An audio steganography by a low-bit coding method with wave files

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ABSTRACT

This paper describes an audio steganography using low bits coding. This approach is to replace the data of lower bit in a cover audio data by a secret data.

We used wave file as an audio data. The wave file format is a subset of Microsoft's RIFF specification for the storage of multimedia files. We used 8 bits mono audio data. The secret data is a written text file.

We propose two kinds of new methods of extended low bits coding. We made a program and experimented to verify the method. We could embed the secret data using new method of extended low-bit coding. From now on, we will make program to extract secret data. Our future works is to increase the capacity as well as improve the confidentiality of audio steganography.

1. Introduction

An audio steganography technique has been used since early times, but the download service of program by Internet is a service with short history. There were no programs that a user can generally access fifteen years ago. But now we can easily get this on the Web through the Internet. However we should proceed the study because such problems as the capacity of the data and improvement of the secrecy still remain unsolved. Besides, there are few users who know what the audio steganography is. We introduce various methods which have been studied about the audio steganography.[1][2] However these approaches have little capacity of embedded secret data.

In this paper we use audio steganography and propose that the new method of embedded secret data has high-capacity by improving the low-bit coding. When we embed the secret data in audio data, it is important for the place of embedding data. It is meaningless that someone can detect the secret data at a glance as well as the image data [3]. It is important to obtain big capacity without the variation in original data context. Our research objective is to make an audio steganography program that is easy to access. In chapter 2 we state the method of the audio steganography and the algorithm. In chapter 3 we discuss the result of the experiment. Finally we conclude and refer to the unsolved problems.

2. My study of audio steganography

2.1. The summary

In this chapter, we explain two kinds of new methods by low bit coding.

2.2. The method

2.2.1. The lowest bit coding. The lowest bit coding is the method that embeds secret data only in the least significant bit (LSB). This method enables us to minimize the transition not only before but also after the audio is embedded. The possible embedding capacity occupies one eighth or 12.5% of wave file, because the audio data use only the lowest bit. In Figure 1. we show the way how the wave data is embedded using the lowest bit method. We express wave data and secret data by binary digits and replace secret data in low bit with the wave data one by one. We express the wave data to embed by the binary digits of the emphasized box in the Figure 2. and Figure 3.

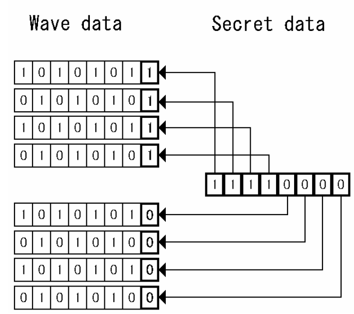

Figure 1. The the lowest bit coding

2.2.2. The variable low bit coding. We improved the lowest bit coding and made a new method to increase embedded capacity.

We used the audio data that the quantization bit rate is 8bit as experimental data (cf. Section 3.2) Therefore, the range of audio data is from 0 to 255. The middle range of audio data is 128 and the sound of audio data is a silent sound. Therefore we don't use this range in audio data for embedding.

If we embed the secret data in the silent sound, everyone notice the existence of the secret data. Therefore we don't embed the secret data into the middle range data. We make

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the middle range 128 to calculate the standard level of sound.

We define the two thresholds 1 and 2 based on the standard level about middle range 128. We set the threshold 1 and 2 in our experimental system (cf. Figure 2.) If the range of the amplitude is lower than boundary value 1, we don't embed the secret data. In this case, we regard it small sound with noise. If the value of the audio data is between threshold 1 and 2, one bit is embedded in cover data. If the level of audio data is beyond threshold 2, two bits are used for the embedding.

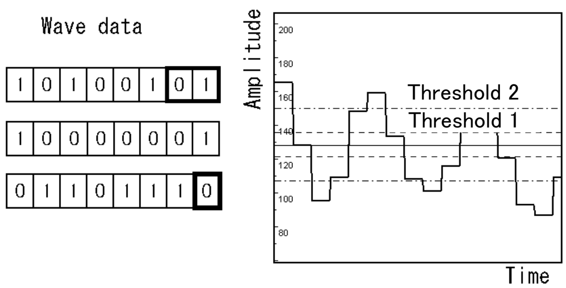

Figure 2. The variable low bit coding

2.2.3. Average amplitude method. It is the method that uses the average amplitude data of surroundings audio data as threshold. The level of the amplitude in each time is shown in Figure 3.

We calculate the average about absolute value of amplitude regarding middle value 128 as value 0.

The average of an amplitude level for audio data is calculated by 10 audio data about before and after 5 audio data except for own audio data about all sample data.

There are 22050 pieces of audio data for 1 second, because the audio data is 22.05 kHz. We calculate the average of the upper 6 bits excluding low 2 bits for 2 bit embedding.

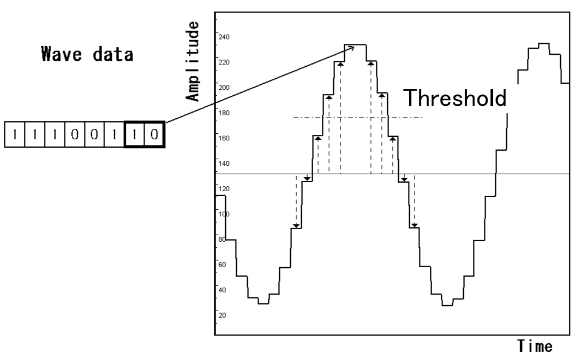

Figure 3. The principle of the average amplitude

If the level of the amplitude is bigger than that of the average value that is calculated by surroundings 10 pieces of audio data, 2 binary digits are used for the embedding data. If not, binary digits are not used for the embedding data. The level of the amplitude is very low and isn't suitable for the embedding data by the same reason such as the variable low bit coding. The numbers of embedding binary digits in this method are unified in two bits.

3. The experiment of audio steganograpy

3.1. The summary

In this chapter, we made a program and experimented to examine the method introduced in chapter 2. We state the procedure and the result of our experiment.

3.2. The experimental method

We did two kinds of different experiments. One is the auditory experiment, the other is the embedding capacity measure experiment. As for the auditory experiment, we embed the secret data by using each program in the wave file and verified the transition of the audio before and after embedding data. We measured the percentage by consulting the embedding part how many bits were used for the secret data. We consulted the stego wave data that the secret data is embedded into the cover data. We omitted the case of the lowest bit coding, because the capacity always indicates 12.5%.

Experimental Condition is as follows.

The number of candidate wave files are sixty (music, voice and effect sound that each data is consisted of 20 pieces of audio data)
Wave file format is a specification by Microsoft.
Sampling rate is 22.05 kHz.
Quantization bit rate is 8bit.
Number of Channels is mono channels.
Embedded information is a written text file.

3.3. Auditory experiment

There was noise by embedding secret data in all methods. The level of noise is different from method. The noise of the average amplitude method was obviously small and we could get the highest confidentiality in the three methods. The lowest bit coding method is some little bit bigger than the average amplitude method.

As for audio data with noise, the noise was eliminated by embedding process to add some noise. Thus, we conclude that it is effective to use the cover wave file with noise.

3.4. The result of the embedding capacity experiment

As the result of the embedding capacity measure experiment in each method, the experimental results are shown in Table 1. with maximum, minimum and the average.

Table 1. The result of the embeded capacity measuring experiment

Embedding method		Embedding capacity[%]		
		Maximum	Minimum	Average
Lowest bit coding		12.5	12.5	12.5
Variable bit coding	ALL	23.5	4.1	13.9
	Music	21.7	7.4	15.3.
	Voice	20.1	4.1	12.3
	Effect sound	23.5	4.1	14.2
Average amplitude method	ALL	18.5	5.7	12.1
	Music	15.6	7.5	12.6
	Voice	13.6	5.7	10.9
	Effect Sound	18.5	6.8	12.7

As the result of the experiment, we found that the embedding capacity of variable bit coding was bigger than that of the lowest bit coding.

As for variable bit coding, the method tends to be in proportion to embedding capacity and amplitude of the audio data. We think that the reason is it is based on threshold depending amplitude of audio data. Furthermore, the silent sound decreased the embedding capacity considerably in the variable bit coding and average amplitude method, when silent and small sounds in cover wave file exist.

It is tendency to have rather more embedding capacity comparatively for music data, which is continuous sound in series without silent sound shown in Figure 4.

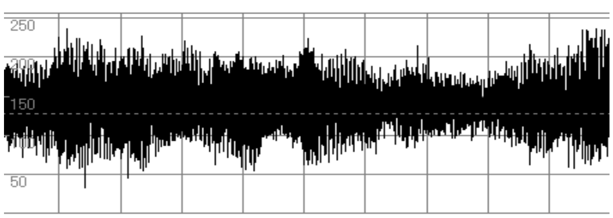

Figure 4. The wave form of music sound data

Conversely, it is tendency to have less embedding capacity for voice data with silent sound as shown in Figure 5. One of the resolutions is to make the bigger amplitude by way of some algorithm before embedding processing.

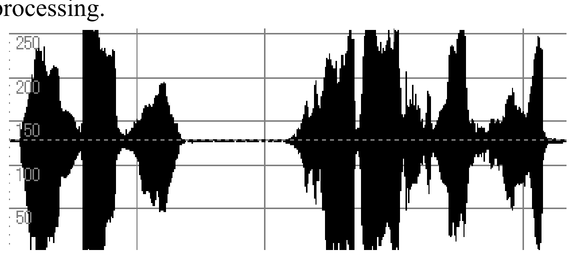

Figure 5. The wave form of voice data

3.5. The evaluation

3.5.1. SNR evaluation We used SNR (signal to quantization noise ratio) method for objective evaluation. The evaluation equation is expressed by following equation using original signal s(n) and the quantization error e(n)

$$SNR = 10\log_{10}\frac{\sum_n s^2(n)}{\sum_n e^2(n)}$$

We calculate the SNR between dummy data (non-embedded data) and stego data (the embedded data with secret data). We clarify the loss amount, SNR [dB], such as the difference value by embedding. We show the SNR characteristic in Table 2.

Table 2. The result of the SNR measure experiment

Embedding method		SNR[dB]		
		Maximum	Minimum	Average
Lowest bit coding	ALL	58.5	42.7	46.5
	Music	50.4	45.2	47.2
	Voice	50.9	44.4	45.9
	Effect sound	58.5	42.7	46.2
Variable bit coding	ALL	50.3	39.9	43.7
	Music	50.3	40.7	44.5
	Voice	49.1	40.4	43.7
	Effect sound	49.7	39.9	42.9
Average amplitude Method	ALL	49.3	40.5	43.2
	Music	49.3	41.6	43.8
	Voice	47.1	41.7	43.1
	Effect sound	44.4	40.5	42.6

3.5.2. The characteristic of the wave. We consult the influence of audio wave by embedding.

We show the Figure 6. (a), (b) and (c) about music of the lowest bit coding method.

We show the Figure 7. (a), (b) and (c) about voice of variable bit coding method.

We show the Figure 8. (a), (b) and (c) about effect sound of average amplitude method.

The (a) is non-embedding wave form of three audio data.

The (b) is embedding wave form of three audio data.

The (c) is the different wave form of three audio data.

There are changeless and even in all methods at a glance. The reason is by restriction that the number of embedding bit is two bits. If we scale up the wave of audio data and check the wave form in detail, there were very small variations of wave shape in the lowest bit coding. There were changes for big level of amplitude in the variation bit method. There were changes for the top of wave form in the average amplitude method.

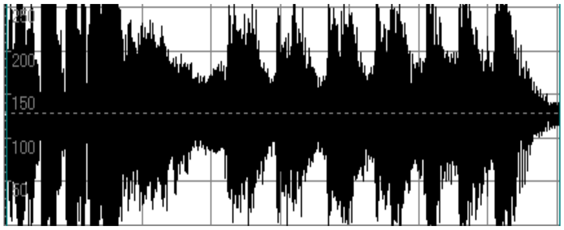

Figure 6. (a) No-embedding wave of music

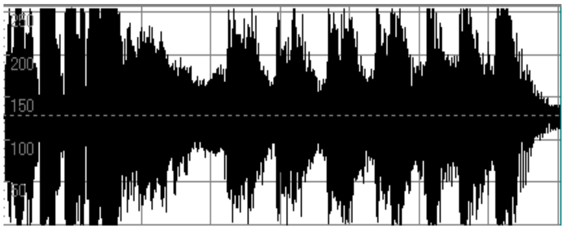

Figure 6. (b) Embedding wave of music (low)

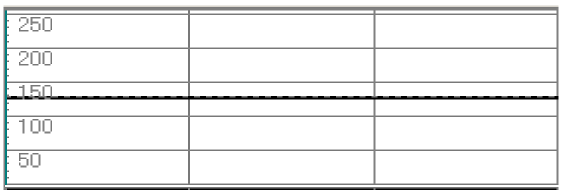

Figure 6. (c) The difference wave of music (low)

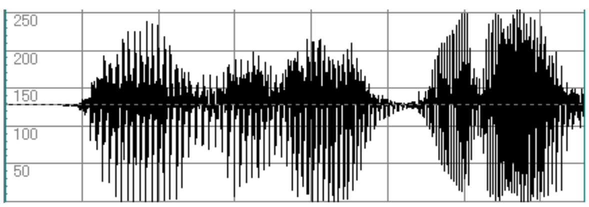

Figure 7. (a) No-embedding wave of voice

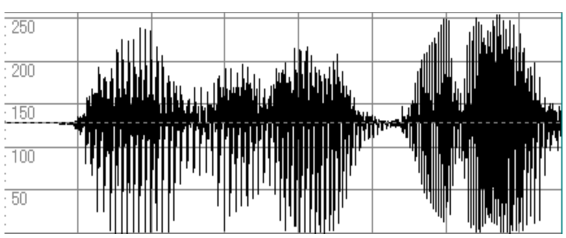

Figure 7. (b) Embedding wave of voice (var)

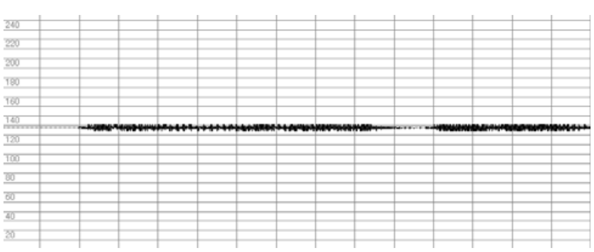

Figure 7. (c) The difference wave of voice (var)

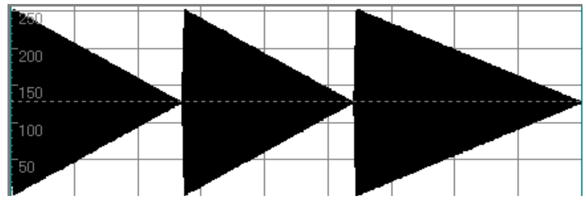

Figure 8. (a) No-embedding wave of effect sound (ave)

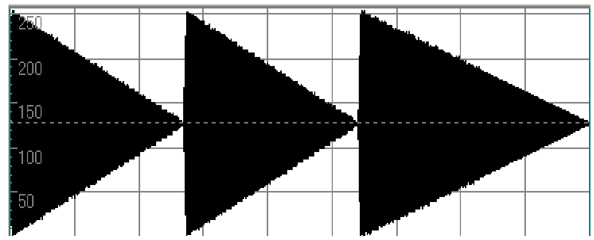

Figure 8. (b) Embedding wave of effect sound (ave)

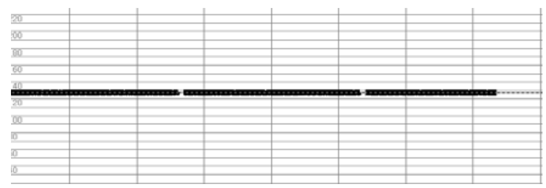

Figure 8. (c) The difference wave of effect sound (ave)

4. Conclusion

We studied the audio steganography using wave file. We could embed the secret data by new extending method of low bit coding. From now on, we will make a program to extract the secret data. Our future works are to increase the capacity of the secret data as well as to improve the confidentiality of audio steganography.

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