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High Imperceptible Copyright Protection: Adaptive Wavelet for Security

Irma Safitri[1], Rizki R. Ginanjar[2], Aliffian S. Laksono[3]

[1, 2, 3]School of Electrical Engineering, Telkom University, Bandung, Indonesia

irmasaf@telkomuniversity.ac.id[1], {qivaijar[2], satrioaliffian[3]}@gmail.com

***Abstract*—This study is an extension of a recently conducted study in audio watermarking system. This study shows the imperceptibility of audio watermarking system based on Bose-Chaudhuri-Hocquenghem (BCH) code, Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) methods. Watermarked image is embedded in the audio host signal accompanied by several attacks. The audio watermarking performances show that perceptual quality of audio with attacks is varies. At quantization spacing of 0.1 perceptual quality, objective difference degree (ODG) can reach -1.55 for level 1 in the audio watermarking system with echo attack. While signal to noise ratio (SNR) can reach 10.5 dB in the audio watermarking sistem with echo attack and bit error rate (BER) performance can reach 0.03 in our audio watermarking system also with echo attack. However, the audio watermarking system with equalizer attack shows that the higher the DWT level, the better imperceptible and BER performance is. Different from that of the system with equalizer attack, the watermarking system with resampling attack shows that the higher the DWT level, the better imperceptible and SNR performance is.**

Keywords—Audio Watermarking; BCH Code; DWT; SVD

I. INTRODUCTION

Audio watermarking is a process of embedding information into a host audio signal in a certain way where it is difficult to be extracted by unauthorize person(s). Watermarking is becoming increasingly needed given the rapid information tranfers over the internet. Therefore, protection methods are required to meet some demands in the multimedia copyright including image, audio, and video files [1, 2].

Some watermarking many studies have been conducted in various methods, such as time [1], temporal [2], DCT (discrete cosine transform) [3, 4], DWT (discrete wavelet transform) domain methods [5-7]. By adding SVD (singular value decomposition) in the DWT based audio watermarking method, authors in [8-11] showed that the system has a high performance. Error correcting coding can enhance the performance of audio watermarking and increase the security of the embedded file [12, 13]. One of these error correcting codings is BCH code.

This study tries to analyze audio watermarking system using adaptive multilevel DWT BCH code method based on SVD system for its imperceptibility. This work is an extended research from [14]. Decomposition level of DWT is selected adaptively. This study, however, also tries to analyze the multilevel DWT effect presented in ODG, SNR and BER.

II. AUDIO WATERMARKING SYSTEM

This study uses adaptive decomposition wavelet level, e. g. level 1, level 2, and level 3 as shown in Fig. 1. The system used in this study adaptively chose the decomposition level based on watermarking purposes, either for high capacity, high robustness or high security. It is designed to include two main sub-systems: embedding and extracting processes as shown in Fig. 2.

An audio watermarking system can produce a good perceptual sound quality and watermark resistance towards attack. Both of these can be measured mathematically based on the values of ODG (Objective Difference Grade), SNR (Signal to Noise Ratio) and BER (Bit Error Rate). ODG is the result of an objective calculation of the difference between two audio files where the highest similarity value is 0 and the lowest difference value is -4. It indicates the robustness of the watermarking system against the attacks. However, SNR is a parameter used to indicate the capacity of embedded watermark image. The last is BER where it can also be used as one of

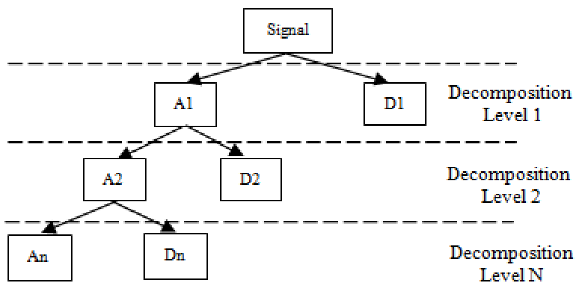

Fig.1. Decomposition Levels

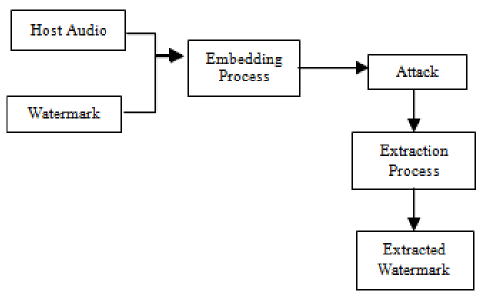

Fig.2. Audio Watermarking System

the quality evaluation parameters of an audio watermarking system in which this value indicates the difference in watermark bits extracted to the embedded watermark.

A. Watermark Embedding

Embedding process is conducted before extraction process, with or without attacks. The audio host is embedded with a watermark image. The purpose of embedding process is to have an imperceptible watermark image. Watermark embedding process in details is as follow. Watermarked image is converted into a bit stream. The position of watermarked image on the bit stream is determined by scanning this stream.

After that, the watermark bit stream is passed to the BCH encoder in order to encode the watermark. By using a certain number of samples, audio host is then segmented. Segments (frames) are equal in size. DWT transform is applied to each of the frames. DWT decomposition levels are provided in multilevel from 1 to 3 to be chosen adaptively. Then DWT level is chosen. Some 2 x 2 square matrices are then formed from the selected wavelet coefficients. SVD matrix decomposition is applied to each square matrix and it is resulted in 3 square matrices including U, S, and V.

By using QIM embedding method, watermark embedding is done by changing the value of S matrix that is component S (1,1). QIM embedding equation for bit 1 can be written in eq. (1) and bit 0 in eq. (2).

$$s(1,1)' = round\left(\frac{s(1,1)}{\Delta}\right) * \Delta \quad (1)$$

$$s(1,1)' = floor\left(\frac{s(1,1)}{\Delta}\right) * \Delta + \frac{\Delta}{2} \quad (2)$$

where Δ is quantization spacing .

SVD reconstruction is done to reconstruct each square matrix. The reconstruction equation is written in eq. (3)

$$M = USV^T \quad (3)$$

where M is an initial matrix before the transformation in the size of m x n, U is a unitary square matrix in the size of m x m, S is a diagonal matrix in the size of m x n with a non-negative real number in each matrix element, and V is a unitary matrix in the size of n x n. S matrix is inserted by watermark image. Each square matrix forms an audio sample stream containing wavelet coefficients. The process is continued by returning to the time domain, i. e., by applying inverse DWT. It ends with combining frame into an audio sample stream.

B. Watermark Extraction

Extraction process is done after the embedding process, with or without any attacks. The watermark image is extracted from the audio host. This process is briefly described as follows. An audio host containing a watermark image is devided into frames (segments). DWT is applied to each frame by adaptively chosen level of 1, 2, or 3. Then the decomposition level is chosen similar to that of in embedding process.

Square matrices are then formed from selected wavelet coefficients. This each square matrix is decomposed into SVD matrix. This SVD matrix decomposition is resulted in 3 square matrices, namely U, S, and V matrices. QIM algorithm is applied for bit determination, i. e., in the form of bit stream. To decode the watermark image this bit stream is passed into the BCH decoder. The last process is reshaping the watermark image to be compared to the original watermark image.

III. Experimental Results

This study involves some experiments in audio watermarking system extended from [14]. In [14], the system is only analyzed in the presence of LPF, noise, MP3 compression and LSC attacks. The experiment spesifications are the same with that of in [14], i. e., an audio host of 10 seconds duration with a sampling frequency of 44100 Hz. The watermark image used in this study is a 65 x 65 pixel black and white watermark image. Each audio segment is divided into 512 samples and is formed in a 2 x 2 square matrix for each 4 samples. High frequency band is used in the embedding process.

In this section tries to present the analysis towards the imperceptible factors in the audio watermarking system. It is started by examining the system, embedding and extraction, without any attack. The results can be seen in Figure 3 for ODG values, Figure 4 for SNR values and Figure 5 for BER values. The analysis is processed to the system at 0.1 quantization spacing. At that spacing, ODG is -0.74 for DWT level 1 and -1.52 for DWT level 3. Level 1 has better ODG than that of level 3. It means that level 1 is more imperceptible than level 3. While SNR value for DWT level 1 is 27.5 dB and that of level 3 is 28 dB. Level 3 has a slightly better SNR than that of level 1. BER values show very good results, before reaching the point of 0.01, DWT levels have reached the zero BER. It means watermarked image can be extracted very well.

After the analysis on the performances of audio watermarking system without attack, the analysis is then continued to some description on the experiment results for that with attacks, i. e., equalizer, resampling and echo attacks.

A. Equalizer

Equalizer attack is an attack to the audio watermarking system that works by increasing and reducing the audio signal gain at a certain frequency. The result of the analysis of audio watermarking system on this attack can be seen in Figures 6-8. At quantization spacing of 0.1, for level 1 ODG= -2.2 while for level 3 ODG= -3.52. Level 3, however, has some inconsistent results. Level 1 is more imperceptible than level 3. However, the SNR of DWT level 1 is 11.83 dB and that of level 2 is very poor. BER reaches 0.04 value for level 1 and 0.15 for level 3. According to those figures, the higher the DWT level the better imperceptible (ODG) and BER performance is.

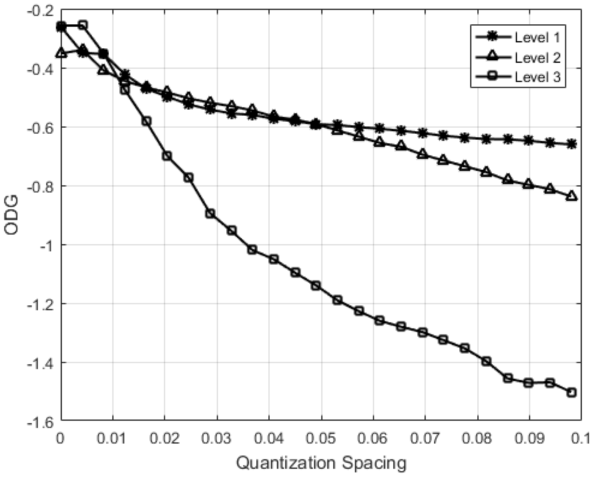

Fig. 3. ODG in Multi Level DWT
Without Attack

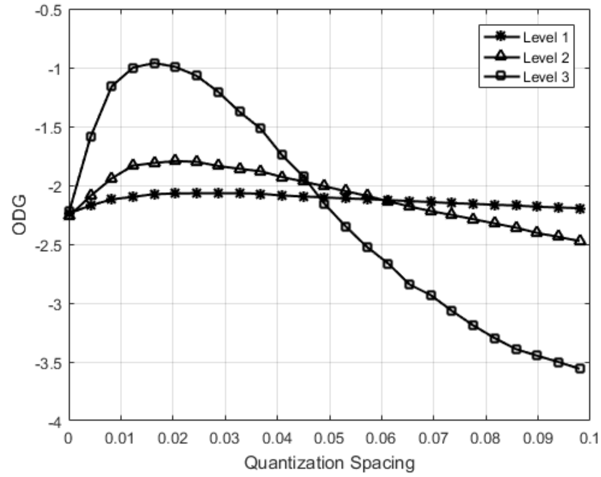

Fig. 6. ODG in Multi Level DWT
With Equalizer Attack

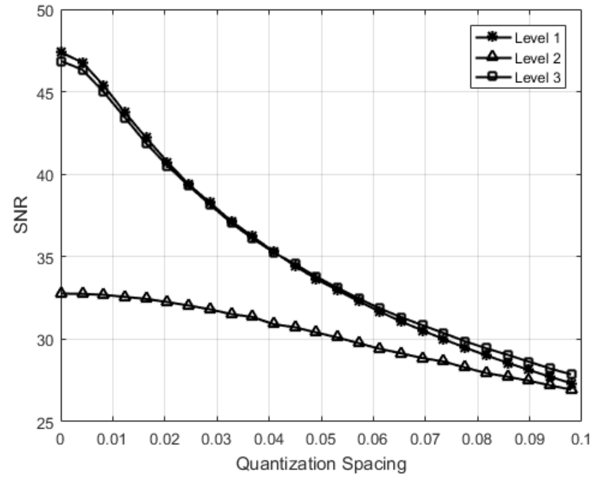

Fig. 4. SNR in Multi Level DWT
Without Attack

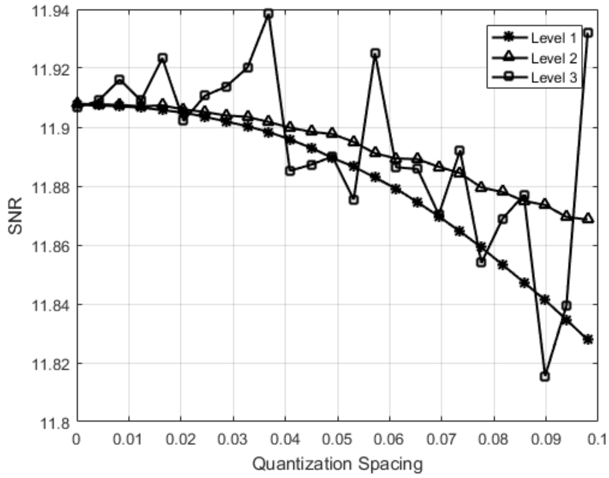

Fig. 7. SNR in Multi Level DWT
With Equalizer Attack

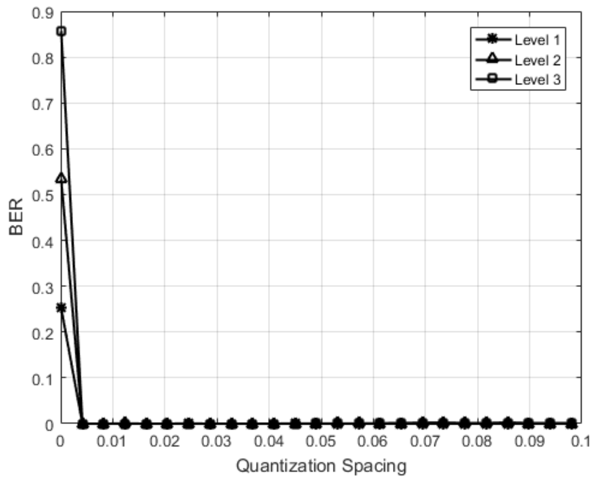

Fig. 5. BER in Multi Level DWT
Without Attack

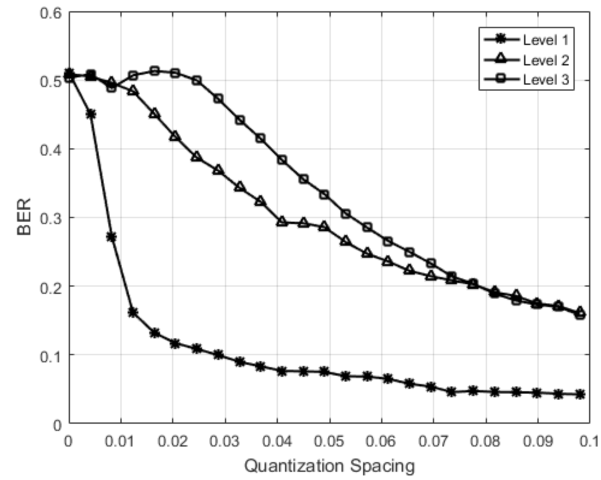

Fig. 8. BER in Multi Level DWT
With Equalizer Attack

B. Resampling

Resampling is a sampling process of an audio signal of which the sampling rate is different from the audio sampling rate. The rate used in this experiment is 22050 KHz, where it is ½ of the initial audio rate (44100 KHz). The experiment results are shown in Figures 9-11. At quantization spacing of 0.1, ODG perceptual performance of level 1 is -2.505 and that of level 3 is -2.476. Perceptual performance of level 3 is more imperceptible than that of level 1. SNR performance of level 1=2.849 dB and that of level 3=2.8525 dB. However, BER performance of level 1 is 0.457 and that of level 3 is 0.458. According to those figures, the higher the DWT level the better imperceptible (ODG) and SNR performance is.

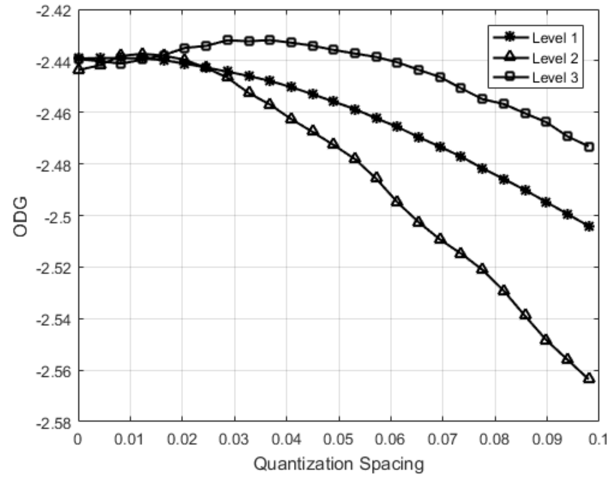

Fig. 9. ODG in Multi Level DWT
With Resampling Attack

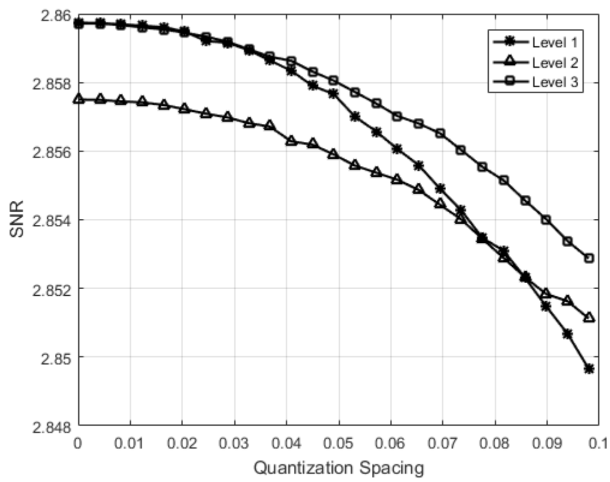

Fig. 10. SNR in Multi Level DWT
With Resampling Attack

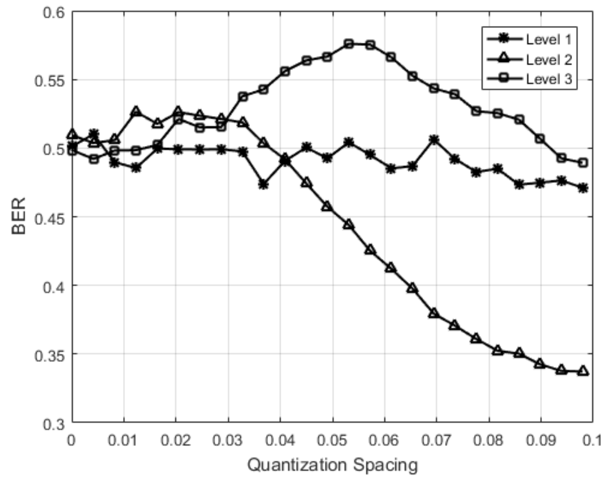

Fig. 11. BER in Multi Level DWT
With Resampling Attack

C. Echo

Echo is a repetition of audio samples that have smaller amplitude values. The repetition is produced without removing the afterward audio sample so that there will be a summing process between echo audio samples and subsequent audio samples. Audio watermarking performances under echo attack are as shown in Figures 12-14. At quantization level of 0.1, ODG perceptual performance of level 1 is -1.55 and level 3 is -2.4. However, the imperceptible level of level 1 is higher than that of level 3. On the other hand, the SNR for level 1 and level 3 shows an identical number of 10.5 dB, and BER values for level 1=0.03 and level 3=0.38. According to those figures, the higher the DWT level the worse imperceptible (ODG) and BER performance is.

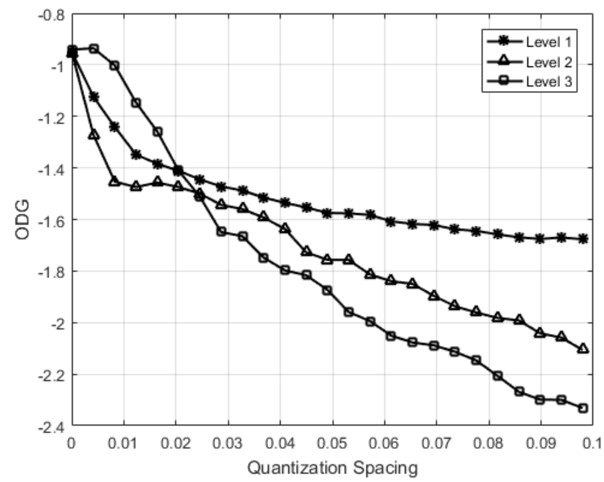

Fig. 12. ODG in Multi Level DWT
With Echo Attack

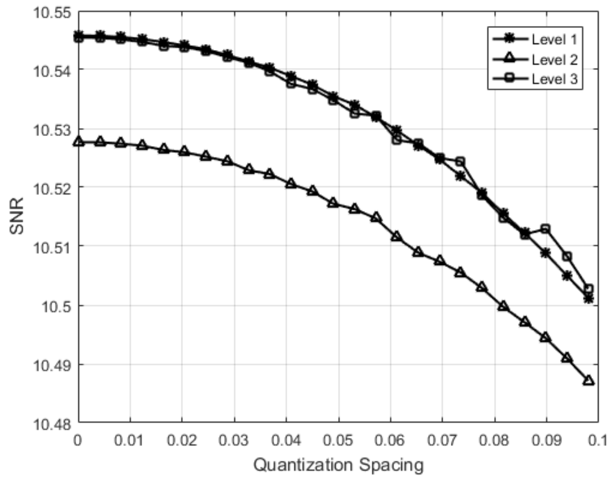

Fig. 13. SNR in Multi Level DWT With Echo Attack

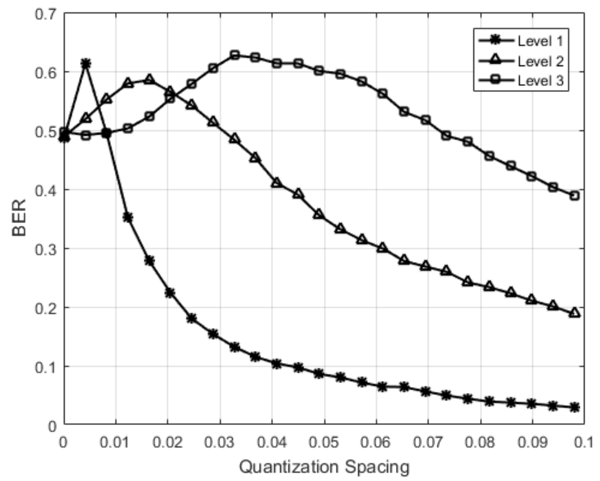

Fig. 14. BER in Multi Level DWT With Echo Attack

IV. CONCLUSION

This study shows the imperceptibility of audio watermarking system with BCH DWT SVD methods. The audio watermarking system with attack varies in the perceptual quality. In the audio watermarking system with echo attack, at quantization spacing of 0.1, the perceptual quality can reach the point of -1.55 for level 1 while SNR can reach 10.5 dB and BER can reach the point of 0.03.

For the audio watermarking with equalizer attack, the higher the DWT level the better imperceptible (ODG) and BER performance is. However, for resampling attack the higher the DWT level the better imperceptible (ODG) and SNR performance and for echo attack the higher the DWT level the worse imperceptible (ODG) and BER performance is.

REFERENCES

[1] P. Bassia, I. Pitas, N. Nikolaidis, “Robust audio watermarking in the time domain,” IEEE Transactions on Multimedia, 2001.

[2] A. N. Lemma, J. Aprea, W. Oomen, L. van de Kerkhof, “A temporal domain audio watermarking technique,” IEEE Transactions on Signal Processing, 2003.

[3] M. Charfeddine, M. El’Arbi, C. B. Amar, “ A New DCT Audio Watermarking Scheme Based on Preliminary MP3 Study,” International Journal of Multimedia Tools and Applications, 2014.

[4] S. Aparna, P. S. Baiju, “Audio Watermarking Technique Using Modified Discrete Cosine Transform,” International Conference on Communication Systems and Networks (ComNet), 2016

[5] S. C. Kushwaha, P. Das, M. Chakraborty, “ Multiple Watermarking on Digital Audio Based on DWT Technique,” International Conference on Communications and Signal Processing (ICCSP), 2015.

[6] N. V. Lalitha, S. Rao, P. V. Y. J. Sree, “ DWT – Arnold Transform Based Audio Watermarking,” IEEE Asia Pasific Conference on Postgraduate Research in Microelectronics and Electronics (Prime Asia), 2013.

[7] R. Alshazly, M. M. Fouad, M. E. Nasr, “ Secure and Robust High Quality DWT Domain Audio Watermarking Algorithm With Binary Image,” International Conference on Computer Engineering & Systems (ICCES), 2012.

[8] A. Al-Haj, A. Mohammad, “Digital audio watermarking based on the discrete wavelets transform and singular value decomposition,” European Journal of Scientific Research, 2010.

[9] S. Vongpraphip, M. Ketcham, “An intelligence audio watermarking based on DWT- SVD using ATS”, WRI Global Congress on Intelligent Systems, 2009.

[10] A. Al Haj, T. Christina, A. Mohammad, “Hybrid DWT-SVD audio watermarking,” International Conference on Digital Information Management (ICDIM), 2010.

[11] P. K. Dhar, “An SVD-based audio watermarking using variable embedding strength and exponential-log operations,” International Conference on Informatics, Electronics, and Vision (ICIEV), 2013.

[12] F. Chaabane, M. Charfeddine, C. B. Amar, “The Impact of Error Correcting Coding in Audio Watermarking,” International Conference on Next Generation Networks and Services (NGNS), 2011.

[13] A. R. Fazli, M. M. Eghbali, Z. Kazemi, G. Sarbisheie, “Security improvement for audio watermarking in image using BCH coding”, International Symposium on Communication Systems, Networks, and Digital Signal Processing (CSNDSP), 2012.

[14] I. Safitri, R. R. Ginanjar, A. Rizal, Azizah, “Adaptive Multilevel Wavelet BCH Code Method in the Audio Watermarking System,” International Conference on Control, Electronics, Renewable Energy and Communications (ICCEREC), 2017.