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Modelling Naïve Bayes for Tembang Macapat Classification

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Abstract

The *tembang macapat* can be classified using its cultural concepts of *guru lagu, guru wilangan,* and *guru gatra*. People may face difficulties recognizing certain songs based on the established rules. This study aims to build classification models of *tembang macapat* using a simple yet powerful Naïve Bayes classifier. The Naive Bayes can generate high-accuracy values from sparse data. This study modifies the concept of *Guru Lagu* by retrieving the last vowel of each line. At the same time, *guru wilangan's* guidelines are amended by counting the number of all characters (Model 2) rather than calculating the number of syllables (Model 1). The data source is serat wulangreh with 11 types of *tembang macapat*, namely *maskumambang, mijil, sinom, durma, asmaradana, kinanthi, pucung, gambuh, pangkur, dandhanggula,* and *megatruh*. The k-fold cross-validation is used to evaluate the performance of 88 data. The result shows that the proposed Model 1 performs better than Model 2 in *macapat* classification. This promising method opens the potential of using a data mining classification engine as cultural teaching and preservation media.

Keywords: Naïve Bayes, Classification, Tembang Macapat, Wulangreh

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INTRODUCTION

Indonesia has various cultural diversity, including *tembang*. *Tembang* is traditional Javanese poetry recited in song form (Daryanto, 2017), which was used to transmit long written texts of one form or another in scenarios ranging from an evening in a palace to letters to a friend (Hatch, 1976). *Macapat* (Santosa, 2016) is one popular genres of *tembang*. Generally, *tembang Macapat* have 11 types: *maskumambang, mijil, sinom, durma, asmaradana, kinanthi, pucung, gambuh, pangkur, dandhanggula,* and *megatruh* (Dewati, 2016; Setiyorini, 2016). Furthermore, *tembang macapat* is bound by the three main rules of *guru lagu, guru gatra,* and *guru wilangan* (Dwi Bambang Putut Setiyadi, 2010). *Guru lagu* is the rhyme sound at the end of the word in each line. *Guru Gatra* is the number of lines in one verse, while *Guru Wilangan* is the number of syllables in each line (Novaeni, 2013). The creation of *macapat* has to follow these rules.

A study reveals that *macapat* (e.g., *sekar pucung*) has a very intellectual significance, but it also aims to train people to be

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religious and humanist (Saddhono & Pramestuti, 2018). The song incorporates positive and negative Javanese educational terms (*piwulang*) of religion, ethics, morals, daily life, and government attitudes(D. B. P. Setiyadi, 2013). Serat Sabdajati, for example, uses *macapat* to explain Islamic doctrine and ethics (Fauziyyah, Warto, & Sariyatun, 2018). The positive should always be followed, whereas the negative should be avoided. Furthermore, *macapat* can be used as a medium for character building (Agus et al., 2021). A bibliometric study of *macapat* from 1981 to 2021 found that most research is focused on cross-cultural and social change perspectives (Irmade & Winarto, 2021). None of them discuss this Javanese song from the computer science or technological aspect.

The concept of *guru wilangan, guru gatra,* and *guru lagu* form patterns for computational modeling. The pattern distinguishes one *macapat* text from others. Javanese artists, experts, or professional teachers may easily recognize these cultural patterns. On the other hand, novice students may find it difficult to notice the *tembang* based on the pattern. Once the rules are broken, a song will not be identified. For example, we cannot label a *tembang* as *pucung* when it is less or more than four *gatra* with the following *guru wilangan* and *guru lagu*: 12u, 6a, 8i, 12a. The false *tembang* may confuse the singer, leading to failure in singing the song. Identifying the correct song will be increasingly difficult to do. This fatal error will be passed on to the next generation. This problematic situation prompted research on computational modeling of *macapat* classification.

In data mining, classification is a typical technique for categorizing data points. This supervised machine learning approach has many classifiers. First, Logistic regression is a probability-based model that works in only binary predicted variables, all independent predictors without missing values (Kasera & Johari, 2021). Second, linear regression assumes that the independent and dependent variables are linearly connected; nonetheless, it is susceptible to overfitting and noise (Schultz et al., 2021). On the other hand, the Support Vector Machine (SVM) displays training data in space, separated into categories by huge gaps; however, it delays generating probability estimates (Gaye, Zhang, & Wulamu, 2021). Finally, the Naive Bayes method assumes that all characteristics are independent of one another and contribute equally to the output (Mansour, Saleh, Badawy, & Ali, 2022). The Naive Bayes Classifier is a well-known generative algorithm that may use generative algorithms to classify unknown data. These classification engines have excellent performance in classifying Javanese alphabets (Diqi & Muhdalifah, 2020; Handayani, Herwanto, Chandrika, & Arai, 2021; Rasyidi, Bariyah, Riskajaya, & Septyani, 2021; Susanto, Atika Sari, Mulyono, & Doheir, 2021; Susanto, Sinaga, Sari, Rachmawanto, & Setiadi, 2018), vowels (Dewa & Afiahayati, 2018), speech levels (Ardhana, Cahyani, & Winarno, 2019; Nafalski & Wibawa, 2016), composition (Agus et al., 2021), dialect (Hidayatullah, Cahyaningtyas, & Pamungkas, 2020). None of research focused on the *macapat* classification, which consider the gap as a novelty in the area of Javanese Culture classification.

This research aims to create classification models of *tembang macapat* based on Naïve Bayes classifier. This Naive Bayes selection is based on its excellent classification performance when only using a small amount of training data (Gupta, Gupta, & Singh, 2005). Two models are proposed. The first model retains the cultural patterns: *Guru Lagu*, *Guru Wilangan*, and *Guru Gatra*. The second model assumes that not all users understand those cultural rules. Therefore, the second model limits the *Guru Lagu* by counting the number of vowels to replace the calculation of the number of syllables. The second model replaces the *Guru Wilangan* by the probabilistic calculation of the characters in each *gatra*. This research is expected to facilitate the public understanding of the types of *tembang macapat* using the models. A promising model will be decided after comparing the two proposed models.

METHOD

This data mining research is concerned with extracting usable and valuable information from enormous quantities of data. The suggested strategy allows for discovering intriguing patterns, which are deeply buried inside the data. The systematic procedures are described in the following sections.

Dataset and Preprocessing

The data was collected from Serat Wulangreh book written by Kanjeng Susuhunan Pakubuwana IV Surakarta Hadiningrat (Wikandaru, Cathrin, Satria, & Rianita, 2020). This book has 11 types of *Tembang* which evaluated in this study, including *maskumambang, durma, pucung, megatruh, gambuh, mijil, kinanthi, asmaradana, pangkur, sinom,* dan *dhandanggula*. The selection of eight song for each type *tembang*, considering dandanggula as the song with the least number of stanzas. Thus, the total training data is 88 of *tembang macapat*.

The next stage is preprocessing, an initial activity required before the classification process (Andini, 2013). This process produces a variable from the *tembang* dataset containing a value set representing the information contained in the *tembang*. This stage splits each row and calculates the number of lines in the lyric.

The following process is to generate model 1, following the rule of *guru lagu*, by removing space and consonants in each line. The remaining vowel letter on each line will be calculated to get the *guru wilangan*. The last vowel is recognized as *guru lagu*. Table 1 presents the preprocessing result of model 1.

Model 2 modifies the rule of *guru wilangan*. As in model 1, this modification starts by removing the space, followed by calculating the characters of each line. The calculation is recognized as the modified *guru wilangan*. The modification considers the reality that mistakes (e.g., typographical errors) could have happened during the *Tembang* writing. Determining the last vowel letter is completed by displaying only vowel letters on each line and then selecting the last vowel letter. Table 2 presents the preprocessing result of the *guru lagu* rule in model 2. The table is similar to Table 1 except for the result. In the same song, the result of table 2 is higher than Table 1 due to all characters' recognition.

Table 1. Pre-processing Result of Model 1

Line	Lyric	Vowel	Result
1	*Sekar gambuh ping catur*	e a a u i a u	7u
2	*Kang cinatur polah kang kalantur*	a i a u o a a a a u	10u
3	*Tanpa tutur katula-tula katali*	a a u u a u a u a a a i	12i
4	*Kadaluwarsa katutuh*	a a u a a a u u	8u
5	*Kepatuh pan dadi awon*	e a u a a i a o	80

Table 2. Pre-processing Result of Model 2

Line	Lyric	Vowel	Result
1	*Sekar gambuh ping catur*	e a a u i a u	20u
2	*Kang cinatur polah kang kalantur*	a i a u o a a a a u	27u
3	*Tanpa tutur katula-tula katali*	a a u u a u a u a a a i	27i
4	*Kadaluwarsa katutuh*	a a u a a a u u	18u
5	*Kepatuh pan dadi awon*	e a u a a i a o	18o

Naïve Bayes Classification

This study uses the Naïve Bayes classification approach. The simple probability classification calculates a set of probabilities, summing up frequency and value combination from a dataset (Suardani, Bhaskara, & Sudarma, 2018). Furthermore, an attribute or variable in Naïve Bayes is assumed to be independent or have no relation to each other (Manino, Tran-Thanh, & Jennings, 2019).

One of Naïve Bayes advantages is its robust performance for classifying limited training data. This advantage is essential and suitable for this study. Equation 1 presents the method of Naïve Bayes (Assiroj, 2018).

$$P(H|X)=P(X|H)P(X) \quad (1)$$

Where:
X = data with unknown class
H = hypothesis from data X
P(H│X) = the probability of hypothesis H based on condition X
P(X│H) = the probability of hypothesis X based on condition H
P(X) = probability of X

Evaluation

A confusion matrix is used to evaluate the classification results. It is a matrix table-based method for determining the accuracy of data generated by an algorithm (Haghighi, Jasemi, Hessabi, & Zolanvari, 2018). Table 3 contains the matrix table for the dataset with two classes.

Table 3. Confusion Matrix

Actual	Predictive	
	Positive	Negative
Positive	True Positive	False Negative
Negative	False Positive	True Negative

If the classification results are precisely classified into the correct class, the classification results are true positives. False-negative values are returned if incorrectly classified the classification results into the correct class. False positives are calculated if the classification results are precisely categorized in the incorrect class. True-negative values are returned if the classification results are incorrectly classified into the incorrect class. The confusion matrix will generate values for accuracy, precision, and recall (Andriani, 2012). Accuracy, precision, and recall can be calculated using equations 2 to 4.

$$\text{Accuracy}= \frac{TP+TN}{P+TN+FP+FN} \times 100\% \quad (2)$$

$$\text{Precision}= \frac{TP}{TP+FP} \times 100\% \quad (3)$$

$$\text{Recall}= \frac{TP}{TP+FN} \times 100\% \quad (4)$$

RESULT AND DISCUSSION

The classification technique, the Naïve Bayes approach, tries to classify the class or type of *tembang macapat*. The classification performance is evaluated using k-fold cross-validation, which generates a confusion matrix table. K-fold cross-validation divides the data into k folds, where k is the fold value. Each fold's test data was derived from the previous k-1 folds categorization. Four-fold k-fold cross-validation will be used in this study.

Table 4. The class of Tembang Macapat

Class	Type	Characteristic	Gatra
a	*Maskumambang*	12i, 6a, 8i, 8a	4
b	*Durma*	12a, 7i, 7a, 7a, 8i, 5a, 7i	7
c	*Pucung*	12u, 6a, 8i, 12a	4
d	*Megatruh*	12u, 8i, 8u, 8i, 8o	5
e	*Gambuh*	7u, 10u, 12i, 8u, 8o	5
f	*Mijil*	10i, 6o, 10e, 10i, 6i, 6u	6
g	*Kinanthi*	8u, 8i, 8a, 8i, 8a, 8i	6
h	*Asmaradana*	8i, 8a, 8e, 8a, 7a, 8u, 8a	7
i	*Pangkur*	8a, 11i, 8u, 7a, 12u, 8a, 8i	7
j	*Sinom*	8a, 8i, 8a, 8i, 7i, 8u, 7a, 8i, 12a	9
k	*Dhandanggula*	10i, 10a, 8e, 7u, 9i, 7a, 6u, 8a, 12i, 7a	10

In this study, both Model 1 and Model 2 are tested using four-fold values. The 88 *tembang macapat* were separated into four-folds, resulting in an equal distribution of 22 songs. We use 22 test data and 66 training data in each fold. As illustrated in Table 4, each existing *tembang macapat* class is denoted by a variable alphabet letter from a to k.

Table 5 contains the confusion matrix for the original *tembang macapat* (Model 1), with k=4. The table demonstrates that all eleven *tembang* of each class are accurately categorized. In other words, the characteristics of *tembang* (Table 4) are recognized by Model 1.

Table 5. Confusion Matrix Modifikasi Model 1

True class	Classification Results										
	a	b	c	d	e	f	g	h	i	j	k
a	8	0	0	0	0	0	0	0	0	0	0
b	0	8	0	0	0	0	0	0	0	0	0
c	0	0	8	0	0	0	0	0	0	0	0
d	0	0	0	8	0	0	0	0	0	0	0
e	0	0	0	0	8	0	0	0	0	0	0
f	0	0	0	0	0	8	0	0	0	0	0
g	0	0	0	0	0	0	8	0	0	0	0
h	0	0	0	0	0	0	0	8	0	0	0
i	0	0	0	0	0	0	0	0	8	0	0
j	0	0	0	0	0	0	0	0	0	8	0
k	0	0	0	0	0	0	0	0	0	0	8

The confusion matrix from Model 2 is presented in Table 6.

Table 6. Confusion Matrix Modifikasi Model 2

True class	Classification results										
	a	b	c	d	e	f	g	h	i	j	k
a	5	0	3	0	0	0	0	0	0	0	0
b	0	7	0	0	0	0	0	0	1	0	0
c	2	0	6	0	0	0	0	0	0	0	0
d	0	0	2	6	0	0	0	0	0	0	0
e	0	0	0	1	7	0	0	0	0	0	0
f	0	0	0	0	0	8	0	0	0	0	0
g	0	0	0	0	0	0	8	0	0	0	0
h	0	0	0	0	0	1	0	7	0	0	0
i	0	0	0	0	0	0	0	0	8	0	0
j	0	0	0	0	0	0	2	0	0	6	0
k	0	0	0	0	0	0	0	1	1	0	6

According to Table 6, eight *tembang macapat* are associated with the *maskumambang* (a) class. The Naïve Bayes technique classified five of the eight songs correctly. While the remaining three were incorrectly labeled as *pucung* due to the pattern similarity. Furthermore, the Naïve Bayes algorithm can accurately identify seven of eight *durma* (b) songs. Only one *durma* is miscategorized as *pangkur*, because of the equal number of *gatra.*

We tested eight p*ucung* (c) *tembang* and found that two were mislabelled as *maskumambang* (a). Six of eight *megatruh* (d) is well classified, while the rest is categorized as *pucung.*

The Naïve Bayes approach accurately classifies seven of eight Gambuh (e) songs. An error is confirmed since one song was labeled *megatruh* (d). On the *mijil* (f), *kinanthi* (g), and *pangkur* (i), the Naïve Bayes algorithm correctly classifies all instances.

Seven Asmaradana (h) songs were correctly classified, while the last remaining song is labeled as Mijil (f). The Naive Bayes approach successfully classified six songs as *sinom* (j) class, while two data are categorized as Kinanthi (g). Finally, eight *dhandanggula* (k) were categorized as six correct classifications and two incorrect songs. The two mistakes are labeled as *asmaradana* (h) and *pangkur* (i), respectively.

The classification performances of the two proposed models can be seen in Table 7.

Table 7. Classification Performance of Developed models

Model	Accuracy	Precision	Recall
1	100%	100%	100%
2	84.09%	86.63%	84.09%

Based on Table 7, Model 1 has better results when compared to Model 2, which has a difference in the accuracy of 15.91%. Model 1 obtained 100% accuracy, precision, and recall. For Model 2, the obtained accuracy and recall are 84.09%, with 86.63% precision. The outstanding results show that the proposed model that accommodates the original rule of *guru lagu* and *guru wilangan* is much better than model 2. While the *tembang* follows the rules, it can easily recognize by model 1. Model 2 could help predict the *tembang* created by a novice, who does not have enough understanding of the cultural rules.

The proposed models show that Naïve Bayes can classify the *macapat* correctly. The models can adopt the cultural rules (*guru lagu* and *guru wilangan*) into numeric features as inputs of the classification engine. In other words, the models are ready to use for *tembang macapat* classification.

A promising usage of the developed models is for Javanese cultural learning and preservation. The *tembang macapat* is still mentioned as teaching material in the Indonesian 2013 curriculum (D.B.P. Setiyadi & Haryono, 2018). *Macapat* can be used as a vocabulary learning media (Wahyudi, 2017). On the other hand, *macapat* is a suitable medium for early character education (Suciptaningsih, Widodo, & Haryati, 2017). In order to teach the *tembang macapat*, teachers have enough experience and knowledge about *titilaras* (scale) and the meaning of *tembang* (Pairin M. Basir & Marifatulloh, 2018). The teachers' competence, willingness, and motivation impact the effectiveness of teaching *tembang*.

The developed classification models as the of Information and Communication Technologies (ICTs) representation could boost the teachers' performance. Teachers are adjusting their digital skills, an ongoing process that must be ongoing and in which knowledge gaps continue to undermine its deployment (Sánchez Prieto, Trujillo Torres, Gómez García, & Gómez García, 2020). Technology can create chances for motivated learners. However, it is unlikely to result in motivation or independent conduct in most students (Stockwell & Reinders, 2019). In other words, a bond between teachers and students is badly required to fill the gap in technology usage.

CONCLUSIONS

This study succeeded in developing a *macapa*t song classification model using Naïve Bayes. Model 1 keeps the original cultural characteristics of *Tembang macapat,* which outperforms Model 2, which computationally modified the *guru wilangan*. For further research, it is recommended to add more data or use other classification methods to compare the performance of developed models. A broader view from text mining and machine translation fields could be beneficial for understanding the textual meaning of *macapat*. Finally, there is no reason for instructors to neglect creativity and innovation in their teaching method, including implementing these classification models. Once teachers recognize the importance of *Tembang* as a worthy cultural asset and a medium of education, the Javanese culture preservation could be achieved as the growth of ICT.

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