Robust Audio Watermarking

GROUP 16

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INTRODUCTION

- Audio signals are exposed to various signal processing operations
- Thus, a Watermark embedding scheme is needed which is robust to these operations
- Described Watermarking scheme maintains audio quality
- And is robust to common techniques such as additive noise, sampling rate change, bit resolution transformation

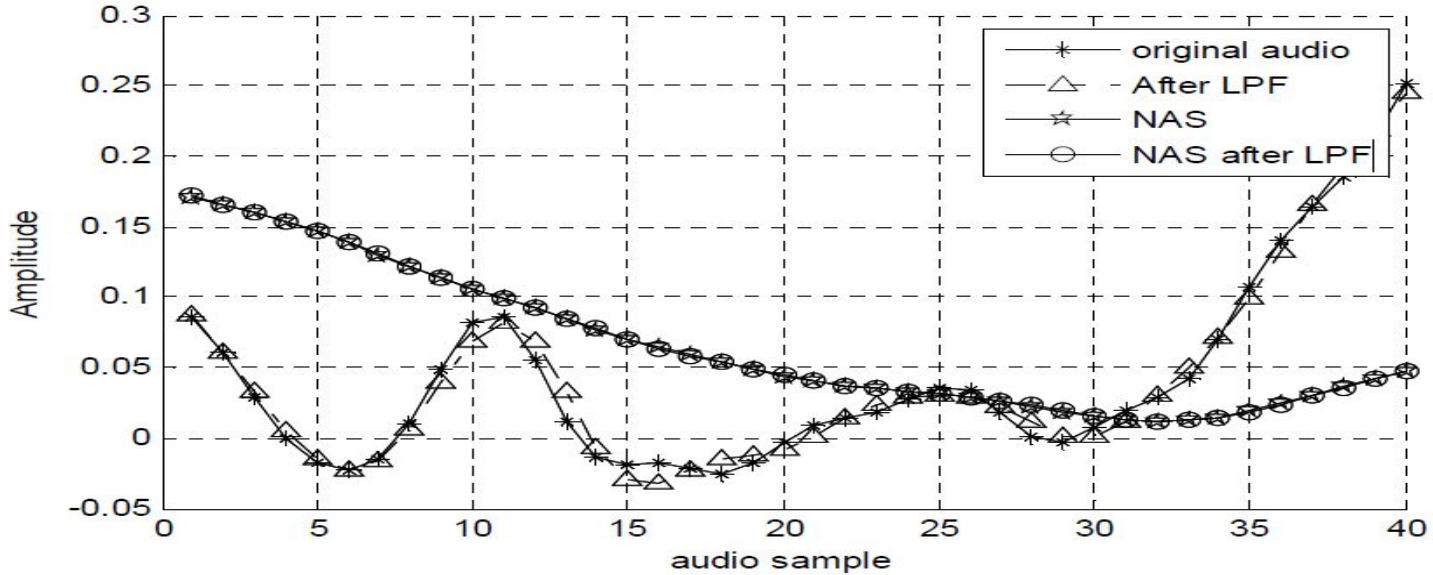
MAS (Moving Average Sequence)

- MAS is a sequence calculated to analyze low pass characteristics of the original sequence of the audio signal, given by

$$M_{B_i} = \frac{1}{b}(x_i + x_{i+1} + \cdots + x_{i+b-1}) = \frac{1}{b}\sum_{k=i}^{i+b-1} x_k \, , i \in (1, R-b+1)$$

- MAS is nearly unchanged after it undergo common signal processing operations, such as additive noise, sampling rate change, bit resolution transformation; because they usually change high-frequency component of and audio signal

Analysis of Low pass filter performance of normal audio vs its MAS



Conclusion: MAS remains same even after Low Pass Filtering

Embedding Watermark Parameters

Choice of b and n

- An appropriate b can be chosen from the number of zero crossing in M_{10},

$$b = L/Z(M_{10})$$

where, Z is the No. of zero crossing in M_{10}, and L is the length of the original signal

- Algorithm shows good results experimentally for $n \in \{8,9,10\}$

Algorithm for Embedding Watermark

- MAS of the audio signal is computed, for window length b.
- For a sequence(audio signal) of length L, we'll have L+b-1 MAS elements.
- The MAS sequence obtained is split into frames of length n*b, starting from the beginning of the sequence.
- A pseudorandom watermark message of length M bits, with each element, $w(k) \in \{1,-1\}$, is chosen
- This w is embedded elementwise into the DCT domain of the frames to make the embedding robust.

Embedding elements of w into frames

- w is a string consisting of equal no's of 1 and -1 (pseudorandom)
- For frame no. k, a bit w[i] is chosen, such that i = k % M
- For each frame DCT is performed
- Then the term with max absolute DCT coefficient, t is chosen and modified by the following equation:

$$t' = \begin{cases} round((t + d[1]) / S) \times S - d[1], & \text{if } w(i) = 1 \\ round((t + d[-1]) / S) \times S - d[-1], & \text{if } w(i) = -1 \end{cases}$$

S: Embedding Strength of the scheme > 0
d[1]= S/4
d[-1]=3S/4

Continued ...

- After the modification the coefficients larger than t’ are adjusted
- For improving robustness coefficients near to t’ may also be reduced
- Then IDCT is performed on the each modified DCT frame to generate the embedded MAS
- After which, we subtract the original MAS from the modified MAS
- We calculate an audio signal which has the MAS equal to this new MAS obtained after subtraction.
- And this audio signal is added to the original audio signal, frame by frame

Extraction Process

- Extraction process is very similar to Embedding process except the actual modification part.
- MAS of the audio signal is computed, for window length b.
- The MAS sequence obtained is split into frames of length n*b, starting from the beginning of the sequence.
- DCT is obtained for each frame, message bit is extracted from the maximum absolute coefficient t', by

$$w_i = \begin{cases} 1, t^* - \lfloor t^* / S \rfloor \times S \geq S/2 \\ -1, t^* - \lfloor t^* / S \rfloor \times S < S/2 \end{cases}$$

Extraction Process

- After extracting watermark message bits from every frame, all the extracted bits corresponding to one particular element in the watermark message is added and sign of the resultant is considered for deciding the element.
- If the message is embedded n times into the signal, then k^{th} element of j^{th} message extracted is denoted by w_k^j, then the k^{th} element is decided according to,

$$w_k = \begin{cases} 1, & if \ (\sum_{j=1}^{n} w_k^j) \geq 0 \\ -1, & otherwise \end{cases}$$

Application

- Watermarking is used to track piracy of Songs and other Audio files.
- The presented algorithm provides provides a good compromise between robustness against common signal processing operations, unlike other common schemes available.
- Along with being robust, it is implemented using computationally inexpensive algorithms, which can be performed on a low power cost efficient Digital Signal Processor.
- And it has very vast and varied scope of application in today’s world.

Reference

The algorithm described for Watermarking is taken from a paper titled,

Robust Audio Watermarking Algorithm Based on Moving Average and DCT: [arxiv:1704.02755]

Authors: Jinquan Zhang, Bin Han

Link: https://arxiv.org/abs/1704.02755

THANK YOU !!!