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Copyright Protection in Audio File Using Watermarking Approach Based on Wavelet-SVD

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Keywords: copyright protection, audio watermarking, wavelet-SVD.

Abstract. The encryption is not be able to protect intellectual properties of audio file completely. Therefore, a technique of audio watermarking is launched to improve the previous technique of the protection. In this paper, we analysis and implements a system that be able to protect a copyright of an audio file by using wavelet-SVD based on watermarking Approach. IWT-SVD produces the best rate of inaudibility compared with DCT-SVD and DWT-SVD, but total processing time of watermarking using DWT-SVD is faster than others.

Introduction

The development of technology has a big influence in spreading information and data to all over the world. There are many data and information such as image file, a video and audio file go into our lives and out every day. However, the development of technology does not always affect positively to all sides of life. There are several bad effects of the development of technology; one of them is a violation of a copyright of a work. We know that many illegal files spread in mass, and it aggravates some parties, especially the author of the files. One of the files that are often spread is an audio file.

To solve this problem, we need strategies; one of them is watermarking. It is a way to insert secret information into host file that cannot be known directly (imperceptible) [4]. On audio files, the information cannot be listened up directly (inaudible) [2] so that it cannot be differed between watermarked audio file and un-watermarked one. The information inserted into host file can be an author's information or other information that sign a copyright of that work. Watermark file inserted into host file must be able to endure each attack (robust) [4] so that the sign of the copyright is still inside of watermarked file until that file is separated legally.

System Design

Generally, watermarking process is to insert secret information into host file where the information cannot be known directly (imperceptible) [4]. Host and watermark files used in this system are wav audio file. It can be stereo or mono file for host file, but for watermark file must be mono one.

Watermarking process needs two audio files: first, host audio file that will be inserted of secret information; second, watermark audio file that signs a copyright of that work. Before host file is transformed using Integer Wavelet Transform (IWT), Discrete Wavelet Transform (DWT), or Discrete Cosine Transform (DCT), the host file will enter into framing process that divides audio file into two parts or frames where the length of the frames can be determined as we need, see Figure 1. The number of sample per frame used in this case is 50000. In other side, it can be done onto watermark audio file by using transformation process and SVD, because the file that will be inserted into audio host file is singular value from SVD process.

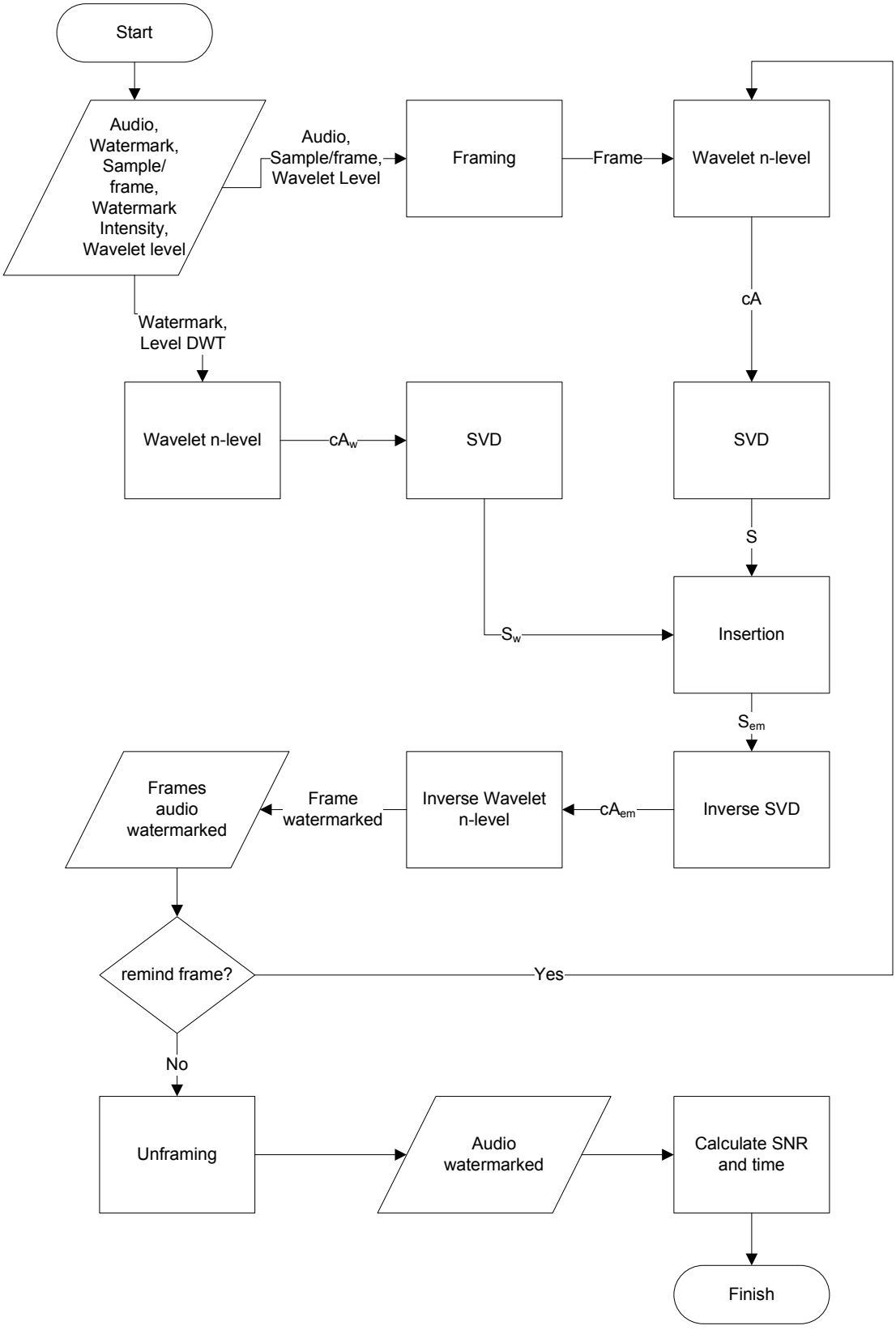

Figure 1. Watermarking Process

The frame produced from framing process of host file will enter into IWT, DWT, or DCT process, and SVD like watermark file that be continued into process of inserting watermark into host file frame. On the scheme of inserting watermark, the intensity value of watermark (k) is 0.01. Then, after the process is completed, it will be continued into SVD inverse process and transformation inverse of

IDCT, IDWT or IIWT to the frame—the result of inserting process that aims to turn back the value of transformation and SVD process. And the process is done for each frame produced from framing process of host file on the first step. After all of the frames are watermarked, the next step is doing framing inverse that combine frames produced from watermarking process become a watermarked audio file. Extraction process is to separate watermark file from watermarked one so that we will get two kinds of file, they are watermark file and host file. Look at the figure below, as steps of doing extraction.

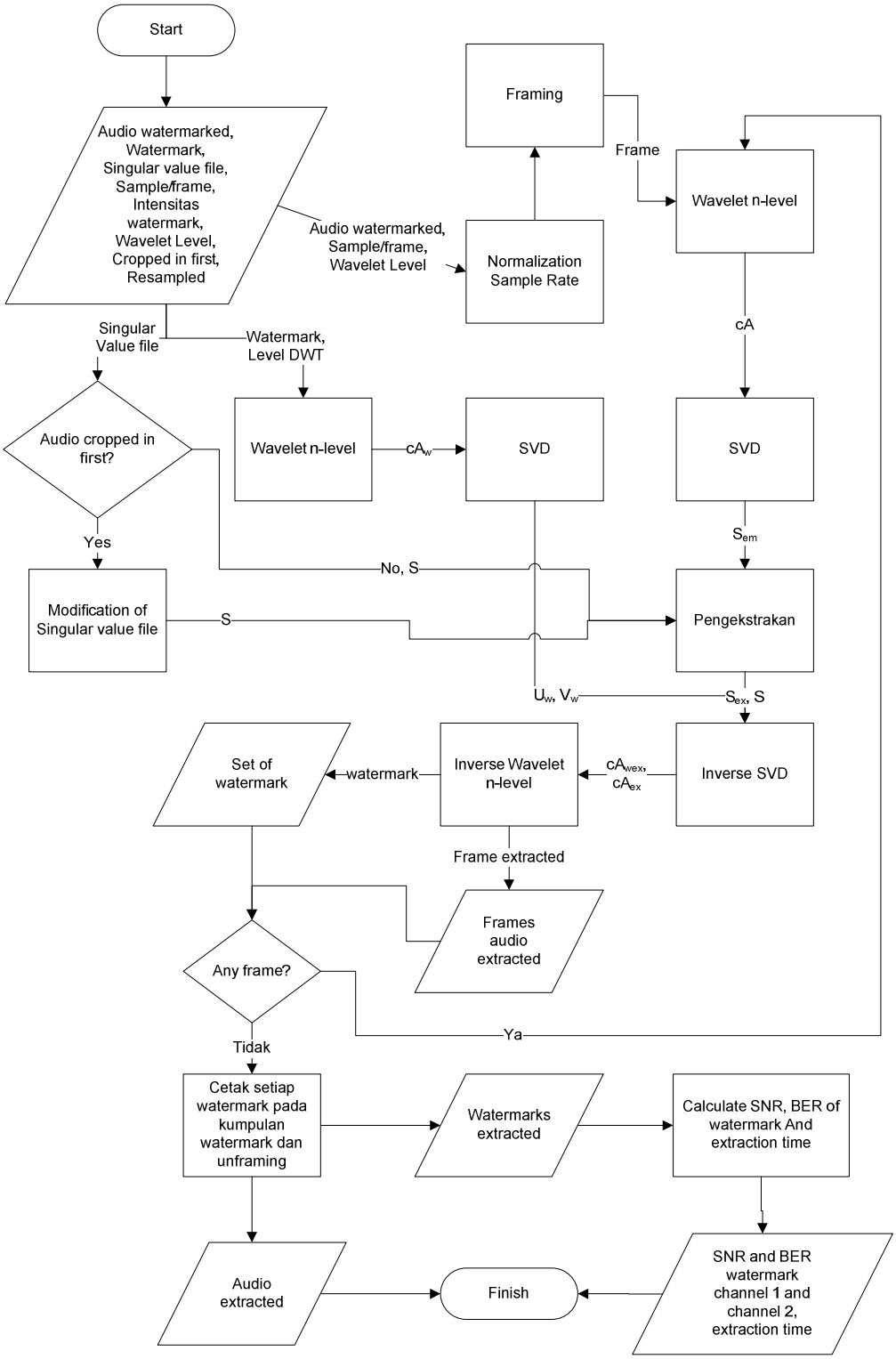

Figure 2. Extraction Process of Watermarked Audio

Before entering framing, watermarked audio file needs to be normalized first, since it can experience a change of specification from the original host audio file before. Then, when it is extracted, it will become two parts, they are host audio file and watermark audio file with the same original specification though they have been attacked. The steps of extraction after normalization process are not really different from watermarking and transformation process of IWT, DWT or DCT, and SVD. The difference is just decreasing value from watermarked audio file frame to gain singular value of watermark and singular value of host that is needed to form host audio file and watermark audio one by using equation $S_w = (S_{wa} - S)/k$ where S_w is singular value of watermark of extraction result, S_w is singular value of watermarked audio file frame, and S is singular value of host audio file frame, k is intensity value [2]. After completing the process above, we need to turn back the value of the file by using the process of SVD inverse and transformation inverse of IIWT, IDWT, or IDCT, and framing inverse so we will get the host audio file of extraction.

Testing system is done by using several kinds of audio file and of attack scheme. Look at the following Table 1:

Table1. Audio File for Testing

Audio Host	Types
Colorado Bulldog	Rock
Fusion	Jazz rock instrumental
Just you	Pop jazz
Kasih Putih	Pop (soft)
Speech	Audio recording
Twilight Solitude	Instrument

Each testing scheme is implemented to different transformations by using IWT-SVD, DWT-SVD, or DCT-SVD. The Testing is done by using the number of sample per *frame* = 50000 with watermark intensity (k) = 0.01 for all kinds of transformation. Process of comparison of performances on each transformation is done by using comparison of Signal to Noise Ratio (SNR) and processing time. SNR is used to measure performances (inaudibility) of audio signal of watermarking [6].

The following table is the result data of the watermarking testing by using system made of IWT-SVD level 4, DWT-SVD level 4, and DCT-SVD.

Table 2. Performance of Inaudibility

Name of Audio	Average of SNR (db)			Total Time (second)		
	DCT	DWT	IWT	DCT	DWT	IWT
Speech	41.23	53.71	**59.86**	5.81	**1.59**	2.37
Fusion	40.45	46.41	**52.56**	5.57	**1.61**	2.37
Twilight	47.75	47.18	**53.33**	6.02	**1.71**	2.39
Just	47.64	53.6	**59.75**	5.01	**1.52**	2.28
Kasih	44.37	50.33	**56.47**	5.77	**1.6**	2.71
Colorado	45.98	51.94	**52.00**	5.64	**1.6**	2.32

Based on the Table 2, SNR value of audio file, the result of watermarking with IWT has the highest value of all (DCT and DWT). Meanwhile, the processing time of DWT needs faster time than DCT or IWT. DCT process will do repetition as much as the number of frame (n x n) before and after inserting, where n is the number of sample per frame that causes how long the transformation process.

Extraction process is done for 6 types of host audio file where each type of host file has got attack suitable with testing scheme explained before.

Table 2. Performance after Attacking

Type of Attack	Average of SNR		
	DCT	DWT	IWT
Without attack	59.32	Inf	Inf
Invert / Flip	59.32	Inf	Inf
Distortion	-31.84	-12.71	-10.31
Noise	30.95	39.28	38.07
Resampling	24.85	26.47	13.16
Cropping	-20.58	28.47	12.17

Based on the experiment, as shown on the Table 2, the SNR values of DWT-SVD are bigger than DCT-SVD or IWT-SVD. The biggest value of SNR of DWT-SVD prevails for most of attack scheme and watermarked audio file that are used in experiments. While, the smallest value of SNR is gained from testing system by using DCT-SVD on most of attack scheme and types of audio file used on the testing system. DWT-SVD needs faster time in the extraction process of watermark than DCT-SVD or IWT-SVD. It is directly proportional with total time needed on watermarking process that produces the smallest total time of the two other types (DCT-SVD and IWT-SVD).

Conclusions

The conclusion of the result of testing system with IWT-SVD, DWT-SVD, and DCT-SVD as follows. On the *watermarking*, IWT-SVD produces the best degree of inaudibility compared with DCT-SVD and DWT-SVD. Total time of the fastest *watermarking* is produced by DWT-SVD process. On the extraction process, the average value o SNR produced from DWT-SVD is higher than DCT-SVD or IWT-SVD. It shows that DWT-SVD produces a robust-watermarked audio file that has higher similarity with original audio file than IWT-SVD. Mean while, the extraction time of DWT-SVD is faster than IWT-SVD or DCT-SVD. Hence, DWT-SVD is a fast watermarking that be able to produce good inaudiblility and robust watermarked for copyright protection on audio file.

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