SSA-based Audio Watermarking with Automatic Parameterization And Parameter Estimation

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Abstract: This paper proposes an audio watermarking scheme based on singular-spectrum analysis (SSA) and differential evolution. In the proposed framework, a watermark is embedded into an audio signal by modifying singular values, and parameters for the modification are determined by differential evolution. Since these parameters are input-dependent, a method for automatic parameter estimation is proposed as well. Test results show that the proposed scheme is robust against many attacks, e.g. MP3 and MP4 compression, and the difference in sound quality between the original and the watermarked one is considerably small.

Keywords: Singular-spectrum analysis, singular value decomposition, differential evolution, automatic parameter estimation, audio watermarking

1. Introduction

Since the last decade, demands for applications such as broadcast monitoring, owner indentification, proof of ownership, and information carrier for digital audio signal have increased considerably due to technologies misusage. To answer such demands, audio information hiding has been suggested.

2. Proposed Framework

Embedding and extraction processes are shown in Fig. 1. Differential evoluation is used to determine modified singular values.

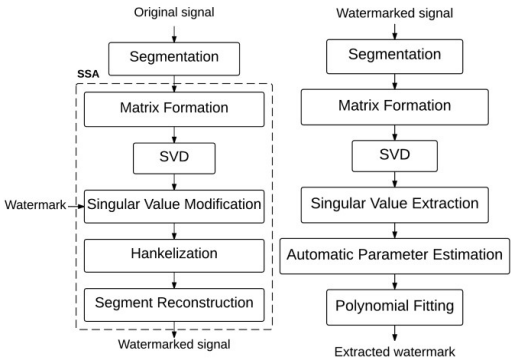

Figure 1. Embedding (left) and extraction (right) processes.

3. Evaluation and Experimental Results

Twelve host signals from RWC database were used in our simulations. The perceptual evaluation of audio quality (PEAQ) and log-spectral distance (LSD) were used to measure the objective sound quality of watermarked signal. Five attacks were performed in order to evaluate the robustness. In the experiments, we implemented three different models: fixed-parameter (Fix.), partially-blind (Par.), and completely-blind (Com.) models.

We compared the proposed models with the conventional SVD-based techniques [1]. Results are shown in tables below.

Table 1. BER (%) comparision of the proposed and the conventional SVD-based methods [1].

	Fix.	Par.	Com.	Con.
Normal	0.11	0.11	0.01	0.00
MP3	1.28	1.17	8.63	59.00
MP4	0.71	2.65	23.25	1.20
AGWN	0.11	0.11	0.01	0.00
Filtering	3.03	5.30	36.97	38.08
Resampling	0.71	1.09	25.63	2.67
Average	0.99	1.74	15.73	16.83

Table 2. Sound quality evaluation.

	Fix.	Par.	Com.	Con.
PEAQ	0.18	0.19	0.18	0.20
LSD	0.32	0.16	0.24	0.11

The fixed-parameter and partially-blind models outperformed the conventional method in robustness. The sound quality obtained from Par., Com., and Con. methods was comparable.

4. Conclusion

In this paper, deploying SSA and differential evolution for audio watermarking does not introduce perceptible noise into the watermarked signal. Furthermore, based on analyzing singular spectrum, the completely blind detection can be achieved. Thus, the proposed framework is a robust, inaudible, and blind scheme.

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Reference

[1] V. Bhat, I. Sengupta, A. Das, "A New Audio Watermarking Scheme Based on Singular Value Decomposition and Quantization," Circ. Syst. Signal. Pr., Vol. 30, No. 5, pp. 915-927, 2011