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Influence Distribution Training Data on Performance Supervised Machine Learning Algorithms

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***Abstract*—Almost all fields of life need Banknote. Even particular fields of life require banknotes in large quantities such as banks, transportation companies, and casinos. Therefore Banknotes are an essential component in carrying out all activities every day, especially those related to finance. Through technological advancements such as scanners and copy machine, it can provide the opportunity for anyone to commit a crime. The crime is like a counterfeit banknote. Many people still find it difficult to distinguish between a genuine banknote and counterfeit Banknote, that is because counterfeit Banknote produced have a high degree of resemblance to the genuine Banknote. Based on that background, authors want to do a classification process to distinguish between genuine Banknote and counterfeit Banknote. The classification process use methods Supervised Learning and compares the level of accuracy based on the distribution of training data. The methods of supervised Learning used are Support Vector Machine (SVM), K-Nearest Neighbor (K-NN), and Naïve Bayes. K-NN method is a method that has the highest specificity, sensitivity, and accuracy of the three methods used by the authors both in the training data of 30%, 50%, and 80%. Where in the training data 30% and 50% value specificity: 0.99, sensitivity: 1.00, accuracy: 0.99. While the 80% training data value specificity: 1.00, sensitivity: 1.00, accuracy: 1.00. This means that the distribution of training data influences the performance of the Supervised Machine Learning algorithm. In the KNN method, the greater the training data, the better the accuracy.**

Keywords—Banknotes, Supervised Machine Learning, Support Vector Machine, K-Nearest Neighbor, Naïve Bayes

I. INTRODUCTION

A banknote is an essential component and becomes an asset valuable to a country. Almost all field of life in a country needs a banknote [1]. Start from the areas of life involving big companies to small companies. The Banknote is becoming essential to the field of life that have high needs, such as banks, transportation companies, and casinos [2]. Along with the development of technology, many are a crime that also appeared in it. One of these is a counterfeit banknote. That crime, of course, will harm many people. Technologies that have used in making counterfeit banknotes such as a scanner and copy machine. Through the technology can allow anyone to commit process counterfeit banknote [3]. The level of similarity from counterfeit Banknotes that have produced is very high, so that can complicate many people to distinguish genuine and counterfeit banknotes [1].

Problem-solving counterfeit Banknote can be done with various technologies such as the utilization of development from a sensor [4] and hardware. The weakness of the techniques is they are expensive, inaccurate, and not easy to carry anywhere [5]. To overcome the vulnerability that can use one of the methods which are developing is Machine learning [3]. The techniques in machine learning can be used to overcome various problems like classification, clustering, association rule mining, and prediction. The accuracy in an election the method becomes the primary key to overcome the problem is happening [6]. The type of machine learning used by authors is supervised Learning that aims to overcome the classification problem.

Based on the background, the Supervised Learning methods being analyzed are Support Vector Machine (SVM), K-Nearest Neighbor (K-NN), and Naïve Bayes to process classification to the problem counterfeit banknotes. Each method of supervised Learning has a different level of accuracy. Many factors can influence the different levels of accuracy in each supervised method, such as the amount of data that used, the method selected to the distribution of data training, and data testing. The aim of authors besides doing process classification to distinguish counterfeit banknotes and genuine banknotes is to compare the level of accuracy of the third method supervised Learning that has mentioned based on the distribution of training data.

II. LITERATURE REVIEW

In this section, the authors will explain previous research related to the research being carried out by the authors. Recently methods in machine learning are being discussed. One problem that is often considered is classification. Classification is dividing classes into the data used to analyze data. The methods used are Artificial Neural Network, Support Vector Machine and K-Nearest Neighbours classifiers. Through the machine learning methods used for breast cancer classification [7], crime prediction [8], and banknotes are generally divided into two classes. Then make the supervised learning method comparison to measure the level of accuracy in each method [9]. Some paper has the same goal to measure accuracy in each method used for classification, especially classification for banknotes. These methods are *Naïve Bayes and Multilayer Perceptron* [6]; *Probabilistic neural network (PNN), Multi-layer Perceptron (MLP), Radial Basis Function (RBF), Decision Tree (DT), and Naïve Base* [3]; *Backpropagation Neural Network (BPN) and Support Vector Machine (SVM)* [1].

In addition to comparing the accuracy of some of the machine learning methods used, some studies only use one method then compute its accuracy. For instance, using the

Convolutional Neural Network method [2] For classification banknote, then calculate its accuracy. Banknotes used are Indian Currency Rupee notes, where the classification process base on color [10]. Another example that uses only one method is classification banknotes from Banglades, which consist of two types are 500 and 1000 BDT. There are three extracted features, which are watermark, latent image dan micro-text. Then use the Support Vector Machine (SVM) method to do the classification base on the extracted features [5].

The level accuracy of each method is used differently. In the Naïve Bayes method and Multilayer Perceptron method, the accuracy rate is 95% and 97%, so the Multilayer Perceptron method outperforms the Naïve Bayes method [6]. Whereas in the comparison of the Probabilistic neural network (PNN), Multi-layer Perceptron (MLP), Radial Basis Function (RBF), Decision Tree (DT), and Naïve Bayes method, the best accuracy of the method is Decision Tree (DT) method. The DT method has accuracy of 99%, followed by Multi-layer Perceptron (MLP) method with accuracy 98.7%, the Probabilistic neural network (PNN) method with accuracy 98.3%, Naïve Bayes method which accuracy method is 85.9% and last Radial Basis Function (RBF) which accuracy rate is 57% [3]. Then Backpropagation Neural Network (BPN) and Support Vector Machine (SVM) method have a level of accuracy in a row of 100% and 98.9% [1].

Source of data that is gotten used in the machine learning method most of the website UCI machine learning repository [1][7][6][3]. Some sources of data came from the result of the extra image that is used for classification [9][4][5]. Then the machine learning methods are implemented in GNU Octave [1], scikit-learn machine learning library on anaconda distribution [7], MATLAB (version 8.4.0 (64bit)) [5], and Python [11]. In this paper, the authors classify Banknote with machine learning methods. Then compare the level of accuracy. The machine learning method used is supervised learning methods, namely Support Vector Machine (SVM), K-Nearest Neighbor (K-NN), and Naïve Bayes. Authors use data that came from the website UCI machine learning repository and implemented in Python. The novelty in this research is to prove the influence of training data on the performance of Supervise Machine Learning algorithm. This is done with categorizing training data to three-part, namely 30%, 50%, and 80% of the total data used in this research.

III. MATERIALS AND METHOD

A. *Materials*

The data used in this paper comes from the UCI machine learning repository website. Where the total data is 1372, this data has five attributes. More details can be seen in table 1.

TABLE I. ATTRIBUTES ON BANKNOTE DATA

Attributes	Type
Variance	Continuous
Skewness	Continuous
Curtosis	Continuous
Entropy	Continuous
Class	Integer

Based on table 1, banknote data has 4 features and 1 class. These four features are obtained by extracting an original and counterfeit banknote image using the Wavelet Transform tool. Data class is a target data that has two choices, integer numbers 0 and 1. Number 0, shows genuine note while number 1, shows a counterfeit note

B. *Method*

In classifying the authors use the Cross-Industry Standard Process for Data Mining (CRISP-DM) methodology [12]. The method arranged at the end of 1996 and has six phases. The six steps are shown in the following figure.

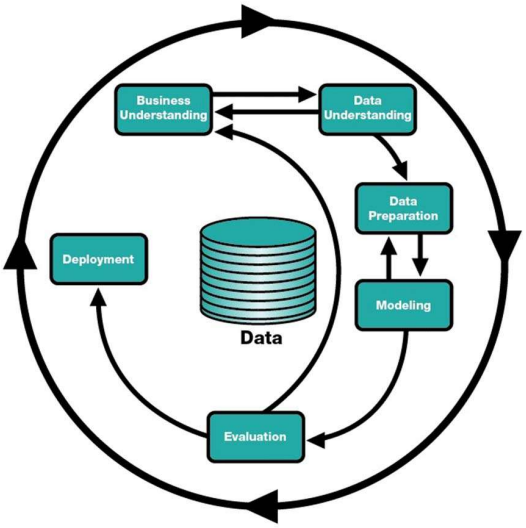

Figure 1 The stages of CRISP-DM

The following will be explained in detail related to the six phases shown in Figure 1.

1. Business Understanding
   This phase has the purpose of determining business goals. Here the researcher must know the meaning of the research to be conducted. In this phase, the authors have understood the purpose of the study. The research objective is to classify genuine and counterfeit Banknotes use supervised learning methods. Then compare the accuracy of each technique. The classification base on the distribution of training data.

2. Data Understanding
   This phase has the purpose of collecting data. Here the researcher collects the preliminary data that will be used. In addition, it must understand the data so that the classification goes well. In this phase, the authors get data that will be used in the next step. Whereas data is obtained from the website UCI machine learning repository. From the data, we have known that the sum of all data is 1372 and has 5 attributes. The attribute consists of 4 features and 1 class.

3. Data Preparation
   This phase has the purpose of select data, clean data, construct data, and integrate data. The data will be used by the authors and have been observed from corrupted data and missing data, so that in this phase that authors do not perform the preparation process.

4. Modeling
   This phase has the purpose of selecting the method that will be used when implementing the method and evaluating the method that has been used. In this phase, the authors have determined the method has been used

for classification banknote. The method to be used is Supervised Learning, namely *Support Vector Machine (SVM), K-Nearest Neighbor (K-NN),* and *Naïve Bayes.* Then the authors compare each method that has been used.

5. Evaluation
   This phase has the purpose of evaluating the result, evaluate the process, and determine the next step. In this phase, the authors will determine the results obtained. Then review the result in seeing the level of accuracy of each method. Besides, the authors provide conclusions and recommendations for further classification.
6. Deployment
   This phase has the purpose of Plan deployment, plan monitoring and maintenance, final report, and review project. In this phase, the authors make reports and reviews these methods.

C. Algorithm Used

1. *K-Nearest Neighbor (K-NN)*
   KNN is one of the learning methods in carrying out the classification process. From its name, it can be seen that the classification process using KNN is based on the closest distance from its neighbors [13][14]. In the process of classification KKN uses training data and testing data. The workings of the KNN method are based on the level of similarity of the data formed in the training data. Training data will be used as a reference for testing data. The closest distance can be calculated using Euclidean distance. Where the closer the Euclidean distance is, the degree of similarity is higher [15][16].
2. *Support Vector Machine (SVM)*
   Support Vector Machine (SVM) have become one of the effective methods in carrying out the process of classification and regression [17]. The working principle of SVM is to find a hyperplane using the principle of Structural Risk Minimization. The goal is to get the best hyperplane. The hyperplane will divide it into two classes [18]. The advantage of SVM is that it can handle semi-structured data and structures. Using the SVM method can reduce overfitting. However, the performance of SVM will decrease if the data is too large. The presence of missing in the data also affects the performance of the SVM [17]. The implementation of SVM in classification is done by dividing the data into training data and predictive data. Data will be predicted based on training data that has been trained in advance [19].
3. *Naïve Bayes*
   In 1970, two groups developed the NB method. The two groups each consist of two people. The first group consisted of CT Yu and G Salton. The second group consists of S. Roberson and K. Spark [20]. Naïve Bayes is an algorithm based on Bayes Theory. The Naïve Bayes method has strong assumptions about the independence of each feature. This method can handle large data and can reduce the risk of overfitting [21][22].
4. *Measuring Classification Algorithms*

   In conducting the evaluation process of each method used in this study, the authors used six variables. The six variables are specificity, sensitivity, accuracy, precision, recall, and F1-score. The calculation of the six variables is based on table 2 matrix confusion.

TABLE II. CONFUSION MATRIX

	Classified Positive	**Classified Negative**
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

TP is the amount of genuine note classified correctly. FN is the amount of genuine note that is classified incorrectly. FP is the amount of counterfeit money classified incorrectly. TN is the amount of counterfeit note which is classified correctly. The formula specificity, sensitivity, accuracy [19], precision, recall, and F1-score [18] in a row can be seen in the following equations:

1. *Specificity*
   Specificity is a process to count counterfeit note. The process is done by the amount of counterfeit note which is classified correctly is divided into the amount of counterfeit note.

$$Specificity\ \% = \frac{TN}{TN+FP}\ x\ 100\% \quad (1)$$

2. *Sensitivity*
   Sensitivity is a process to count genuine note. The process is done by the amount of genuine note classified correctly is divided into the amount of genuine note.

$$Sensitivity\ \% = \frac{TP}{TP+FN}\ x\ 100\% \quad (2)$$

3. *Accuracy*
   Accuracy describes the closeness between the predicted value and the actual value. *Accuracy* is done by the amount of genuine and the amount of genuine note classified correctly note is divided into the amount of money.

$$Accuracy\ \% = \frac{TP+TN}{TP+TN+FP+FN}\ x\ 100\% \quad (3)$$

4. *Precision*
   Precision describes the level of accuracy expected by the user with the answer from the system. *Precision* is done by the amount of genuine note classified correctly is divided into the amount of genuine note classified correctly plus the amount of counterfeit money classified incorrectly.

$$Precision\ \% = \frac{TP}{TP+FP}\ x\ 100\% \quad (4)$$

5. *Recall*
   Recall is the system process rate the information rediscovered. The process to count *recall* the same with the process to count *sensitivity*.

$$Recall\ \% = \frac{TP}{TP+FN}\ x\ 100\% \quad (5)$$

6. *F1 – Score*
   F1 – Score is a harmonic mean of precision and recall gives a score.

$$F1 - Score\ \% = 2\ .\frac{Precision\ .\ Recall}{Precision\ +\ Recall} \quad (6)$$

IV. RESULT AND DISCUSSION

In this section, the authors will present the results of the study and then discuss it. The authors have followed the stages of CRISP-DM. Banknote data has class 0 for genuine banknotes and class 1 for counterfeit banknotes. The amount of data is 762 and 610, respectively. Both classes have data that are sufficiently balanced to carry out the process of comparing performance using supervised machine learning methods. The data used by the author does not have missing, so the authors do not do the preparation process. Then the authors will analyze the performance of supervised learning methods, namely: K-Nearest Neighbor (K-NN), Support Vector Machine (SVM), and Naïve Bayes (NB) in recognizing genuine banknotes and counterfeit banknotes.

In the process of distribution training and testing data, the authors use scikit-learn machine learning by importing train_test_split. To see the effect of training data on the performance of supervised learning methods, the authors divide the training data into three groups, namely 30%, 50%, and 80%. 30% of the total data was about 411, 50% of the total data was about 686, and 80% of the total data was about 1097. Then the authors again use scikit-learn machine learning to call the supervised learning methods used in this paper. In all methods, the author uses random_state = 4. After that, the authors make the prediction process of the test data.

After that, the authors evaluate all the methods that have been used by importing classification_report and confusion_matrix. Where the attributes displayed are True Positive (TP), False Negative (FN), False Positive (FP), and True Negative (TN). Then based on the results of the confusion_matrixs the authors display the accuracy, precision, recall, f1-score. In evaluating the author also shows sensitivity and specificity. Following in table 3, the authors show the accuracy, sensitivity, and specificity of each supervised learning method based on the distribution of training data that has been determined.

TABLE III. EVALUATION OF METHODS USED BASE ON SPECIFICITY, SENSITIVITY, DAN ACCURACY

Data Training	Methods	Specificity	Sensitivity	Accuracy
30%	K-NN, K=1	0.99	1.00	0.99
	K-NN, K=3	0.98	1.00	0.99
	K-NN, K=5	0.99	1.00	0.99
	SVM	0.98	1.00	0.99
	NB	0.86	0.82	0.84
50%	K-NN, K=1	0.99	1.00	0.99
	K-NN, K=3	0.99	1.00	0.99
	K-NN, K=5	0.99	1.00	0.99
	SVM	0.98	1.00	0.99
	NB	0.85	0.81	0.83
80%	K-NN, K=1	1.00	1.00	1.00
	K-NN, K=3	1.00	1.00	1.00
	K-NN, K=5	1.00	1.00	1.00
	SVM	0.98	1.00	0.98
	NB	0.83	0.83	0.83

Table 3 displays the Specificity, Sensitivity, and Accuracy values of the K-NN, SVM, and NB methods based on the distribution of training data. In the distribution of training data by 30%, the NB method has the lowest accuracy value compared to the K-NN and SVM methods. While both SVM and K-NN methods that have a value of k = 1, k = 3 or k = 5 have the same accuracy value of 0.99. Then in the 50% training data division, the NB method has the lowest accuracy value compared to the SVM and K-NN methods. While in the distribution of training data by 80%, the K-NN method has the highest accuracy, either having a value of k = 1, k = 3, or k = 5. Then followed by the SVM method and, finally, the NB method with an accuracy of 0.83.

The distribution of training data influences the three methods used by the authors, although the effect is not significant. In the K-NN method, both those with a value of k = 1, k = 3, or k = 5 have an accuracy of 0.99 when the training data are 30% and 50%, but when the training data is 80%, the accuracy level becomes 1.00. However, in the SVM method, the accuracy is 0.99 when the training data is 30%, and 50% then decreases to 0.98% when the training data is 80%. In the NB method, the accuracy reached 0.84 when the train data was 30% and decreased to 0.83 in the training data by 50% and 80%. The authors display an evaluation of machine learning methods based on precision, recall, f1-score on table 4.

TABLE IV. EVALUATION OF METHODS USED BY PRECISION, RECALL, DAN F1-SCORE

Data Training	Methods	Precision	Recall	F1-Score	Class
30%	K-NN, K=1	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	K-NN, K=3	1.00	0.99	0.99	0
		0.98	1.00	0.99	1
	K-NN, K=5	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	SVM	1.00	0.99	0.99	0
		0.98	1.00	0.99	1
	NB	0.86	0.86	0.86	0
		0.83	0.83	0.83	1
50%	K-NN, K=1	1.00	1.00	1.00	0
		1.00	1.00	1.00	1

	K-NN, K=3	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	K-NN, K=5	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	SVM	1.00	0.99	0.99	0
		0.99	1.00	0.99	1
	NB	0.85	0.86	0.85	0
		0.82	0.81	0.82	1
80%	K-NN, K=1	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	K-NN, K=3	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	K-NN, K=5	1.00	1.00	1.00	0
		1.00	1.00	1.00	1
	SVM	1.00	0.98	0.99	0
		0.97	1.00	0.99	1
	NB	0.87	0.84	0.85	0
		0.79	0.84	0.81	1

In table 4, the authors display the values of precision, recall, and f1-score of the three methods. In the 30% training data, the K-NN method with value of k = 1 and k = 5 has the highest precision, recall, and f1-score both in class 0 and in class 1. This observation means that the K-NN method has a value that is the highest compared to other methods. In comparison, the NB method is the method that has the lowest value. Then in the training data of 50% and 80%, the K-NN method either k = 1, k = 3, or k = 5 has the highest precision, recall, and f1-score compared to the SVM and NB methods. At the same time, the NB method has the lowest precision, recall, and f1-score values.

Based on table 3 and table 4, when the training data is 30%, the K-NN method has an accuracy value of 0.99, a specificity value of 0.99, sensitivity 1.00 at k = 1 and k = 3. While at k = 2, the accuracy value is 0.98, the specificity value is 0.99, sensitivity 1.00. These three values are the same as the SVM method. While the NB method has an accuracy value of 0.84, the specificity value is 0.86; sensitivity is 0.82. This means that the K-NN method is the method that has the highest accuracy compared to the other two methods. Then in the 50% training data, the K-NN method has an accuracy value of 0.99, a specificity value of 0.99, sensitivity 1.00. While for the SVM method, the accuracy value is 0.99, the specificity value is 0.98, sensitivity 1. Likewise, for the 80% training data, the K-NN method has an accuracy value of 1, the specificity value is 1, sensitivity 1. While for the SVM method, the accuracy value is 0.98, the value of specificity is 0.98, sensitivity 0.98. And the NB method has an accuracy value of 0.83, a baseline specificity value of 0.83, sensitivity 0.83. This observation means that the K-NN method has accuracy, specificity, sensitivity values better than the other two methods.

Based on the data in table 3 and table 4, this means that the distribution of training data influences the performance of the supervised machine learning algorithm used in this research. The effect of the distribution of training data on the KNN method is that the greater the training data, the better the performance. On the other hand, the SVM and NB methods the smaller the training data, the better the performance.

V. Conclusion

Identifying genuine or counterfeit money is an important thing. Many methods have been established to do this. Here the authors use the K-NN, SVM, and NB methods. Before using these methods, the authors first carry out the process of collecting data. The data used in this study were obtained from the UCI machine learning repository website. After that, the authors apply the three methods using sci-kit-learn machine learning python. Then the authors see the effect of training data sharing on the three methods. The distribution of training data conducted by the authors is 30%, 50%, and 80%. Then the authors analyze the results obtained using several attributes, namely the specificity, sensitivity, accuracy, precision, recall, and f1-score. The distribution of training data influences the performance of the KNN, SVM, and NB methods. Where if the training data is getting bigger, the performance is getting better for the KKN method. On the other hand, the SVM and NB methods the smaller the training data, the better the performance. K-NN method is a method that has the highest specificity, sensitivity, and accuracy of the 3 methods used by the authors both in the training data of 30%, 50%, and 80%. Where in the training data 30% and 50% value specificity: 0.99, sensitivity: 1.00, accuracy: 0.99. While the 80% training data value specificity: 1.00, sensitivity: 1.00, accuracy: 1.00.

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