MPEG-4 Version 2 Audio Workshop:
HILN - Parametric Audio Coding

Heiko Purnhagen

Laboratorium für Informationstechnologie
University of Hannover, Germany
Outline

● Introduction
● What is "Parametric Audio Coding"?
● HILN  -  MPEG-4 Parametric Audio Coding
● Audio Demonstration
● Outlook
Introduction: MPEG-4 Audio Coding

- MPEG-4 Audio Requirements:
  - efficient coding (various content types / bitrates)
  - other functionality (e.g. scalability)

=> Combination of coding techniques required
  - utilise different source and perception models
Introduction: Speech & Audio Coding

- Established coding techniques:
  - Speech coding: Excitation + Resonances (CELP)
    => *source model* extensively exploited
  - Audio coding: Spectral Decomposition (transform coding)
    => *perception model* extensively exploited

=> "waveform" coding techniques
What is "Parametric Audio Coding"?

- Representation of audio signal $x$
  - physical: waveform $x(t)$
  - abstract: musical score (compact, ambiguous)
  => promising approach for efficient audio coding

- Encoding: physical repr. => abstract repr.
  but: automatic transcription to score very difficult !!!

- Audio Coding:
  Compact representation of audio 
  automatically derived from real-world signal
What is "Parametric Audio Coding"?

Some source models for audio signals:

**Model Assumption:**
- (quasi-)stationary
- physically generated
- pure tones
- transients
- noise

**Model Parameters:**
- spectral samples
- excitation + resonances
- freq. & ampl. of sinusoids
- amplitude envelope
- noise spectrum

=> Problem: Choice of source model?

*Efficiency vs. Generality*

(specialised model not suitable for arbitrary signals)
What is "Parametric Audio Coding"?

- **Parametric Audio Coding**
  - combination of different source models
    - decompose audio signal into components
  - utilise perception models
    - pick "most relevant" components

- **Sound** represented by model parameters
  - waveform approximation not necessary

- **Parameter Quantisation and Coding**
  - quant. step size: "just noticeable differences"
  - entropy coding
MPEG-4 Parametric Audio Coding

- MPEG-4 Audio Version 2: HILN
  "Harmonic and Individual Lines plus Noise"

  *harmonic lines*: fundamental freq. & LPC spectrum
  *individual lines*: frequency & amplitude
  [opt.: ampl. envelope, start phase]
  *noise*: LPC spectrum

  => 4 .. 16 kbit/s @ 8 kHz bandwidth (typ.)
MPEG-4 Parametric Audio Coding

Hannover

Perception Model

selection of relevant components

Parametric Audio Encoder (HILN)

Audio Signal

Model Based Decomposition

Parameter Estimation

Parameter Coding

Harmonic Components

Sinusoidal Components

Noise Components

Quant

Quant

Quant

Mux

Bit Stream
MPEG-4 Parametric Audio Coding

**Demo:** HILN 16 kHz mono @ 6 kbit/s

Parametric Audio Decoder (HILN)
MPEG-4 Parametric Audio Coding

- Additional Functionality of HILN
  - Bitrate scalability:
    - base layer (major signal components)
    - enhancement layer(s) (minor signal components)
  - Signal modification in decoder:
    - speed and pitch change (parameter modification)
  - Error Robustness (UEP)

- Integrated Parametric Decoder (HVXC + HILN)
  - Example: speech + background music
    2 kbit/s HVXC + 4 kbit/s HILN = 6 kbit/s
Audio Demonstration

- **Demo:** HILN 16 kHz mono @ 6 kbit/s

- Signal modification in decoder:
  - pitch change +20%
  - speed change +20%

- Comparison of MPEG-4 coding techniques:
  - original (8 kHz bandwidth)
  - speech coding (CELP) 6 kbit/s
  - transform coding (TwinVQ) 6 kbit/s
  - parametric audio coding (HILN) 6 kbit/s
Outlook

- HILN Encoder Optimisation (not normative)
  - improved signal segmentation
    (e.g. tonal / noise discrimination)
  - improved parameter estimation & tracking

- Combination of coding techniques
  - select best coding technique for actual signal
  - segmentation into audio objects
    (e.g. automatic segmentation of speech / music)

... but: *Audio objects are transparent!*
further reading ...

- **Official MPEG Home Page**
  
  [http://www.cselt.it/mpeg/](http://www.cselt.it/mpeg/)

- **MPEG Audio Web Page**
  
  [http://www.tnt.uni-hannover.de/project/mpeg/audio/](http://www.tnt.uni-hannover.de/project/mpeg/audio/)

- **Parametric Audio Coding Bibliography:**
  
  [http://www.tnt.uni-hannover.de/~purnhage/](http://www.tnt.uni-hannover.de/~purnhage/)