Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Acoustics II: audio watermarking

Kurt Heutschi
2013-01-18

audio watermarking: introduction

audio watermarking: introduction

- idea: hide additional information in the audio data stream
- motivation:
  - for copyright management
  - to proof that an audio signal has not been modified
  - to label the originator
  - to monitor the usage by television or radio
- watermarking techniques are in use today but no details are published

audio watermarking: requirements

audio watermarking: requirements

audio quality, transparency should not affect audio quality, ideal: not audible (= totaly transparent)

capacity high information density of the watermark

robustness not easily detectable for an attacker and insensitive regarding manipulations. Ideal: watermark information remains conserved as long as audio material is of any use.

reliability watermark shall be detectable with high reliability

above requirements can't be maximized all together $\rightarrow$ depending on application an optimum has to be found.

audio watermarking

- ideas for audio watermarks?
- $\rightarrow$ discussion of the requirements
  - transparency
  - capacity
  - robustness

audio watermarking: published methods

audio watermarking: published methods

time domain methods make usage of attributes in the time domain

frequency domain methods attributes in the frequency domain

wavelet domain methods attributes in the wavelet domain

code domain methods attributes in code domains (e.g. MPEG)

audio watermarking: time domain methods

time domain methods: superposition of 'noise'

time domain methods: superposition of 'noise'

- strategy: add suitably modulated signal
  - low level
  - "noise-like character"
- detection process: evaluation of correlation between signal and modulation pattern
- relatively robust, low information density

time domain methods: modulation of the LSB

time domain methods: modulation of the LSB

- modifying the least significant bit in each sample
  - very high information density
  - noise floor is increased by 6 dB
  - extremely sensitive to signal manipulations

time domain methods: addition of 'echoes'

time domain methods: addition von 'echoes'

- make usage of precedence effect of the ear:
  - echo with short delay re. direct sound is inaudible
- level of artificially added echo typically 20. . .40 dB below original signal
- watermark information coded as echo delay (e.g.: 10 ms $\mapsto$ 0, 30 ms $\mapsto$ 1)
- detection by evaluation of autocorrelation function
- method is robust and transparent but information density is low

audio watermarking: frequency domain methods

frequency domain methods: modification of phase

frequency domain methods: modification of phase

- make usage of inaudibility of signal phase:
  - block-wise FFT
  - modification of phase according to watermark information
  - inverse FFT
- high information density but easily destroyable

frequency domain methods: addition of a modulated tone

frequency domain methods: addition of a modulated tone

- make usage of frequency masking of the ear:
  - addition of tones with level below the shifted hearing threshold
  - coding scheme: $f_1 \mapsto 0$, $f_2 \mapsto 1$

frequency domain methods: suppression of frequency bands (notch filter)

frequency domain methods: suppression of frequency bands (notch filter)

- make usage of the limited frequency resolution of the ear:
  - coding process: attenuation of a small frequency band of the audio signal
  - implementation by block-wise FFT, removal of a few lines, inverse FFT
- high transparency, relatively low information density, easily detectable

robustness tests of audio watermarks

robustness tests of audio watermarks

extract of the catalogue *StirMark Benchmark for Audio (SMBA)*:
(attacks with specified parameter setting)

Original	original
Compressor	dynamic compression
Highpass	high-pass filtering
Lowpass	low-pass filtering
Echo	addition of an echo
Reverb	addition of reverberation
Flanger	addition of an echo with variable delay

robustness tests of audio watermarks

Pitchshifter pitch-shifting without modification of the time axis

Timestretcher time stretching without pitch modification

AddNoise addition of white noise

AddSinus addition of a pure tone

CutSamples removal of 7 samples after 1000 samples

CopySamples duplicating every x-th sample

robustness tests of audio watermarks

Exchange	exchange of neighbor samples
LSBZero	set LSB to 0
Normalize	apply maximal amplification without clipping
Resampling	alter the sample rate
Smooth	average over neighbor samples
ZeroCross	set samples with value < 1000 to 0
ZeroRemove	elimination of all samples with value 0

eth-acoustics-2