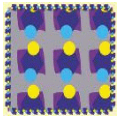

Listening to Perceptual Audio Coders:

Artifacts of Parametric Coding

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AES 112th Convention, München 11-May-2002

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What is Parametric Audio Coding?

- Idea: use “abstract” representation of audio signals (*musical score is more compact than waveform*)
  - decompose input signal into components
  - select appropriate **source models** for components
  - describe components by model *parameters*
  - use **perceptual models** to pick relevant components

  → attractive for very low bitrate coding

- Sound represented by model parameters

  → waveform approximation not necessary

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Examples of Parametric Coders:

- Sinusoidal coding

$$\hat{x}(t) = \sum_{i=1}^{N} a_i(t) \cdot \sin(\varphi_i + 2\pi \int_0^t f_i(\tau)\, d\tau)$$

- Extensions to sinusoidal coding: +noise, +transients

→ various approaches, ongoing research & development

- MPEG-4 HVXC (parametric speech coder)
- MPEG-4 HILN (parametric audio coder)
- Philips parametric audio coder (MPEG proposal, see Paper J2)
- Q-Design QDMC (?)

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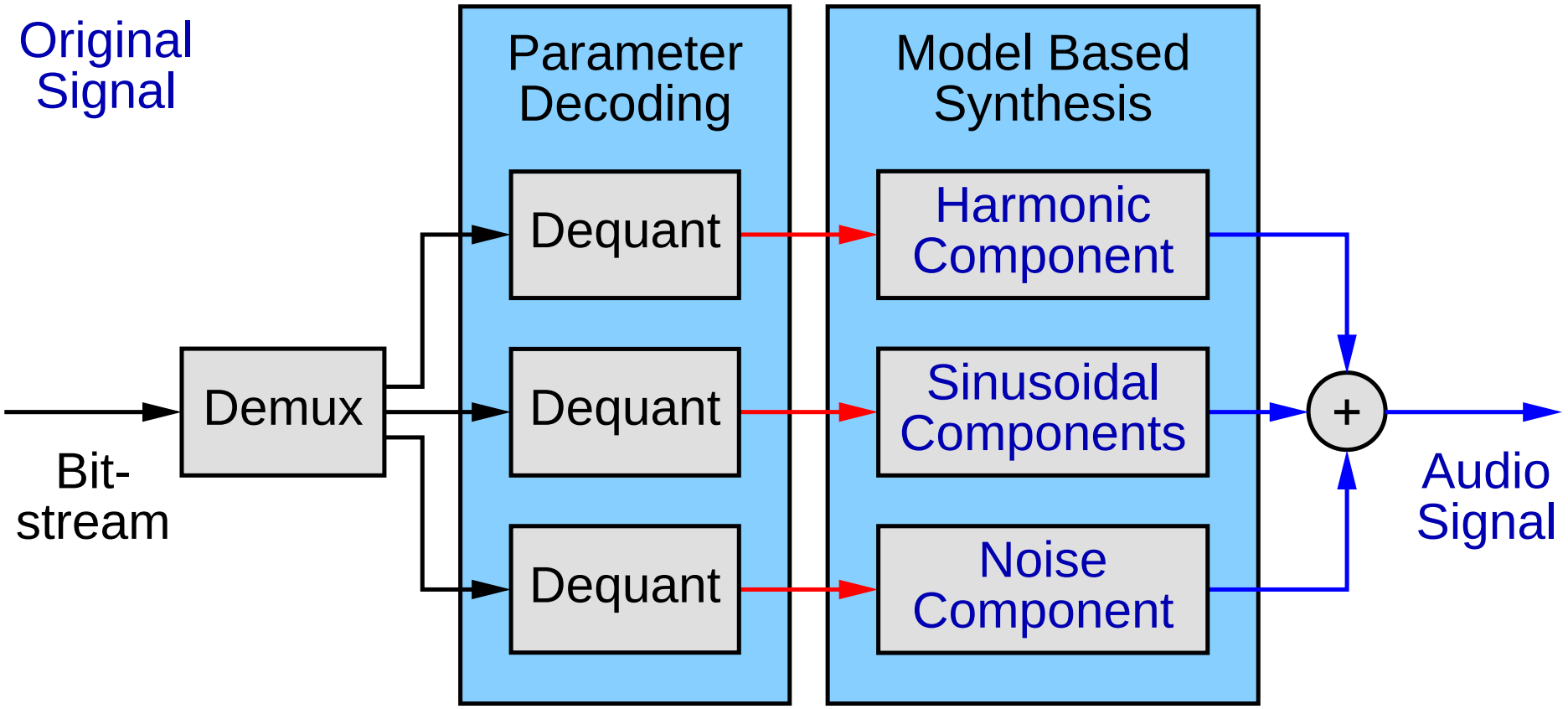
Example: MPEG-4 HILN @ 6 kbit/s (f_s = 16 kHz)



Harmonic and Individual Lines plus Noise (HILN) decoder

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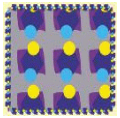

Potential Parametric Coding Artifacts

Potential artifacts related to source models:

- limitations of source models
- bad decomposition (hard decisions are problematic)
- bad parameter estimation

Potential artifacts related to perceptual models:

- quantisation (consider “just noticeable differences”)
- selection of most relevant components
- is phase information irrelevant?
  (transients, clipping in sinusoidal synthesizer)

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Examples of Artifacts

- Parametric coding: no waveform approximation
  → difference signal meaningless
  - original: pop music
  - coded by parametric audio coder
  - difference signal (original-coded)

- Limitations of source models:
  plain sinusoidal coder (no noise and transient model)
  - coded by parametric audio coder
  - coded by sinusoidal coder

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Examples of Artifacts

- Limitations of source models:
  model noise with sinusoids (e.g. applause)
  - original: white noise
  - coded using 0 to 120 sinusoids

- Limitations of source models:
  no model for transient (percussive) components
  - original: castanets
  - coded using sinusoids + noise
  - same, but with amplitude envelopes enabled

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Examples of Artifacts

- Limitations of source models:
  specialised speech model not suitable for music
  - original: speech
  - coded by parametric speech coder
  - original: pop music
  - coded by parametric speech coder

- Bad signal decomposition:
  many sinusoids forced on harmonic grid
  - original: orchestral music
  - coded (harmonic component too strong)

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Summary: Parametric Coding

- attractive for very low bitrate audio coding
- new types of artifacts (sounds “synthetic” ?)
- more chances for “unlucky” decisions in encoder

Outlook: ongoing development

- parametric audio coding is still a young technique
- encoders will improve . . .
- parametric encoding = “auditory scene analysis” ?

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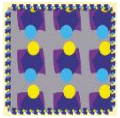

further reading ...

- Parametric Audio Coding Bibliography
  http://www.tnt.uni-hannover.de/~purnhage/
- MPEG Audio Web Page
  (tutorials, test reports, etc.)
  http://www.tnt.uni-hannover.de/project/mpeg/audio/

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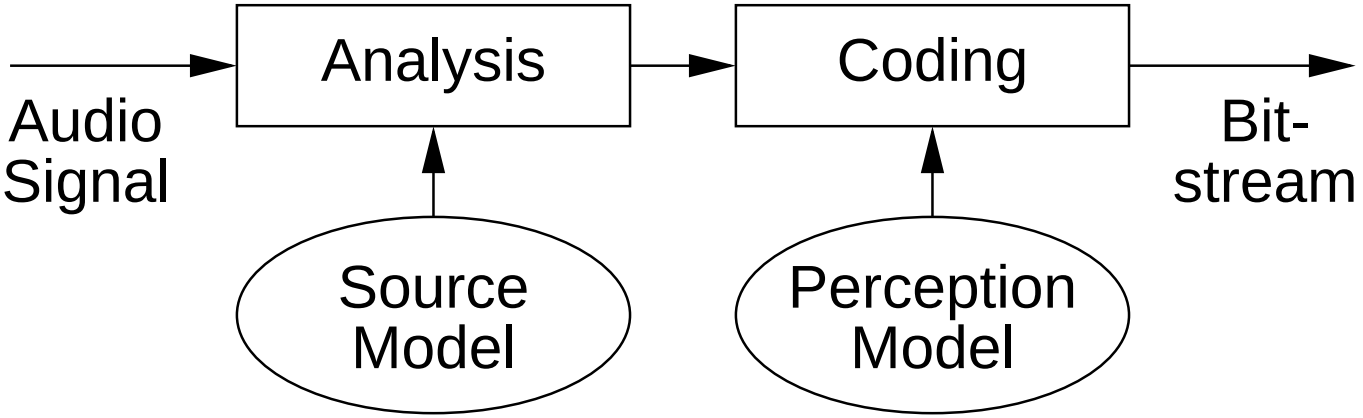
Introduction: Parametric Coding



Established coding techniques:

- Speech coding: Excitation + Resonances (CELP)
  → source model extensively exploited
- Audio coding: Spectral Decomposition (MPEG-1/2)
  → perceptual model extensively exploited

→ waveform coding techniques

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Example: MPEG-4 Parametric Audio Coder HILN

("Harmonic and Individual Lines plus Noise")

Component models and parameters in HILN:

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

Note: non-deterministic decoder behaviour
(noise generator, random start phases)

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