



Gamelan Rindik Classification Based On Mood Using K-Nearest Neighbor Method

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ABSTRACT

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The Balinese rindik gamelan is a traditional Balinese music that has a function as a balih-balihan art or as entertainment among the people during the royal era and has the same function until now. The simple rindik gamelan technique will produce a harmonious and melodious composition of tones, so that it acts as a stimulus carrier that can affect psychology and mood for the listener. This condition is caused by stress levels and energy levels. According to the mood theory by Thayer, music with positive stress levels and low energy refers to a pleasant (calm) mood, while positive stress levels and high energy levels refer to a happy (happy) mood. This study applies a branch of data mining, namely Music Information Retrieval (MIR) by classifying gamelan rindik labels based on the mood of the K-Nearest Neighbor strategy method. The algorithm is suitable to be implemented in nonlinear data sets such as music/song data, because the class decision line generated by K-NN is flexible. The data used are pieces of music files in mono .wav format with a duration of 20 seconds, which are then classified using the K-NN algorithm by the system. The resulting output is in the form of a mood label, namely satisfaction or joy. The results of the test using the confusion matrix obtained the percentage of classification accuracy 81%, recall 90.5%, precision 76%, and F-score 82.6% to find the average harmonic precision and recall. When compared with tests with accuracy, the same accuracy results are obtained, namely 81% or the best accuracy at a value of $k = 7$ and the fastest processing time is 0.0258 seconds.

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1. Introduction

Gamelan is one of the means of art or art developed by the Hindu kingdom in the past which has now become the nation's cultural heritage. Gamelan has functions that are grouped as wali art (as an accompaniment to religious ceremonies/sacred rituals), bebali (semi-sacred), and balih-balihan (secular/entertainment) [1]. Gamelan at this time, especially Balinese gamelan has a dual nature, function, and position, apart from being a means of accompanying various religious rituals as well as performing arts [2]. One of the famous Balinese gamelan is the rindik gamelan. Rindik is made of several bamboo sticks arranged in such a way [1]. Gamelan rindik is said to have functioned as entertainment from the previous kingdom and now also as entertainment among the people which is synonymous with feelings of joy, and calm. As time goes by, the function of Balinese rindik has been widely adopted as a means of musical accompaniment in public places such as hospitality, performing arts accompaniment and as a conductor of tranquillity for reflexology so that the calm or relaxed effect can give the impression of silence so that it can affect a calm mood. relaxed and happy/carefree. In music psychology, mood models can be adapted or labelled with adjectives, then modelled with two dimensions, where emotional states are represented by energy and stress which are adjusted for arousal/passion and valence [2] [3]. According to a percussion expert, I Wayan Sedia and Ni Ketut Sediani, the labelling of Balinese rindik gamelan mood is influenced by the level of tone, dynamics, frequency, rhythm, and timbre. However, in the context of Balinese gamelan playing, there are also other factors called ubit-ubitan, kotekan and cecandetan or Balinese gamelan



techniques resulting from a combination of on-beat/pepolosan and off-beat/sangsih systems to produce a beautiful and beautiful sound. When viewed from the function of the rindik gamelan itself, it includes gamelan that is balih-balihan or for entertainment, so that through the expert opinion which was later adapted into a mood model and the assessment of the mood of the Balinese rindik gamelan into the first quadrant, namely happy/cheerful and the fourth quadrant is calm [4].

Determining the type of mood is something that is often investigated in MIR (Music Information Retrieval) but not only that, various studies have been carried out on MIR such as the introduction of music genres, research in psychology, signal processing, machine learning, and others [5]. There are several stages before the various types of music/gamelan are grouped, namely the pre-data processing and data processing stages. The data that has been labelled expert then segmented into mono.wav format and has a duration of 20 seconds[1] . The results of the data segmentation were then evaluated for mood labels by other experts which aims to minimize data with ambiguous and subjective assessments so that the classification system can work well. From the results of various labelling, the data is then divided into training data and test data for the data processing stage. The data processing stage consists of feature extraction and classification. The feature extraction stage is the stage to determine the characteristics of a song file. It begins with changing the data from the time domain to the frequency domain using the FFT (Fast Fourier Transform) method. FFT has the advantage of fast and efficient performance in calculating discrete Fourier transforms so that it is suitable for continuous signals such as voice signals. In feature extraction, some spectral analysis of the sound signal is carried out to obtain spectral feature values which will be the basic attributes for mood classification, including centroid, skewness, roll-off, kurtosis, spread, and flatness[6]. The next stage of data processing is classification using the K-NN (K-Nearest Neighbor) data mining algorithm, which is an algorithm that classifies new objects through the nearest value from their neighbor based on attributes and existing training data samples. The algorithm is suitable to be implemented on nonlinear data sets such as music/song data because the class decision line generated by K-NN is flexible[6]. In a similar study [7] it was found that the performance of the K-NN algorithm on music classification based on mood showed the best accuracy and fastest processing results when compared to several other algorithms.

Mood assessment of the Balinese gamelan rindik is needed to avoid mistakes in choosing accompaniment music that is not following the atmosphere you want to create in a place, a performance or a ritual of a certain religious event due to the many performing arts and religious ceremonies in Bali that use gamelan so that it will bring harmony. Based on the explanation above, the classification of Balinese rindik gamelan based on mood using the K-Nearest Neighbor method is carried out to determine the mood that can represent the Balinese rindik gamelan and also know the performance of the K-NN algorithm and the level of accuracy when calculated using a confusion matrix compared to conventional accuracy calculations. , as well as calculating precision, recall, F-score and the speed of the classification process. This research is expected to be used as a reference by the Balinese people to pay more attention to the role of Balinese rindik gamelan music to prevent errors in the selection of gamelan percussions in Bali, as well as become a reference for other MIR research.

2. Method

2.1 Rindik Balinese Gamelan

Gamelan rindik is one of the traditional musical instruments originating from the island of Bali. Rindik is made of bamboo which consists of several bamboo sticks. The Balinese rindik gamelan is included in the middle gamelan group which at that time the people in Bali used as a classical Balinese performing art and as entertainment. The Balinese rindik gamelan percussion uses the aesthetic principle of tri angga, which consists of 3 (three) main parts, namely the head, body, and feet. These three parts are realized into pengawit, pangawak, and pangecet. Pengawit provides an introduction or introduction to the atmosphere, pengawak is the essence of the atmosphere, and pangecet is the density of the crew with an accelerated tempo [1].

2.2 Music Information Retrieval

MIR is one part of data mining to find information from a data source in a document, it can be in the form of metadata or content such as tone, melody, and tempo. The information search aims to explore and detect various information held by the data, especially music from various existing features so that pattern recognition can then be searched. MIR calls for information on a music/instrument to provide complex song information[3].



2.3 Fast Fourier Transform (FFT)

Can be defined as a mathematical operation calculation technique used to transform analogue signals into frequency-based digital signals. The sound signal contained in music is an analogue signal that must be converted into a digital signal. FFT will convert this analogue signal into a digital signal in the form of frequency-based sound spectrum waves. This algorithm can calculate discrete Fourier transformations to a finite sequence of complex data quickly and efficiently because the signals in the communication system are continuous, so the results can be used for Fourier transformations[8]. The Fourier transform is defined by equation (1) below:

$$s(f) = \int_{-\infty}^{\infty} s(t)e^{-j2\pi ft} dt \quad (1)$$

Information:

$s(f)$ is the signal in the frequency domain

$s(t)$ is the signal in the time domain

$e^{-j2\pi ft}$ is a constant of the value of a signal

f is frequency, and t is time

From the integral equation above, it can be seen that the Fast Fourier Transform (FFT) can be used to calculate the frequency, amplitude and phase values of a signal wave. Meanwhile, calculating the frequency spectrum of the signal on a digital computer requires a Discrete Fourier Transform (DFT) algorithm [9].

2.4 Feature Extraction

Feature extraction is an important process/step in the research on mood classification in music/instruments. Feature extraction is done by taking various characteristics from the characteristics of input data, to obtain the feature value which is then used as the basis for determining the class or group of the incoming input signal. In this study, the classification of Balinese rindik gamelan based on mood applies a spectral analysis technique consisting of several feature extractions. Audio features are analyzed based on the tone along the audio signal, this describes the harmony in music. To get the value of audio features based on signal properties, spectral flatness is used [10].

2.5 Data Mining

Data mining is an analytical technique to find and to mining knowledge, patterns and/or relationships between data automatically from databases with large amounts of data. Data mining has been used, namely descriptive and predictive. The descriptive use of DM means that it is used to find various patterns that can be understood by humans to explain the characteristics of the data. While predictive means DM is used to form a knowledge model that will be used to make a prediction. The discovery of hidden knowledge from the database is done by recognizing data patterns through the process of extracting and identifying information using statistical techniques, mathematics, artificial intelligence, and machine learning [11] [6].

2.6 K-Nearest Neighbor (KNN)

The K-Nearest Neighbor (K-NN) algorithm is a method for classifying objects based on the learning data that is closest to the object. K-NN is a supervised learning algorithm where the results of the new query instance are classified based on the majority of the categories in the K-NN algorithm. Where the class that appears the most will be the class resulting from the classification [12]. K-NN decides that the new data d belongs to class C based on some of the closest neighbor of d . If the Euclidean distance is used as a measure of proximity, then d will be the centre of the hypersphere with a radius r equal to the Euclidean distance. What it does is increment r so that the hypersphere contains k data. The class for data d is given based on the highest number of class members that appear in the hypersphere centred on d . Near or far neighbors are usually calculated based on the Euclidean distance with Equation (11) as follows:

$$d = \sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2 + \dots + (a_n - b_n)^2} \quad (11)$$

$$d = \sum_{i=1}^n (a_i - b_i)^2$$

K-NN classification is done by finding the k -nearest neighbors and selecting the class with the most k_i in the $_i$ class. The steps for K-NN classification if a set of training data vectors has N data points in total, then identify the k -nearest neighbors of the sample x where k is an odd number. From the k -nearest neighbors, identify the number of vectors k_i in the class ω_i , $i = 1, 2, \dots, m$ with $\sum_i k_i = k$. Enter x in ω_i class with maximum k_i value. If there are two or more ω_i classes that have E closest neighbors, then a balanced

condition (conflict) occurs and a conflict resolution strategy is used. For each class involved in the conflict, determine the distance between x and class ω_i based on the nearest E neighbors found in class ω_i . If the m -th training pattern of class ω_i involved in the conflict is indicated by dengan $y^{im} = \{y_1^{im}, \dots, y_N^{im}\}$ then the distance between x and class ω_i is:

$$d_i = \frac{1}{E} \sum_{j=1}^N |(x_j - y_j^{im})| \tag{12}$$

Enter x into the class, i.e. $x \in \omega_C$, jika $d_C < d_i$ for $i, C \in [1, \dots, M]$ and $i \neq C$.

2.7 Classification Model Evaluation

Evaluation of the classification model or system testing process in this study uses accuracy, precision and recall testing techniques, F-score with the confusion matrix method and compares ordinary/conventional accuracy tests[13]. this study will also compare the conventional accuracy test with Equation (13) - (15) as follows:

$$\text{Mood Contentment Accuration} := \frac{\text{Appropriate amount of test data}}{\text{Amount of contentment tes data}} \times 100\% \tag{13}$$

$$\text{Mood Exuberance Accuration} := \frac{\text{Appropriate amount of test data}}{\text{Amount of exuberance tes data}} \times 100\% \tag{14}$$

$$\text{KNN Method Accuration} := \frac{\text{Appropriate amount of test data}}{\text{Amount of tes data}} \times 100\% \tag{15}$$

3. Result and Discussion

3.1 Research Stages

In this study there are several stages which can be seen in Figures 1 below:

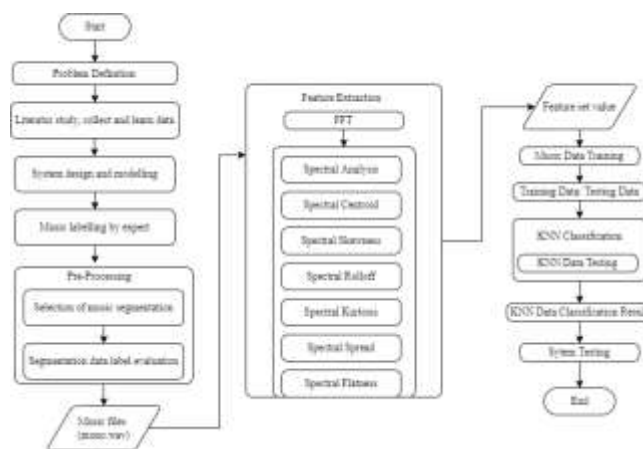


Figure 1. Research Flow

Based on Figure 1, it can be explained that this research uses sample data obtained from conventional Balinese gamelan rindik music CDs from Bali records and various records as well as several digital music platforms such as YouTube and Joox. The samples of Balinese rindik gamelan music files used in this study were taken from 4 areas in Denpasar City, namely Banjar Tenten in West Denpasar, Sanur in East Denpasar, Pedungan in South Denpasar and Peguyangan Kangin in North Denpasar. The dataset used is 140 gamelan rindik files that have been converted into mono.wav format with a duration of 20 seconds. Labeling is done by experts. The preprocessing stage of music data uses the Adobe Audition application to cut the part of the music data that is considered the most representative of the mood. The process of segmenting music data by taking the most representative parts of the composer, crew, and pusher in a percussion unit that lasts 20 seconds with mono .wav data format. The next stage is the evaluation of mood label data by other experts to prevent misjudgments of mood and seem subjective. The evaluation was carried out by listening to the data set on Balinese gamelan rindik music experts and asking them to choose what mood they felt when they heard it. After evaluating the data segmentation, a dataset is obtained which is then divided into training/training data and testing/testing data. The feature extraction stage is the stage of taking special features from music files that have been converted into mono.wav format. This process begins by converting



the sound signal from the music file (time-domain) that has been entered into the frequency domain using FFT. After changing the signal, a spectral analysis is carried out to obtain a set of attribute values/feature sets using six types of spectral analysis. In the data analysis process, starting from the formation of training data from a set of files that have been converted into mono.wav format and the signal has been converted into a frequency domain using FFT, then feature extraction is carried out with spectral analysis. The feature set resulting from the six attributes is a special feature of the gamelan rindik music file that is used as training data. These traits or characteristics are used as the basis for determining mood labels by the system. It can be seen in Table 1 that the categorization of music set data on mood is an example of categorizing rindik gamelan music files.

TABLE 1.
CATEGORIZATION OF MUSIC DATA SET ON MOOD

No.	Song Title	Spectral Analysis	Mood Label
1	Sample Music 1	Spectral centroid, spectral skewness, spectral rolloff,	Contentment
2	Sample Music 2	spectral kurtosis, spectral spread, dan spectral flatness.	Exuberance
3	Sample Music 3		Contentment
4	Sample Music 4		Exuberance

3.2 Interface System

This study is divided into two interfaces, namely the data training process interface and the K-NN classification testing process interface. The training process interface is used to enter training data, resulting in six feature extraction attributes along with the class code attributes or mood categories of the Balinese rindik gamelan instrument. The interface of the K-NN classification testing process is used to detect the musical mood category of the Balinese rindik gamelan instrument which is interpreted by the test data based on the close relationship between the feature extraction attributes and the training data.

3.2.1 Tested Data Input Process

The test data input process is initiated by the user pressing the Input File .wav button which will then appear in the Choose File .wav window to select the place and audio file that was previously prepared as test data. This is what is referred to as the test data input process because the process is entering test data into the system, the process can be seen in Figure 2 test data input interface.



Figure 2. Test Data Input Interface

3.3 FFT Extraction Process

The FFT (Fast Fourier Transform) extraction process is the process of converting the audio signal that has been inputted from the time domain into the frequency domain. Users can press the FFT button to start the extraction process which will then display a "Done" notification to the right of the FFT button. Next, a graphic will appear on the FFT Audio Signal panel and an image on the Spectrogram Audio File that will display the Original Audio Wave and FFT Audio Wave. In Figure 3 can be seen the overall FFT extraction interface.

training data and test data. There are 70 audio files with a category 1 mood, namely exuberance or happy and 70 audio files with a category 4 mood, namely contentment or calm. The following is a training dataset for each mood category and is shown in 20 data per type of mood category which can be seen in Table 2, music mood training data for category 1/exuberance and Table 3 for music mood training data for category 4/contentment.

TABEL 2.
MUSIC MOOD TRAINING DATA CATEGORY 1/EXUBERANCE

No	Music Code	Spectral Analysis Values						Category
		Centroid	Skewness	Roll Off	Kurtosis	Spread	Flatness	
1	E1	1562.4	28.38	3002.4	874.33	755.22	0.030118	1
2	E2	820.22	28.956	5004	931.87	906.57	0.059097	1
3	E3	1732.6	29.25	4336.8	945.33	1310	0.04273	1
4	E4	2128.8	27.689	6984.1	826.43	1406.5	0.03363	1
5	E5	1841.9	25.32	3841.8	714.06	1008.4	0.02955	1
6	E6	1397.5	29.101	4304.5	937.12	1248.3	0.031273	1
7	E7	1986.1	28.856	5402.2	891.85	994.71	0.074235	1
8	E8	1736	24.806	4029.3	719.53	1020.6	0.014979	1
9	E9	1416.9	29.495	4498.2	931.2	1013.7	0.048737	1
10	E10	901.39	28.9	4121.6	914.49	755.93	0.045843	1
...
20	E20	1786.8	27.505	3949.4	872.86	1156.2	0.034754	1

TABEL 3.
MUSIC MOOD TRAINING DATA CATEGORY 4/CONTENTMENT

No	Music Code	Spectral Analysis Values						Category
		Centroid	Skewness	Roll Off	Kurtosis	Spread	Flatness	
1	C1	2609.9	28.016	7866.5	859.43	1683.1	0.05014	4
2	C2	2403.1	28.3	4982.5	867.93	1529.2	0.038907	4
3	C3	1935.7	26.617	5563.6	799.04	1486.6	0.038671	4
4	C4	2057.9	28.12	4982.5	889.54	1107.3	0.041379	4
5	C5	2170.7	27.137	5466.8	831.36	969.17	0.03512	4
6	C6	2336.7	29.788	9480.8	993.69	2779.4	0.071907	4
7	C7	1961.9	27.081	6026.4	826.21	1416.6	0.056166	4
8	C8	2703.4	26.645	6112.4	803.15	1398.7	0.060672	4
9	C9	3144.6	26.424	6779.6	787.62	1385.2	0.059802	4
10	C10	3084.3	30.325	5542.1	1035	1899.8	0.097073	4
...
20	C20	1904.6	27.867	5369.9	866.94	1224.7	0.064216	4

The training dataset in the table above has a music code or code from a piece of Balinese rindik gamelan music, then six spectral analysis values that produce a feature set value and a category or class code for labeling certain moods. This training dataset will be used as a reference in the classification process to determine the type of musical mood from the audio files entered into the system. To compare the characteristics of the spectral feature set values that have been obtained, a graph of the value of the Balinese rindik mood set feature value is made against the six Spectral feature values can be seen in Figure 7 a graph of the value of the exuberance or happy feature set and the contentment or calm feature set.

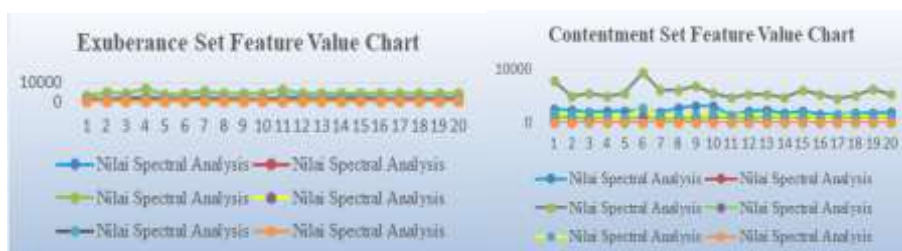


Figure 7. Graph Of The Value Of The Exuberance Or Happy Feature Set And The Contentment Or Calm Feature Set

From the graph above, we can see that the spectral analysis values are very striking, namely spectral roll off, spectral centroid and spectral spread, while spectral skewness and flatness show almost similar graph movements, namely stable but low.

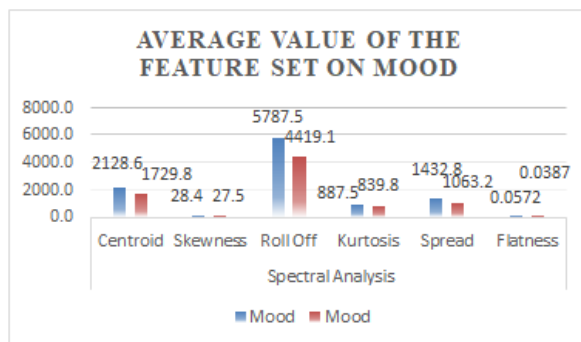


Figure 8. Average Feature Set Values Against Mood

In Figure 8 the average value of the feature set on the mood of gamelan rindik music, there is a very significant difference in the average value of the feature set, the highest being spectral roll off, centroid, spread, kurtosis, skewness, and finally the lowest. the value is spectral flatness. From the graphic analysis above, the attribute or feature of harmony in music, which in this case is interpreted by spectral flatness, is less able to determine the classification of Balinese gamelan rindik based on mood because the very low average value of the feature set, 0 makes the attribute or feature of harmony in music less needed.

3.7 Testing Using Confusion Matrix Method

The initial stage of testing is to find the TP (true positive), FN (false negative), FP (false positive), and TN (true negative) values from each based on the testing dataset of exuberance mood and contentment against the classification results by the system as a reference for calculating the size of the K-NN evaluation using the confusion matrix method. Parameter on K-NN serves to adjust the level of generalization of the test data to produce values for the calculation of accuracy, precision, and recall, F-score can be seen in Table 4 below.

TABEL 4. RESULT OF KNN EVALUATION USING CONFUSION MATRIX

k	Accuracy (%)	Recall (%)	Precision (%)	F-score (%)
1	81.0	81.0	81.0	81.0
2	69.0	57.1	75.0	64.9
3	71.4	61.9	76.5	68.4
4	69.0	57.1	75.0	64.9
5	76.2	81.0	73.9	77.3
6	73.8	66.7	77.8	71.8
7	81.0	90.5	76.0	82.6
...
15	71.4	85.7	66.7	75.0

Based on the results of Table 4, for the evaluation size of the K-NN classification from = 1 to = 15, the best results were obtained at the value of k = 7, namely the percentage accuracy of 81%, the recall percentage of 90.5%, but having a precision percentage value of 76 %, so that the average harmonic precision and recall or F-score measurement is used and the percentage is 82.6%. However, from the results of the F-score of 82.6%, it can be said that there are 17.4% of data that are not suitable, this is due to the average value of the feature set on the attributes or features of harmony in music which in this case is interpreted by the spectral flatness which has a very low value of 0 compared to other spectral which have a value of tens to thousands, thus making the harmony feature in music or spectral flatness less necessary or inappropriate to use in this study. According to previous research [14] stated that the value of = 1 will make the classification results feel stiff because it only takes into account one closest neighbor or one record of closest data characteristics. Another explanation is that if = 8 or an even number, it is possible that the number of closest patterns in the class is the same so KNN has difficulty classifying[11]. In a study conducted in 2020, it was stated that using precision or accuracy alone in measuring the performance of an algorithm/method can cause a very fatal bias,



so it is necessary to calculate the F-score. Very good accuracy is used as a reference for algorithm performance if the dataset has a very close number of false-negative (FN) and false positive (FP) data. However, if the number is not close, then use the F-Measure (F-Score) as a reference [15].

3.8 Conventional Accuracy Testing

Accuracy testing applies an assessment of the calculations of Equations (13), (14), and (15) so that the results can be seen in Table 5 below.

TABEL 5.
KNN CLASSIFICATION RESULT WITH CONVENTIONAL ACCURACY

<i>k</i>	KNN Accuration Percentage			
	<i>Exuberance</i>	<i>Contentment</i>	<i>Average</i>	<i>Average Time</i>
1	81.0	81.0	81.0	0.0867
2	81.0	57.1	69.0	0.0316
3	81.0	61.9	71.4	0.0273
4	81.0	57.1	69.0	0.0307
5	71.4	81.0	76.2	0.0258
6	81.0	66.7	73.8	0.0267
7	71.4	90.5	81.0	0.0262
8	81.0	81.0	81.0	0.0303
9	66.7	85.7	76.2	0.0276
10	71.4	76.2	73.8	0.0258
...
15	57.1	85.7	71.4	0.0282

The conventional accuracy calculation produces the highest accuracy of 90.5% at = 7, while the exuberance mood produces the highest accuracy of 81% at =1, =2, =3, =4, =6, = 8. The highest average percentage of accuracy was obtained at the value of = 1, = 7, = 8 with an accuracy of 81%. Based on the results of the highest average accuracy, which has the highest accuracy value at = 1, = 7, = 8, so the best accuracy is at = 7 with a percentage of 81%. The longest processing time when classification uses the value of = 1 which is 0.0867 seconds and the fastest processing time when classification uses the value of = 5 and = 10 which is 0.0258 seconds.

4. Conclusion

In this study, the results obtained from the measurement of the evaluation of the K-Nearest Neighbor classification using a confusion matrix from = 1 to = 15, the best k value was obtained at k = 7. The percentage accuracy is 81%, the recall percentage is 90.5%, but has a precision percentage value of 76%, so the F-score measurement percentage is 82.6%. This study also tested the accuracy with conventional methods and obtained the highest accuracy value in the contentment mood category of 90.5% at = 7, while the exuberance mood resulted in the highest accuracy of 81% at = 1, = 2, =8. The highest average percentage of accuracy is obtained at the value of = 1, = 7, = 8, which is 81%. The accuracy calculation using the confusion matrix with conventional accuracy produces the same percentage value. The longest processing time during classification was 0.0867 seconds and the fastest processing time during classification was 0.0258 seconds. When viewed from the mood category, contentment or calm mood dominates over exuberance or happy mood, because the average value of the contentment feature set is higher than exuberance, namely spectral centroid (2128.6), skewness (28.4), roll off (5787.5), kurtosis (887.5), spread (1432.8), and flatness (0.0572).

References

- [1] I. M. Bandem, *Gamelan Bali Di Atas Panggung Sejarah*. Yogyakarta: Badan Penerbit Stikom Bali, 2013.
- [2] R. E. Thayer, *The biopsychology of mood and arousal*. Oxford University Press, 1990.
- [3] Y. S. Seo and J. H. Huh, "Automatic emotion-based music classification for supporting intelligent IoT applications," *Electron.*, vol. 8, no. 2, pp. 1–20, 2019, doi: 10.3390/electronics8020164.
- [4] R. E. Thayer, J. R. Newman, and T. M. McClain, "Self-regulation of mood: strategies for changing a bad mood, raising energy, and reducing tension.," *J. Pers. Soc. Psychol.*, vol. 67, no. 5, p. 910, 1994.
- [5] N. Zhou, "Database design of regional music characteristic culture resources based on improved



- neural network in data mining,” *Pers. Ubiquitous Comput.*, vol. 24, no. 1, pp. 103–114, 2020.
- [6] T. H. Fratiwi, M. Sudarma, and N. Pramaita, “Sistem Klasifikasi Musik Gamelan Angklung Bali Terhadap Suasana Hati Menggunakan Algoritma K-Nearest Neighbor Berbasis Algoritma Genetika,” *Maj. Ilm. Teknol. Elektro*, vol. 20, no. 2, p. 265, 2021, doi: 10.24843/mite.2021.v20i02.p10.
- [7] G. Harsemadi, M. Sudarma, and N. Pramaita, “Implementasi Algoritma K-Nearest Neighbor pada Perangkat Lunak Pengelompokan Musik untuk Menentukan Suasana Hati,” *Maj. Ilm. Teknol. Elektro*, vol. 16, no. 1, pp. 14–20, 2017, doi: 10.24843/mite.1601.03.
- [8] R. Y. Sipasulta, A. S. M. Lumenta, and S. R. U. A. Sompie, “Simulasi Sistem Pengacak Sinyal Dengan Metode FFT (Fast Fourier Transform),” *J. Tek. Elektro dan Komput.*, vol. 3, no. 2, pp. 1–9, 2014.
- [9] D. T. Kusuma, “Fast Fourier Transform (FFT) Dalam Transformasi Sinyal Frekuensi Suara Sebagai Upaya Perolehan Average Energy (AE) Musik,” vol. 14, no. 1, pp. 28–35, 2021, doi: <https://doi.org/10.33322/petir.v14i1.1022>.
- [10] A. Lerch, *An introduction to audio content analysis: Applications in signal processing and music informatics*. 2012. doi: 10.1002/9781118393550.
- [11] D. Suyanto, “Data Mining untuk klasifikasi dan klasterisasi data,” *Bandung Inform. Bandung*, 2017.
- [12] A. J. T, D. Yanosma, and K. Anggriani, “Implementasi Metode K-Nearest Neighbor (KNN) dan Simple Additive Weighting (SAW) Dalam Pengambilan Keputusan Seleksi Penerimaan Anggota Paskibraka,” vol. III, no. 0065, pp. 98–112, 2016.
- [13] K. Shah, H. Patel, D. Sanghvi, and M. Shah, “A comparative analysis of logistic regression, random forest and KNN models for the text classification,” *Augment. Hum. Res.*, vol. 5, no. 1, pp. 1–16, 2020.
- [14] M. A. A. K. Indrayanti, Devi Sugianti, “OPTIMASI PARAMETER K PADA ALGORITMA K-NEAREST NEIGHBOUR UNTUK KLASIFIKASI PENYAKIT DIABETES MELLITUS,” pp. 823–829, 2017.
- [15] F. Satria, Z. Zamhariri, and M. A. Syaripudin, “Prediksi Ketepatan Waktu Lulus Mahasiswa Menggunakan Algoritma C4.5 Pada Fakultas Dakwah Dan Ilmu Komunikasi UIN Raden Intan Lampung,” *J. Ilm. Matrik*, vol. 22, no. 1, pp. 28–35, 2020, doi: 10.33557/jurnalmatrik.v22i1.836.

