Audio Watermarking

presented by

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Presentation Outline

- Introduction
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- Techniques
- Applications
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Introduction

- Idea: Embedding an inaudible mark into an audio signal
- Originally proposed as a technique to counter music piracy
- Analogical to the technique used for paper (e.g., money)
- First audio watermarking techniques were directly inspired from previous research on image watermarking

Introduction

- Fingerprinting vs Watermarking
  - Fingerprinting analyzes the signal and constructs a unique signature
    - Signal is not modified
    - Requires a repository
    - No preprocessing required
  - Watermarking hides information in the audio signal
    - Signal is altered
    - Self-contained
    - Signal must be preprocessed

Watermarking Systems

- Devices or systems should check for watermark before proceeding with operations
- A detection mechanism is required
- A key (as in cryptography) is generally used during construction and detection
  - Symmetric (same key)
    - Both construction and detection use a private key
  - Asymmetric (different keys)
    - Construction uses a private key and detection uses a public key
- Watermark is permanent. Audio data can still be used.
  - Contrasts with encryption: temporary and content only usable when decrypted

Watermarking Systems

- Properties
  - Inaudibility: No sound quality degradation
  - Robustness: Resistance to ANY signal transformation
  - Capacity: Bit rate
  - Reliability: Error rate during detection
  - Low Complexity: Efficiency

Watermarking Systems

- Psychoacoustic models are often used to ensure inaudibility

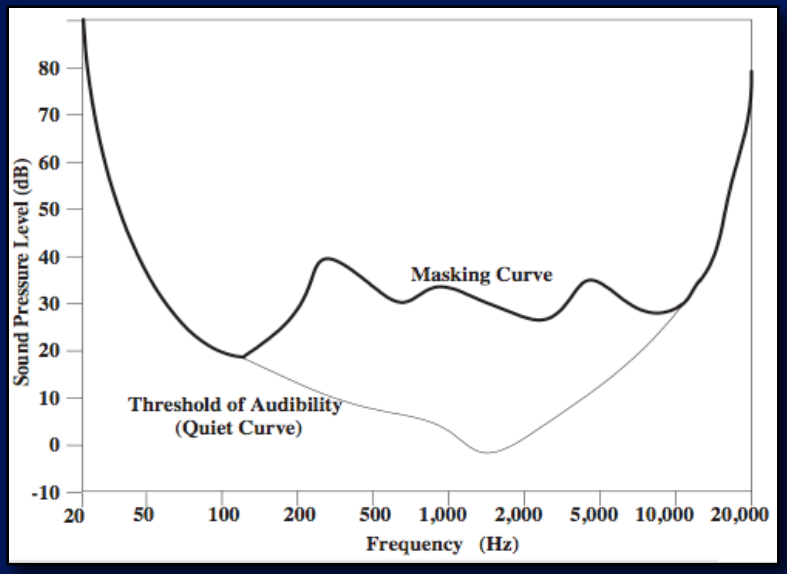

Figure 1: Masking curve example. (Kim 2003)

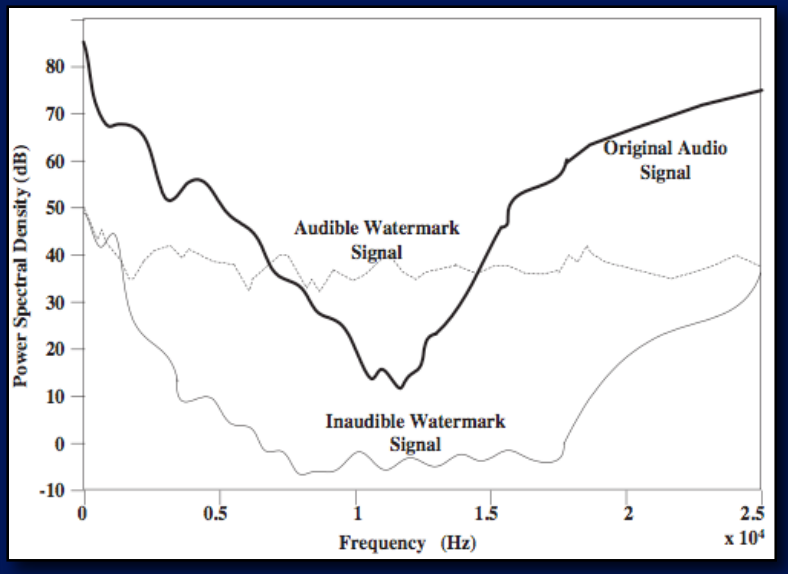

Figure 2: Watermarking shaping example. (Kim 2003)

Techniques

- Spread-Spectrum
  - Spreads pseudo-random sequence across time-domain signal or transform signal
  - Pseudo-random sequence is generated using a secret key
  - Watermark is embedded as a modulation of pseudo-random sequence
  - Watermark is scaled according to a psychoacoustic model

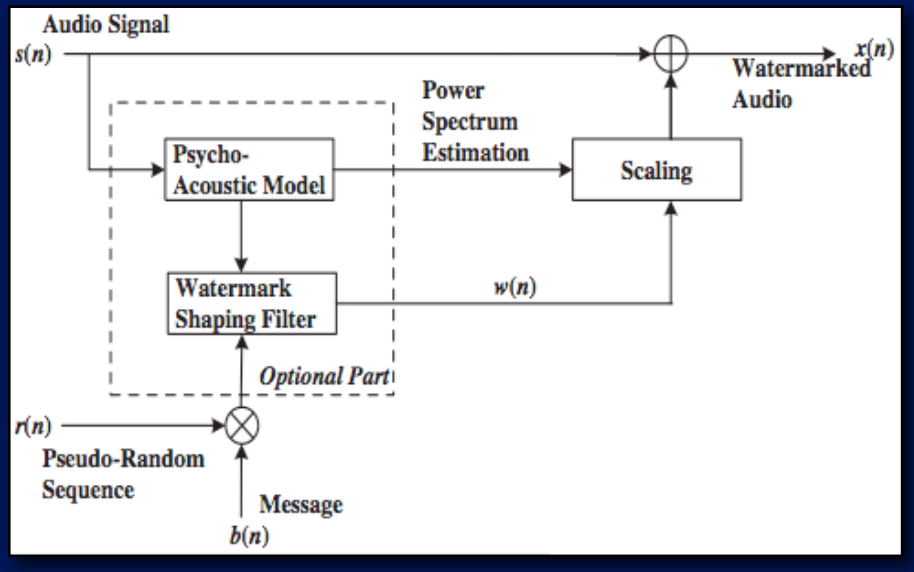

Figure 4: Spread-spectrum scheme. (Kim 2003)

Techniques

- Replica
  - Uses the original signal itself to create the watermark
  - Example: Echo Hiding
    - Introduce echo in time domain
    - Watermark bit values are embedded using 2 different delay values
    - Detection finds delay length used to determine watermark
    - Masking is used
  - Could also be done in frequency domain
    - Example: Frequency shifting

Techniques

- Self-Marking
  - Embed special signal in the audio
  - Example: Embedding a peak in frequency domain

- Two-Set
  - Statistical method based on hypothesis testing and relying on large data sets
  - Pseudo-random process to insert a certain statistic into the audio signal
  - Usually applied in frequency domain
  - Example: Patchwork Algorithm

Applications

- Copyrights
  - Proof of ownership
  - Enforcement of usage policy
- Forensic watermarking
  - Fragile watermarking
  - Fingerprint watermarking
- Information hiding
  - Added value
  - Annotation

Discussion

- Is watermarking really useful? What could it be used for?
- What could be done for copyright protection?

References

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- Kim, H, Y. Choi, J. Seok, and J. Hong. 2004. Audio watermarking techniques. In *Intelligent watermarking techniques,* edited by J. Pan, H. Huang, and L. Jain, 185–219. River Edge, N.J.: World Scientific.