WRAPPER FEATURE SUBSET SELECTION FOR FEATURE EXTRACTION OF BONANG BARUNG SINGLE TONE CONVERSION INTO NUMERIC NOTATION

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Abstract

Several researches have been done to study the characteristics of the *Bonang Barung*, one of Javanese *gamelan* music instruments. One of them is conversion of *Bonang Barung* single tone to numeric notation using Harmonic FFT as feature extraction and backpropagation artificial neural network (ANN) for classification. The tone detection accuracy result from previous research is 70,74%. In this research, we try to improve the detection result by searching the dominant features using wrapper feature subset selection (WFSS). Sequential forward selection (SFS) and sequential backward selection (SBS) are used as searching algorithm. The input of the system is a song recorded from a *Bonang Barung* then the detected tone is converted into numeric notation. From the experiment, WFSS-SFS produced 6 features with 86,4% accuracy while WFSS-SBS give a better result, it produced 13 features with 92,9% accuracy of tone detection.

Keywords: *Bonang Barung*; Wavelet Packet Decomposition; WFSS-SBS; WFSS-SFS.

1. Introduction

Javanese *gamelan* is a set of typical Javanese musical instrument handed down for generations. *Bonang Barung* is one of the Javanese *gamelan* musical instruments. *Bonang Barung* is a musical instrument made of iron, brass and bronze. They are typically hit with padded sticks (*tabuh*). *Bonang Barung* is a major head melodic instrument in the gamelan. This tool serves as *pemurba* song, which play a role as the course start-piece serving piece. Some research has been done to study the characteristics of the *Bonang Barung*. One of research has been done is conversion of *Bonang Barung* single tone to numeric notation using Harmonic FFT as feature extraction and Backpropagation Artificial Neural Network (ANN) for classification. By using tansig purelin activation function, learning rate 0.01, 1000 epoch and 20 hidden neurons as the properties of Backpropagation ANN, the best accuracy is 74.33%.[1] The feature extraction method is used without considering the usage of the feature data.

Mostly, the high accuration result are obtained by using a better classification method at the expense of computation time. We try to improve the detection result by searching the dominant features using Wrapper Feature Subset Selection (WFSS). By using an appropriate feature we get: feature dimension reduction, better performance of the classifier and reduction of computation time. The data used are *Bonang Barung* single tones which obtained from direct recording saved in wav audio file format.

2. Feature Extraction Based on Wavelet

Wavelet has generated a tremendous interest in both applied and theoretical areas. Like Fourier

Figure 1 *Bonang Barung*

transform, the wavelet transform use inner product to quantify the similarity between an analyzing function and the source signal such as speech. In continuous wavelet transform, the analyzing function is a wavelet (ψ), it compares the signal to shifted and compressed stretched versions of wavelet. Wavelet transform locked the variable of the signal in time and in scale. [2]

2.1 Wavelet Packet Decomposition

Wavelet packet decomposition is a wavelet transform which passed the source signal into more filters compared to discrete wavelet transform. Signal is divided into an approximation and a detail. The approximation then being divided again into an approximation and a detail, this process is repeated for n-level decomposition. There are n+1 and generate more than $2^{2^{n-1}}$ different ways to encode a signal. In discrete wavelet transform, each transformation level is calculated by passing approximation coefficients to both discrete time low and high pass quadrature mirror filters shown in Figure 3.

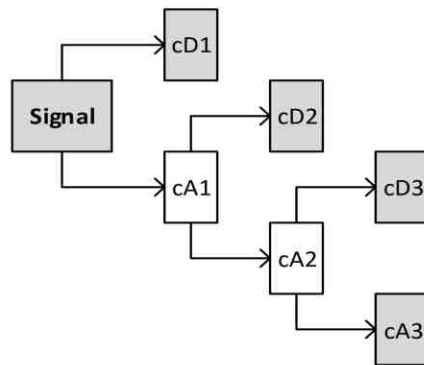Mathematically 3 level wavelet decomposition can be written as:
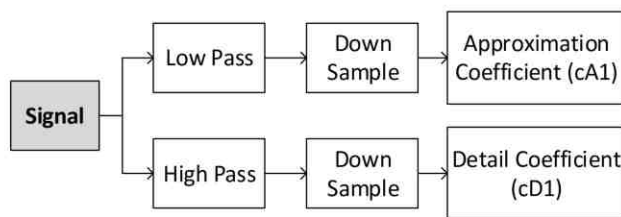
Figure 2 Wavelet Packet Decomposition

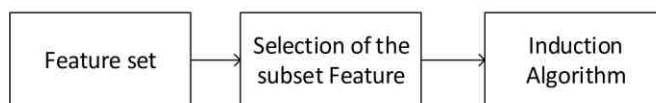Figure 3 Wavelet Decomposition Process [2]

Figure 4 Filter approach for feature selection [4]

$$X = cA_1 + cD_1$$
$$X = cA_2 + cD_2 + cD_1 \qquad (1)$$
$$X = cA_3 + cD_3 + cD_2 + cD_1$$

cA_1 and cD_1 are obtained from the operation as described in Figure 2 and 3.

2.2 Wrapper Feature Subset Selection (WFSS)

Feature selection is a process that selects a subset of original features. Feature selection is one of the important and frequently used techniques in data preprocessing for data mining. Feature selection can reduce the dimension of a data, it select a subset of predictor variables to create a model. The minimization error prediction of a specific measurement is used in the criteria selection process so that the models can fit into different subsets.

Feature Subset Selection (FSS) is a process to determine the best subset for an atribute of a feature which reviewed from the contribution for class separability. This process reduces the data dimension and determines the feature which made the difference between classes and also does a better performance for the classifier. There are two techniques for FSS: [3]
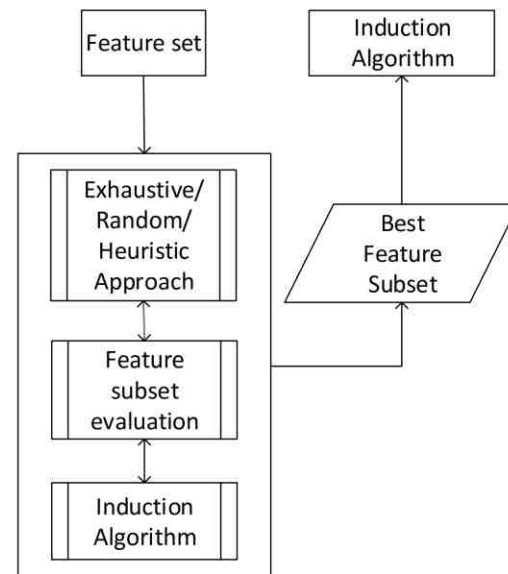

Figure 5 Wrapper Approach for Feature Selection [4]

1. Filter Approach for Feature Selection

The filter approach is self-sufficient from the induction algorithm and the computation is fast, scalable and being executed before the classification process. By using this method, the feature selection only done once and it can be used as the classifiers directly. [4]

2. Wrapper Approach for Feature Selection

Wrapper approaches use the classifier accuracy to do optimization from the feature selection process so that the accuracy can be increased. This model is dependent to the system classifier, because it use the classification method itself to determine the performance of the system features [4]. The weakness of this approach is the processing time. It takes longer time to process because every subset must be evaluated independently in the training process and in the classifier algorithm. [5, 6, 7]. Examples for wrapper technique is Sequential Feature Selection. This method has two variants: Sequential Forward Selection (SFS) and Sequential Backward Selection (SBS).

In SFS, the features are added to an empty candidate sequentially. Each features added is tested to measure the given effect to the classifier algorithm. The best feature result is chosen and combined with the next feature. This combined feature is tested again in the classifier algorithm and measure the result. The best result is being added again with the next feature, this process is repeated until several best accuracies obtained and does not decrease the criterion.

SBS algorithm works the opposite ways with SFS. Features are sequentially removed from a full candidate set. First, several N features are used to find the best accuracy, when 1 feature is removed and it is not give a huge effect for the accuracy, then it will be permanently deleted. The next step, from
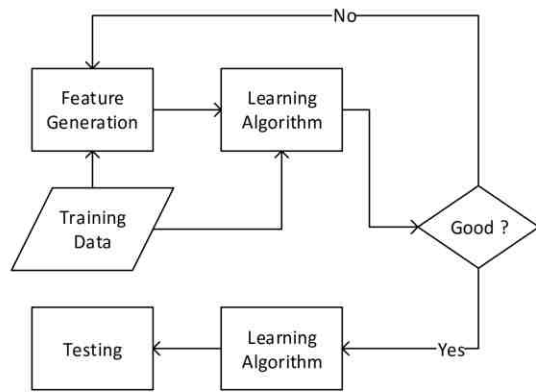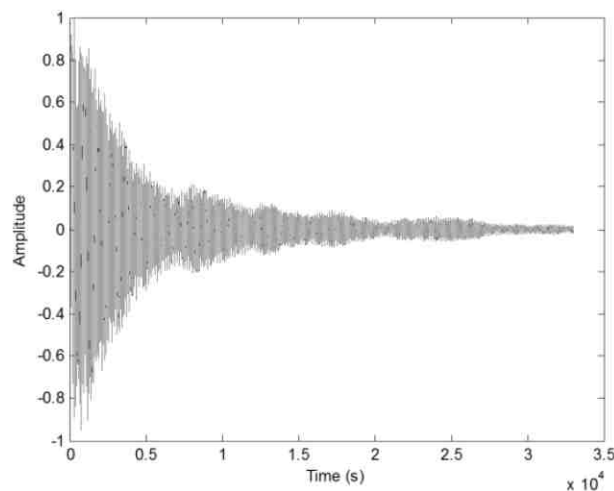
Figure 6 Wrapper Process [3]

Figure 8 "Low Tones 1.wav" frequency spectrum

Figure 7 "Low Tones 1.wav"
Time-Amplitude graph
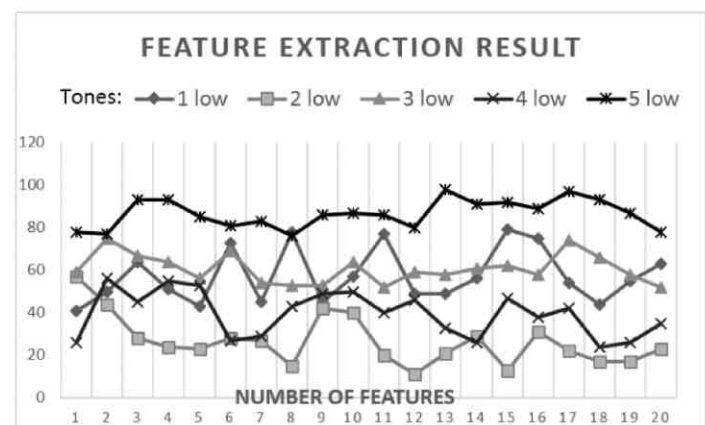
Figure 9 Feature Extraction Result Samples

the N-1 feature, 1 feature is removed again, we get N-2 feature tobe tested. If the removed feature did not give a huge effect for the accuracy, then it will be permanently deleted. This process is repeated until the removal of the next features reduces the accuracy significantly. [3]

The wrapper process in Figure 6 will reduce the number of features. The system only uses the features which give the significant result to the system accuracy.

3. Analysis

The first scenario done in this research used wavelet packet decomposition as feature extraction and the second scenario used WFSS as feature extraction. Backpropagation ANN used as the classifier. The result from this two scenario is compared.

The training data is 10 data for each class of tones, with total 140 training data. The testing data used 10 data for each class of tones and a recorded song with single tone stroke (*nggamel*).

3.1 Feature Extraction

One training data set consist of 7 low tones and 7 high tones. There are 10 sets of training data, with total 140 training data. From experiment, the average number of feature produced by each *Bonang Barung* single tone is 20 features.

3.2 Classification and Detection wihout Feature Selection

Backpropagation ANN is used for tone classification and detection. The parameters of Backpropagation ANN used are:

Epoch : 1000
Hidden Neurons : 20
Activation Func : Purelin
Learning Rate : 0.01

The result sample is shown in Table 1. From 140 sample data extracted by wavelet packet decomposition, we conduct a test using another 140 tones data to be detected and classified. From the testing, the result we can conluded that the accuracy of the system is

$$(104/140) \times 100\% = 74.3\%$$

This result will be compared using the classification using feature extraction selected by WFSS.

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Table 1 Detection Result using Wavelet Packet Decomposition as Feature Extraction

Tones	Detection Result													
	1L	2L	3L	4L	5L	6L	7L	1H	2H	3H	4H	5H	6H	7H
1L	7			1		1					1			
2L		6		2					1				1	
3L	1		8			1								
4L				9			1							
5L				5			3		1		1			
6L			1			7	2							
7L		1					8			1				
1H								10						
2H			1				2		6		1			
3H							1			8		1		
4H	1		2			2					4			1
5H						1		2			7			
6H													10	
7H							1							9

Table 2 Detection Result using WFSS-SFS as Feature Extraction

Tones	Detection Result													
	1L	2L	3L	4L	5L	6L	7L	1H	2H	3H	4H	5H	6H	7H
1L	8					1					1			
2L		9							1					
3L	1		8			1								
4L				9			1							
5L					8		1		1					
6L						8	2							
7L							10							
1H								10						
2H							2		7		1			
3H									1	9				
4H	1		2								7			
5H				1								9		
6H													10	
7H							1							9

3.3 WFSS Analysis

The first experiment, SFS method is used to find the best features. From the simulation, we get 6 features which made a significant result, they are features number: 2, 5, 9, 11, 17 and 19. The tones classification and detection result are shown in Table 2. The accuration of the system is

$$(121/140) \times 100\% = 86,4\%$$

From this experience, it is showed that from 20 features, there are 6 features which can made a significant result for increasing the accuration.

The second experiment, SBS method is used to find the best features. From the simulation we get 13 features which made a significant result, they are features number: 1, 3, 4, 5, 8, 9, 11, 13, 14, 15, 18, 19 and 20.

The tones classification and detection result are shown in Table 3. The accuration of the, system is

$$(130/140) \times 100\% = 92,9\%$$

Table 3 Detection Result using WFSS-SBS as Feature Extraction

Tones	Detection Result													
	1L	2L	3L	4L	5L	6L	7L	1H	2H	3H	4H	5H	6H	7H
1L	10													
2L		9								1				
3L	1		8			1								
4L				9						1				
5L					10									
6L						8			2					
7L							10							
1H								10						
2H								1	9					
3H										10				
4H	1										9			
5H			1									9		
6H													10	
7H								1						9

Table 4 Tones Detection Result from Songs

Song	Number of Actual Tones	The Number of Correctly Detected Tones		
		Wavelet	WFSS SFS	WFSS SBS
Aja Lamis	6	6	6	6
Ande-Ande Lumut	13	10	11	13
Ayun-Ayun	11	9	11	11
Gugur Gunung	8	6	8	8
Kagok Semarang	8	7	7	8
Lencir Kuning	8	6	5	7
Manyar Sewu	5	4	5	4
Pangkur	14	9	9	12
Runtung	14	10	10	13
Udan Mas	13	11	9	11

From the simulation using wraping technique, there are 13 significant features from 20 features extracted from *Bonang Barung* single tones using wavelet packet decomposition.

From the feature selection it is can be seen that from 20 features there are only 13 features which can differentiate each class significantly.

Compared to SFS, the SBS resulted more features, and better accuracy than SFS. The selection process in SFS is stopped because the accuracy is decreasing. This is happened because the best first algorithm force the system to halt the process when the accuracy is decreased. The weakness of this method is the computing time.

4. Conclusion

From the experiment, we can conclude that the wrapping process using SBS resulted a better tone detection. SBS also using fewer features compared with Wavelet Packet Decomposition. The features used by WFSS-SBS method are only 13 features while Wavelet Packet Decomposition used 20 features. The accuracy of the detection system using

WFSS-SBS is 92,9%. It is better than WFSS-SFS, 86,4%, and Wavelet Packet Decomposition, 74,3%. The computation time of the detection system is reduced because the use of smaller number of features. It is better for the next research to use exhausted search method than best first method to find another possibilities of features combinations.

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