Research on Audio Digital Watermark and realization in MATLAB

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Abstract: Based on improved algorithm of DCT(discrete cosine transform), the Audio Digital Watermarks is embeded and detected in this paper.The watermark embedding process is simulated by MATLAB was described in this paper. The experimental results shows that the watermarks by this algorithm has good stability and non sense. Audio watermarking with MATLAB software can meet the real-time requirements and can better protect the copyright information.

Key words: Audio watermarking; DCT; watermark embedding; watermark extracting

1. Introduction

In order to prevent piracy and protect copyright, a lot of people are embedding watermark in the works. To embed watermark in audio is relatively difficult, it's not easy to identify only through the ear. The human ear system is sensitive to additive noise.It is difficult to detect the robustness and the non sense of the watermark by embedding the watermark in the time domain. For example,watermark can be embedded by using the masking effect of human ear system and non-sensitive properties of the human ear system to absolute phase.

2. Audio digital watermark embedding

The steps of audio watermark embedding are as follows:

Firstly, using the discrete cosine transform to segment the Audio data Ae embedding with watermark .

$$\mathrm{De} = \mathrm{DCT\,Ae} = \{\mathrm{De(k)} = \mathrm{DCT\,Ae(k)}\}\ \ 0 \le \mathrm{k} < \mathrm{M1} \times \mathrm{M2} \tag{1}$$

$\mathrm{De(k)} = \mathrm{de(k)(m)},\ 0 \le \mathrm{m} < \mathrm{N}$ is the m coefficient during the the discrete cosine transform $\mathrm{De(k)}$ of k Audio data segment.

Secondly, the DCT transform is used to determine the intermediate frequency coefficients of the digital audio signal, which is used to embed the corresponding elements $Vp(k)$ in the sequence Vp. The number of audio data segment data $Ae(k)$ is N, the change result $De(k)$ of DCT with N DCT transform coefficients, for the DC component $de(k)(0)$ is the zero DCT coefficients of $de(k)(0)$, AC component of low frequency to high frequency isN-1 DCT coefficients. In order to improve the robustness of the embedded watermark, usually we choose the low frequency AC component $de(k)(1)$ as intermediate frequency coefficient, if choose $de(k)(2)$ as intermediate frequency coefficient, that $m_w = 2$.

Thirdly,modify the intermediate frequency coefficient $de(k)(m_w)$ and embed it into element $Vp(k)$ of sequence Vp.

$$de^{'}(k) = de(k)(m)(1+\partial vp(k)), m = mw \quad (2)$$

α is the ratio coefficient, which can control the position of intermediate frequency coefficient. If theα value is too small,the watermark robustness will be worse; if the value is too large, the actual use value of the original digital audio signal is too low. Before the digital audio watermark is obtained, the audio watermark is a watermark which is a discrete cosine transform.

$$Ae^{'} = IDCT(De^{'}) = \{IDCT(De^{'}(k), 0 \le k < (M_1 \times M_2)\} \quad (3)$$

Finally,we put the results obtained into the formula and complete the embedding.

$$A_w = A_r + Ae^{'} \quad (4)$$

3. Audio digital watermark extracting

Firstly, the original digital audio signal A and the digital audio signal As to be detected are segment processed.

$$A = Ae + Ar \quad (5)$$

Secondly,the watermark part Ae of the original audio signal will be used to embed and the watermark part Ase of the audio signal to be detected are discrete cosine transformed .

$$De = DCT(Ae) = De(k) = DCT(Ae(k)),\ 0 < k < M1 \times M2 \quad (6)$$

The obtained signal is extracted from the discrete cosine transform domain, and the watermark sequence is obtained by the formula (6)

$$x = 1/(\alpha \times de(k)(m_w))(dse'(k)(m_w)de(k)(m_w)) \tag{7}$$

Thirdly, the extraction sequence Vsp of fake random sequence reverse sort (i.e. anti scrambling), to get a sequence Vs of watermark extraction.

$$Vs = InversePermute(Vse) = \{Vs(k), 0 < k < (M1 \times M2)\tag{8}$$

Fourthly, Two-dimensional transform processing the Vs ,getting the image of two-dimensional sequence, so as to successfullyextract the watermark .

In order to prevent the results from being affected by other factors, the normalized correlation coefficient is used to evaluate the similarity between the original watermark and the extracted watermark, as shown in the formula (9):

$$\rho(W,Ws) = \frac{\sum_{i=1}^{M_1}\sum_{j=1}^{M_2} W(i,j)Ws(i,j)}{\sqrt{\sum_{i=1}^{M_1}\sum_{j=1}^{M_2} W(i,j)^2}\sqrt{\sum_{i=1}^{M_1}\sum_{j=1}^{M_2} Ws(i,j)^2}} \tag{9}$$

When the image resolution is assumed to be 32 x 32, dividing them into 4 * 4=16 blocks.When the watermark image resolution is assumed to be 64 x 64, and then dividing them into 64 blocks, you can get a piece of the size of 64. Then we can remove the16 intermediate frequency coefficients of the image and watermark blocks embed into watermark. Theshadows in the left picture 8 * 8 block coefficient part is being pumped out of . As shown in figure 1.

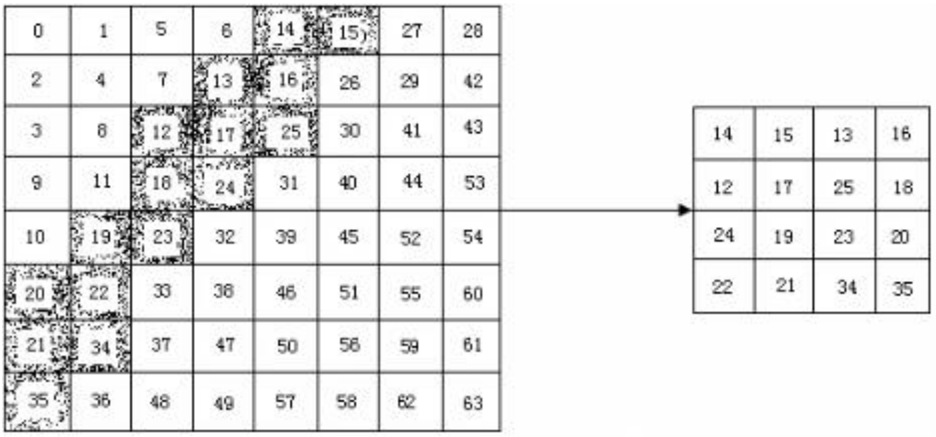

Figure 1 Selecting 4 x 4 intermediate position coefficient in DCT area

4. MATLAB simulation

In the experiment,the audio sampling rate we selected is WAV format 44.1kHz voice signal, the watermark image is the gray image of 16bit. Thewaveform of original audio carrier work, and the audio work waveform after embedded watermark as shown in figure 2:

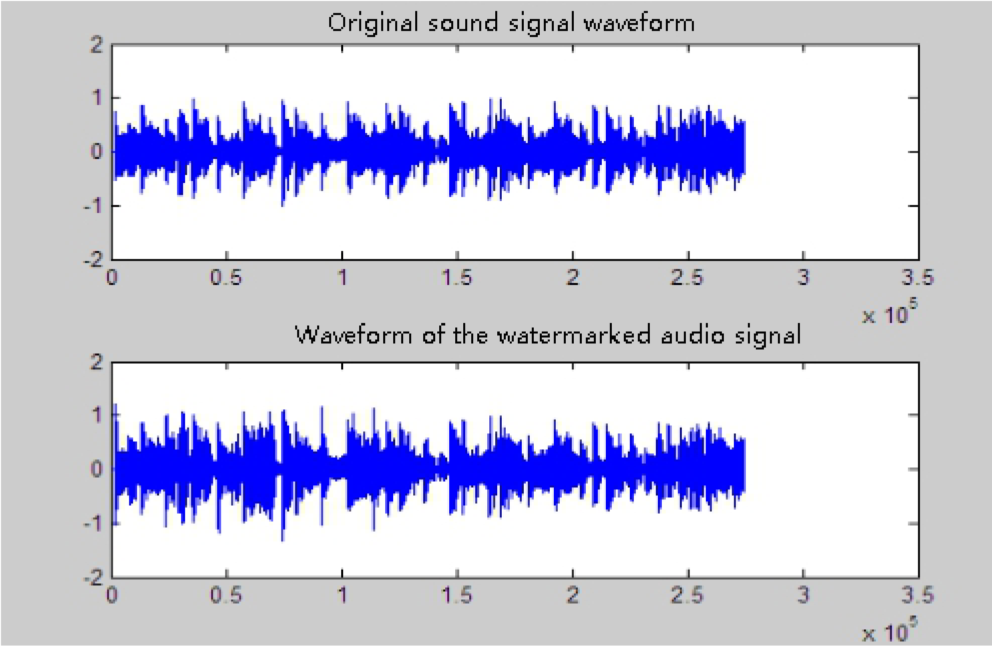

Fig. 2 The audio waveform before and after embedding watermark

By comparing the audio waveform before and afterembedding watermark , the front parts of the 2 waveform are different. This is because that the watermark is added in the previous section,the waveform diagram has changed.

5. Conclusions

This design uses the MATLAB software programming, the discrete cosine transform to carry on the watermark embedding and the extracting. Discrete cosine transform (DCT) has better sensitivity and concentrating energy, which is very effective to audio signal processing. The improved algorithm DCT intermediate frequency watermark embedding algorithm can be obtained through the DCT transform coefficients to determine the embedding place.

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