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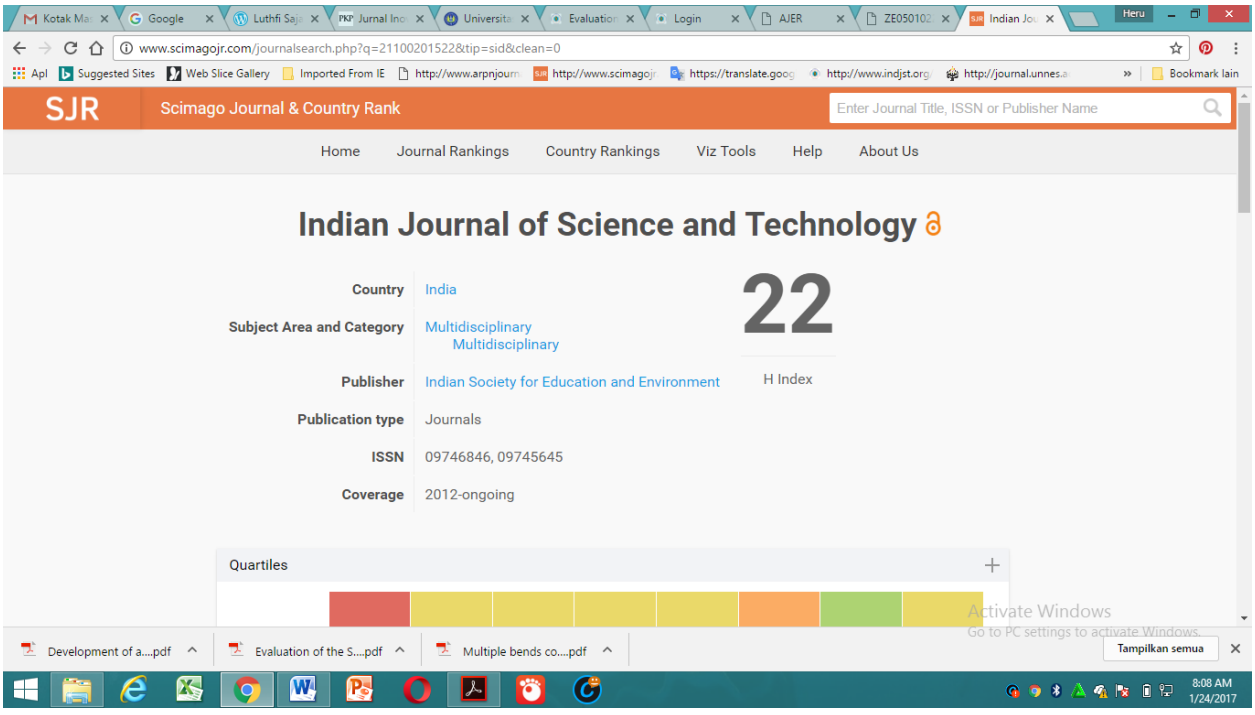
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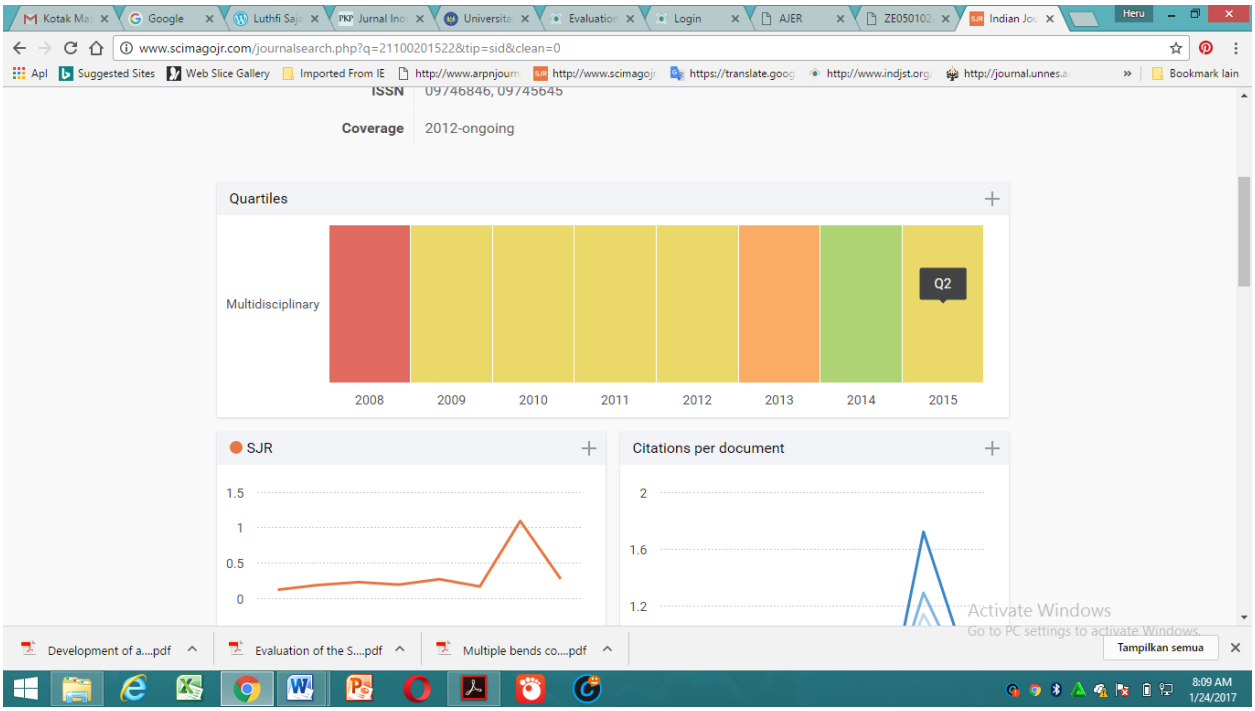
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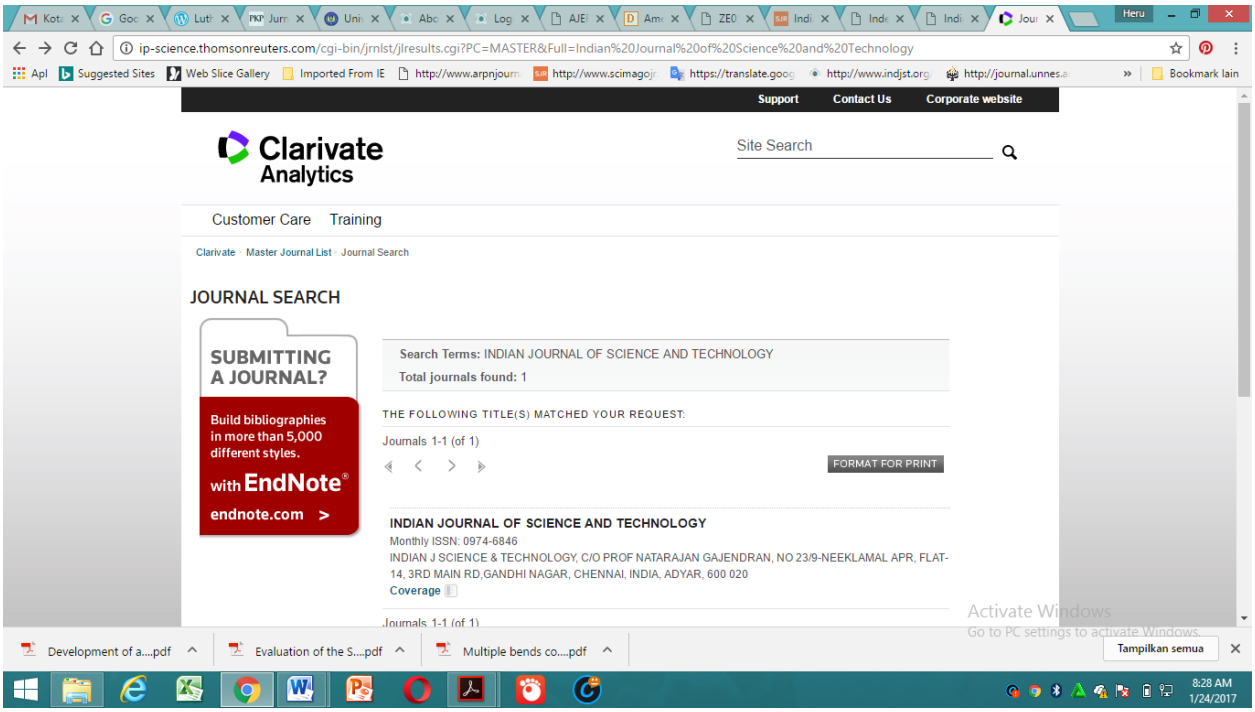
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Evaluation of the Suitability of Acoustic Characteristics of Electronic *Demung* to the Original *Demung*

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Abstract

The study was conducted to evaluate the suitability of acoustic characteristics of electronic *demung* with original *demung*. *Demung* is one of the important instruments in the gamelan, a traditional music ensemble in Indonesia which involves no less than 70 instruments. Electronic *demung* was made in an attempt to miniaturization of gamelan instruments which are generally large and heavy. Acoustic characteristics studied were waveforms, timbre and spectrogram. Product testing was also conducted by questionnaire to teachers of music and master of gamelan. The analysis showed that the fundamental frequency for each key of electronic *demung* was slightly higher than the key of the original *demung*. The increase in the fundamental frequency of the keys in one octave, both have a similar tendency. The numbers of overtones of the original *demung* were more than that of electronic *demung*. ED is considered useful because it can be easier to introduce gamelan music and easy to carry.

Keywords: *Demung*, Electronics, Gamelan

1. Introduction

Gamelan is a traditional Indonesian musical ensemble. We can find it easily in Java and Bali. Now one can find gamelan both in Europe and America. Gamelan attracts researchers because of its uniqueness of it which differs from western music. Gamelan does not have a standard tuning system. Although there are two tuning systems are *pelog* (seven keys to one octave) and *slendro* (five keys to one octave), but each of gamelan instruments is tuned to a set of the gamelan itself. Researchers from Indonesia and abroad are generally interested in the art of playing the gamelan and its content meaning [1-7]. Various researches on acoustic character of gamelan were also conducted in order to understand the model of tuning and comparing it with western music[8-13].

The term gamelan can also refer to a set of musical instruments. One set of gamelan (*pangkon*) can reach no less than 70 instruments. These instruments are generally made of bronze, alloy of copper and tin. Each instrument is played one note or key. These instruments are grouped by function. One group is having a role as the main melody. This function is performed by a group of instruments called *balungan*. There are three types instruments that play *balungan* i.e. *demung*, *saron*, and *peking* each have one octave. *Demung* has octave lower than *saron*. *Peking* has the highest octave. The number of instruments on *demung* is depending on the type of tuned, *pelog* or *slendro*. *Demung* and *pelog* has seven keys, *slendro* has five keys.

Many groups tried to gain artificial gamelan lighter than the original gamelan. Attempt to create artificial gamelan has been carried out by some group both in Indonesia and abroad. This encouraged the need to obtain the gamelan instruments that can be transported easily. The group of the University of Dian Nuswantoro Semarang (UDINUS)[14] has attempted to play a musical by using portable computers. Each portable computer

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contains a program that can represent one group of instruments. Therefore, we need a portable computer that is equal to the number of group to be played. A similar effort has been made by Joko of Prembun Kebumen[15]. Group of the United Kingdom also offers a downloadable virtual gamelan[16]. Group of Massachusetts Institute of Technology (MIT) combines western musical instruments with gamelan called Galaktika. Some gamelan instruments formed from a combination of resistors, piezos and capacitive sensitive sensing[17,18]. Gamelan *sampul* try to combine laptops and sensing devices that are outside. This combination produces a sound similar to gamelan[19].

In this study, the instrument that has been made does not require a portable computer at the time of play. Players can carry easily because of its small size. Thus, the instrument can be used to assist students in learning and play gamelan without having to have a set of gamelan or portable computer, although we recognize that playing original gamelan is actually better. Electronic gamelan is made of an electronic device that is filled with the sound of the original gamelan. In this paper we report on the suitability of acoustic characteristics of electronic *demung* (ED). For comparison the original *demung* (OD) of gamelan in *Karawitan* Laboratory Faculty of Language and Art, State University of Yogyakarta, Indonesia was used.

2. Methods

The first step, we recorded the sound of instruments. Figure 1 shows the set-up of equipment that is used to record the sound of OD. The number of keys in the OD are seven, meaning that this OD used on *pelog* tuning. Microphone is placed at a distance of 15 cm above OD. Microphone is connected to the personal computer (PC). OD is played by the third author. He is a lecturer and performer of the gamelan. PC operator recorded the sound just after the *OD* beaten. Recording was stopped when the sound disappears. Beating is done five times. The next beating is done when the sound of the previous beating disappears. Data is stored on a PC.

The second step was to design a circuit board which will be filled with electronic devices. The main circuit design is taken from the data sheet aP8942A[20]. The sound be conditioning so that the sound source can be stored in the IC recorder. Sound sources obtained from the OD were previously recorded. The recorded sound wave has format with the extension * .wav with a data width of 32

Figure 1. The arrangement of instrument to extract the acoustic data from the OD.

bits and a sampling rate of 44.1 kHz frequency. To be at the input to the IC recorder, recording format to be changed with the file format *.wav or *.voc with a sampling rate of 8 bits and mono channel. Sound editing process was implemented using sound editing software. Figure 2.a and Figure 2.b show the product.

In the box of ED there are seven buttons. These buttons replace the function of the key on the OD. When this button is pressed, it will produce the same sound with the sound of a key in the OD. The size of this box is 5cm × 7cm × 15cm with a weight of 0.3kg, making it easy to carry. The product test was performed as previously recorded stage. The position of OD was replaced with ED. When the button of ED is pressed, the recording is done, and then stored in the PC.

Product testing was also conducted by questionnaire supplied to teachers of music and master of gamelan. To measure the performance of the product, instrument rating scale form were given to teachers and masters to use the same statement. The statement in the instrument is grouped into: the effectiveness of the design, ease of use, consistency, organization, and expediency.

3. Results and Discussion

Figure 3 shows an example of waveforms obtained from (a) the OD and (b) ED. Both were taken from key # 2. Wave forms are taken at the beginning. The waveform of the OD showed five radiating waves together. This situation is different from that of produced by ED. There are two waves that run along.

Figure 4 is a spectrum of (a) OD, and (b) ED. Spectrum was taken with the Fast Fourier Transform. The number

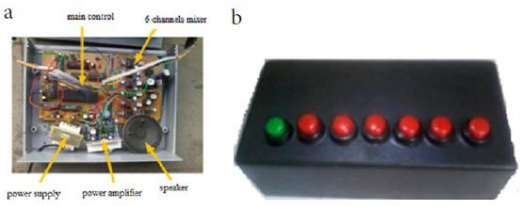

Figure 2. (a) The main components in ED and **(b)** The outside of the ED. There are seven buttons, each have a function like the key of ED.

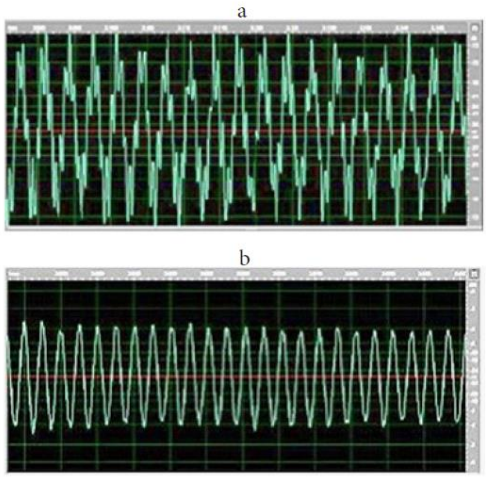

Figure 3. The waveform obtained from the #2 key (a) of OD and (b) of ED.

of samples taken is 16384. Windows that is used is Blackman-Harris. Spectrum peaks normalized to the highest peak. The frequency that has the highest intensity for the #2 key of OD is 323 Hz, while the ED is 396 Hz. This frequency is the fundamental frequency, a frequency which marks the tone produced by a musical instrument. The fundamental frequency followed by overtones which have a lower intensity. This behavior is characteristic that differentiates one musical instrument with others though with the same tone produced. OD and ED have six and five overtone respectively.

Figure 5 shows a comparison of the fundamental frequency generated by OD and ED for the seven keys. The increase in the fundamental frequency of the key #1 through #7 key parallels, although the frequency is not the same value. These results are similar to results conducted

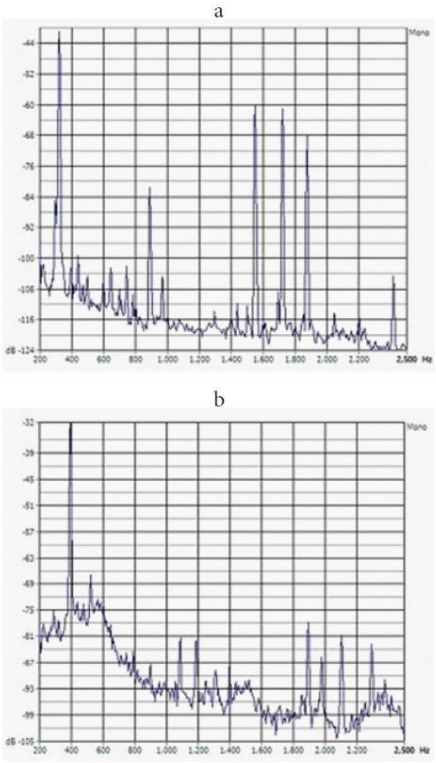

Figure 4. The spectrum obtained from the #2 key (a) of OD and (b) of ED.

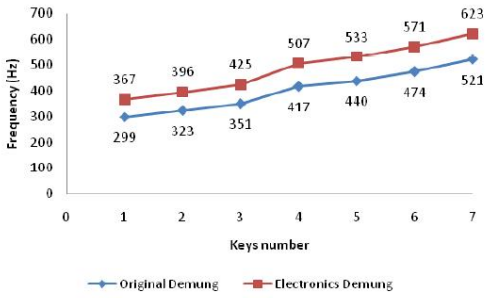

Figure 5. Comparison of fundamental frequency of OD and of ED.

by Surjodiningrat *et al*[8]. They studied a numbers of famous gamelan in Jogjakarta and Surakarta. Fundamental frequency for each gamelan instruments are different, but have parallels in the increase in frequency between the

Table 1. Comparison overtone frequencies generated by the OD and the ED

Keys number of original *Demung* (OD)							Keys number of electronics *Demung* (ED)						
#1	#2	#3	#4	#5	#6	#7	#1	#2	#3	#4	#5	#6	#7
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.41	2.31	1.20	1.14	1.08	**2.00**	**2.00**	1.19	1.33	1.20	2.76	**2.99**	1.87	
2.73	2.75	**2.00**	**2.00**	**2.00**	0.24	2.25	1.81	**3.02**	**3.01**				
4.80	4.80	2.76	2.16	2.05	2.67	2.65	**1.98**	4.81	3.30				
5.25	5.32	4.82	2.78	2.67	4.48	**3.01**	2.40	**5.01**	5.28				
6.40	5.81	5.32	**3.02**	**3.01**	4.70	4.17	2.72	5.35					
7.49	7.46	5.40	4.35	4.61	**5.04**	4.51	2.81						
			5.23	4.75			**3.01**						
			5.30	**5.05**			4.83						
			5.36				5.24						

keys. Similar results were obtained by Kuswanto *et al*[13], when comparing the fundamental frequencies of the two gamelan *Sekati* of *Kraton* (palace) of Yogyakarta. This result was realized considering that the gamelan tuning is not based on a specific frequency as the western musical instruments. Tuning of gamelan instruments adapted to the harmony in the one set of gamelan[1,3]. Tuners of gamelan rely on their ability of the trained hearing.

Table 1 presents the number of overtones for each key. The value of the frequency has been normalized to the fundamental frequency. The value of one indicates the fundamental frequency. Values in bold, whose values approximated an integer, show harmonics of the fundamental frequency. For OD, key # 1 and # 2 do not have a harmonic frequency. We see there is some frequency harmonics on keys # 3, # 4, # 5, # 6 and # 7. The keys of ED do not all have harmonic frequencies. Even for key # 7 was not followed another frequency. Key # 4, # 5 and # 6 followed by a single frequency respectively. Table 1 reveals that the keys of the OD have a number of overtone frequencies greater than that produced by the ED. This indicates that the electronic device reduces the number of OD overtone.

Fundamental frequencies have longer life time than the overtone. This situation is encountered in the OD and ED as indicated by the spectrogram in Figures 6a and 6b respectively. Overtone which has a lower intensity vanishes more quickly.

The results of the assessment given by the master of gamelan are slightly different from that given by music teacher as shown in Figure 7. In general, the assessment

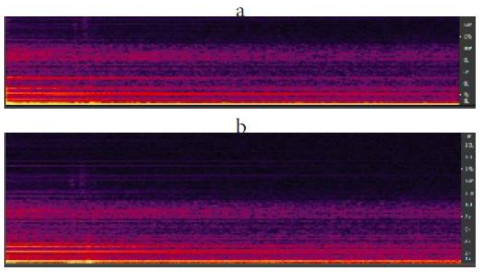

Figure 6. The spectrogram obtained from the #2 key (a) of OD and (b) of ED.

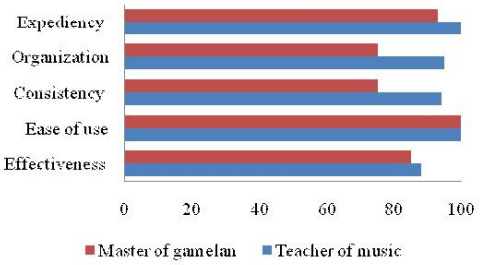

Figure 7. Results of the assessment by the music teacher and master of gamelan to ED.

given by the music teacher is higher than the master of the gamelan. The differences are so noticeable for consistency and organizational components. Music teachers rate higher these two components than the made by the

master of the gamelan. All the teachers were asked to give an assessment of the electronic gamelan is making a judgment that this device is very useful. Usefulness relates to: facilitate students in learning gamelan, learning can be done by playing, motivating children to learn gamelan, and the price of the device that can be reached.

4. Conclusion

The tendency of increase in the fundamental frequency of each key on the OD and ED are equal. The fundamental frequency of each key of ED is higher than that of OD. ED is considered useful because it can be introduced to gamelan music easily and easier to carry.

5. Acknowledgement

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