracy in terms of classification or prediction and forecasting in a dataset (Shojaee, Mustapha, Sidi, & Jabar, 2013) (Amiruzzaman, Curtis, Zhao, Jamonnak, & Ye, 2021) (Bandekar & C, 2020) (Stalidis & Semertzidis, 2018). Moreover, machine learning algorithms' accuracy results can always be enhanced through dataset enhancement

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and integrating other statistical approaches.

Natural language processing is a process of analyzing text-based reports which was improved through time with the application of text mining. Machine learning that uses a bagging approach is found to have a better classification in natural language processing however, SVM was also noticed to provide a high accuracy in larger datasets (Balyan, McCarthy, & McNamara, 2017). Furthermore, neural network was making its name after giving a higher accuracy result against other sophisticated machine learning algorithms used in natural language processing such as SVM, xgboost and naïve bayes (Widiastuti, 2018) (Singh, Desai, Ashar, Tank, & Katre, 2021). Neural network was even found to make a significant contribution in developing an intelligent system for classifying crimes to assist its user in identifying crime by giving secondary classification (Pinho, Brito, Motta, & Lima, 2017). Hence, machine learning algorithms and neural networks are an innovative approach in natural language processing and text mining in classifying crimes (AL-Saif & Al-Dossari, 2018) (Tyagi & Sharma, 2018).

The main objective of this study is to create a model for classifying felonies in local government units through text mining and natural language processing.

2 MATERIALS AND METHODS

In this paper, the process of text mining was followed in order to satisfactorily finish the research. Figure 1 shows how the dataset will be processed to produce new knowledge that is more substantial. It is composed of four (4) different phases—document collection, preprocess document, analyze text and knowledge.

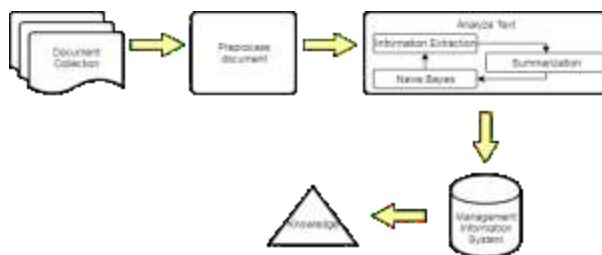


Figure 1. Steps in text mining process

Data Collection

Blotters and ordinances from Barangay Mayondon and Los Baños, were gathered. The documents are the recent three (3) year record of the barangay expanding from 2017-2019. The data is in paragraph form since it is

the real report of complaints from the citizens of the said barangay. It contains name, sex, age and address of the complainant and the respondent, and the complaint. Basically, every report did not have specific crime classification which is vital in this study. In addressing this problem, classifying the reports was included in manual preprocessing.

Preprocessing Document

The preprocessing of documents in this research paper includes two (2) phases, the manual preprocessing and the automated preprocessing. Manual preprocessing was the first phase to be done in preparing the dataset. In assuring that the reports will be classified correctly, an expert in Philippines’ law was consulted to classify each report included in the gathered documents. Upon classifying, the hardcopies of report with classification were all converted into a .txt file as preparation for automated preprocessing. In the second phase of preprocessing of documents, the reports underwent text cleanup, tokenization, stemming and vectorization. This was done to improve the process of classification when developing a model. After accomplishing the following process, the dataset was divided into 2 parts; training and testing set, wherein the eighty percent (80%) of the dataset is the training and the remaining twenty percent (20%) is the testing dataset.

Table 1. Train and test dataset

Label	Train Set	Test Set
	Number of Cases	Number of Cases
Physical Injury	100	25
Qualified Theft	100	25
Damage on Property	100	25
Grave Threat	100	25
Estafa	100	25
Total	500	125

Analyze Text

Analyzed text is where the model was developed using a machine learning algorithm. In this paper, some of the most famous algorithms used in natural language processing and text mining processes would be used and analyzed. Information was first extracted to the preprocessed data by removing words without any significant meaning like the prepositions. Next, each

remaining word was trimmed down once again to summarize and leave only highly meaningful words and create a bag of words. From here the chosen algorithm was used to classify what kind of crime is committed in the bag of words is now created.

Naïve Bayes has been a well-known machine learning algorithm in text classification for the past years. It uses a probabilistic approach in the documents when classifying. Through the Bayesian network concept, this machine learning algorithm treated each word inside the bag of words independently, meaning it did not correlate the presence of the words to each other. Here is the architecture of Naïve bayes:

$$P(y) = \frac{P(x)P(x)}{P(y)} \quad (1)$$

where x is the class and y are the data, this process purely relies on the probability.

Support vector machines, on the other hand, did not depend on the numbers of features in data but learned the singularity of the dimensionality of feature space. This strategy enhances the learning capability of the model at a high confidence level. SVM is famous to be the most prominent machine learning algorithm that learns in hyperplane in the feature space. Moreover, SVM is capable of exploring different kinds of combinations inside the dataset without increasing the computation complexity. Below is the architecture of the SVM.

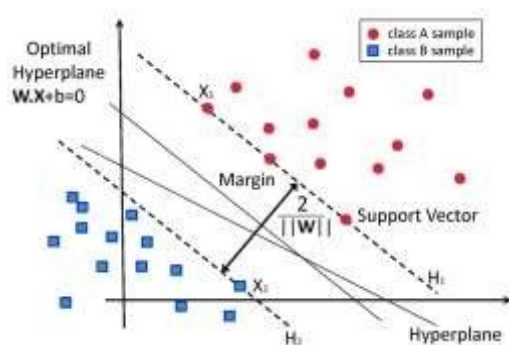


Figure 2. Support vector machine (svm) architecture

Neural network is currently one of the most effective algorithms in terms of classification (Ates, Bostanci, & Guzel, 2020). It learns from a series of hidden layers which form the majority of the artificial brain through its connection, the neural network will provide the output layer. The neural network has three (3) layers namely, input layer, hidden layer and output layers. Input layer was basically the words that were inside the bag of words while hidden layer is the combination of each word to produce the output layer of the crime classification itself in this case. Here is the graphical representation of the neural network.

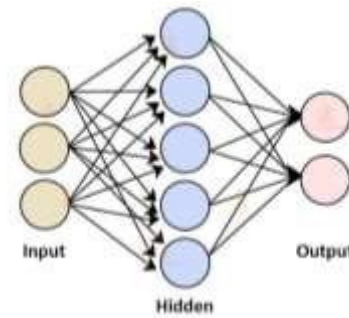


Figure 3. Neural network architecture

Knowledge

The knowledge section involves evaluation of the model. Different metrics that are commonly used in model development are used in this study. These are the three metrics for evaluating machine learning algorithm performance in classifying.

The recall metric focuses on the capability of the model to retrieve relevant features in the document. The equations show the metric formula of recall;

$$Recall = \frac{TP}{TP+FN} \frac{TP}{TP+FN} \quad (2)$$

The precision metric is for showing all the correct classified documents. The equation below shows the metric formula of precision;

$$Precision = \frac{TP}{TP+FP} \frac{TP}{TP+FP} \quad (3)$$

F-score is the harmonic mean of precision and recall. It is used to maximize the capabilities of both the metrics to further evaluate the accuracy of the developed model. The equation below shows the metric formula of F-score;

$$F-Score = 2 * \frac{Precision*Recall}{Precision+Recall} \quad (4)$$

3 RESULTS AND DISCUSSION

In this study, aside from the result of evaluating the models, data visualization and analysis of the given reports from the barangay were also shown to produce knowledge from it. This section will show two different sections to further discuss the results of the study, the model evaluation and data visualization. The data visualization was included to visualize the commonality of the crime.

Accuracy and kappa are the first step to know which among the machine learning algorithms is capable of classifying data with high correctness. In table 2, it is noticeable that the neural network stands out among all

three algorithms having a total accuracy rating of 90% and kappa of 0.875. Since, the neural network shows an impressive result, it would be then further evaluated to assure that there is no bias in these results.

Table 2. Result of accuracy and kappa evaluation of the algorithms

Algorithm	Accuracy	Kappa
Naïve Bayes	83.33	0.791
Support Vector Machine	82.85	0.762
Neural Network	90	0.875

Table 3 shows the result of evaluating the neural network since it has the highest accuracy and kappa. It shows that the recall has a total mean of 0.90 which means that the classified labels are correct with minimum error. Also, as indicated in precision, the correctness of the algorithm in terms of predicting the cases is accurate, gaining a total mean of 0.90. The F-score got a total mean of 0.90 approaching 1 which is the base of prediction appropriateness.

Table 3. Result of neural network classification evaluation

Label	Recall	Precision	F-score
Damage on Property	0.77	0.77	0.77
Estafa	1	0.92	0.96
Defamation	1	1	1
Grave Threat	0.82	0.90	0.86
Physical Injury	0.92	0.92	0.92
Weighted mean	0.90	0.90	0.90

The data visualization is based on the chronological data that was gathered in Barangay Mayondon, Los Baños, Laguna after being classified by the law expert. In this result, the ages were group into four (4) categories namely Child=0-16, Young adults=17-30, Middle-aged adults=31-45 and Old-aged adults=46+.

It is shown in Figure 4 that most of the respondents are in middle-aged group and physical injury is the most common crime committed in local government unit like Barangay Mayondon.

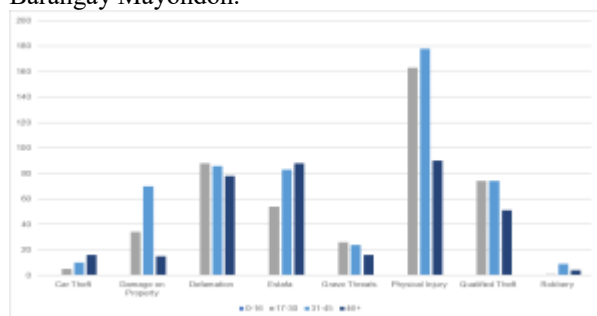


Figure 4. Crime distribution based on age group of respondents

Figure 5 reflects the distribution of crime committed based on the sex of the respondents. As shown in the figure, most of the male respondents are involved in physical injury cases while the female respondents are commonly involved in estafa and defamation.

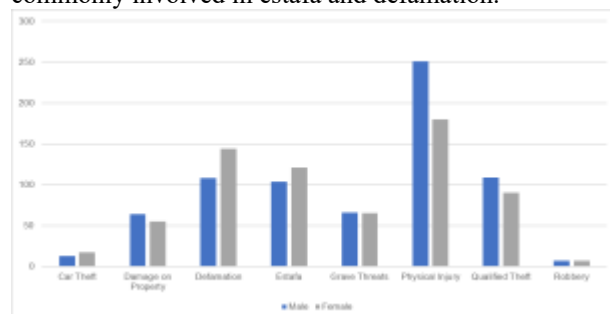


Figure 5. Crime distribution based on the sex of respondents

Among all the purok in Barangay Mayondon, Purok Tres is the most vulnerable in crime incidents. Shown in figure 6 that crime like damage on property, estafa, grave threats and physical injury is common in Purok Tres. Likewise, it is also noticeable in the figure that Physical injury is the most common crime committed in all of the Purok of Barangay Mayondon.

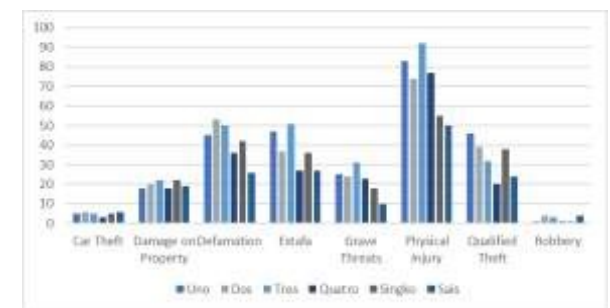


Figure 6. Distribution of crime committed in every purok

4 CONCLUSIONS AND FUTURE WORKS

After completing the research, it is found out that among the tested machine learning algorithms, the neural network is the most accurate algorithm for developing a model of crime classification through natural language processing. It is also shown in this paper, the capability of natural language processing in classifying crime regardless of the language. Further, it is found that physical injury is the most common crime that is being committed in the local government unit like Baragnay Mayondon and males are mostly likely to commit this kind of crime while females were commonly the violator of crime involving money like estafa.

To further examine the effectiveness of neural networks, it is recommended that another study involving natural language processing must be done. It is also recommended that the scope of this study must improve

and do the same experiment in larger government units like municipalities and provinces. An intelligent system for classifying crime in barangay must be developed using a neural network.

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