Digital Signal Processing for Music

Part 25: Waveform Coding

alexander lerch

waveform coding
introduction

- **goal**:
  - encode waveform in a way that the decoded waveform is as close to the original waveform as possible

- **approaches**:
  - PCM (analogue to digital)
  - non-linear quantization
    - Question: how is the principle of non-linear quantization related to Entropy coding?
  - **DPCM & ADPCM**

waveform coding
introduction

- **goal**:
  - encode waveform in a way that the decoded waveform is as close to the original waveform as possible

- **approaches**:
  - PCM (analogue to digital)
  - non-linear quantization
    - Question: how is the principle of non-linear quantization related to Entropy coding?
  - **DPCM & ADPCM**

waveform coding
introduction

- **goal**:
  - encode waveform in a way that the decoded waveform is as close to the original waveform as possible

- **approaches**:
  - PCM (analogue to digital)
  - non-linear quantization
    - Question: how is the principle of non-linear quantization related to Entropy coding?
  - **DPCM & ADPCM**

waveform coding
introduction

- **goal**:
  - encode waveform in a way that the decoded waveform is as close to the original waveform as possible

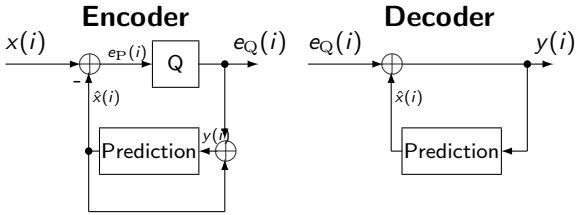
- **approaches**:
  - PCM (analogue to digital)
  - non-linear quantization
    - Question: how is the principle of non-linear quantization related to Entropy coding?
  - DPCM & ADPCM

waveform coding
introduction

- **goal**:
  - encode waveform in a way that the decoded waveform is as close to the original waveform as possible

- **approaches**:
  - PCM (analogue to digital)
  - non-linear quantization
    - Question: how is the principle of non-linear quantization related to Entropy coding?
  - **DPCM & ADPCM**

waveform coding
DPCM



- predictor is updated from **reconstructed signal**
  - **no transmission of predictor coefficients** necessary
  - reconstruction error:

$$\begin{aligned} r(i) &= x(i) - y(i) \\ &= x(i) - (\hat{x}(i) + e_Q(i)) \\ &= e_P(i) - e_Q(i) \\ &= q(i) \end{aligned}$$

$\Rightarrow$ reconstruction error **identical** to quantization error

waveform coding
ADPCM

- ADPCM:
  - coefficient **adaptation for every block of samples**
  - quantization step size (scale) adjusts to signal power

- **forward adaptive** implementation
  - coefficients are *calculated from the input* signal and *transmitted*
  - *robust* against transmission errors
  - requires *additional side information* (coefficients)

- **backward adaptive** implementation
  - coefficients are *calculated from the reconstructed signal*
  - *no additional side information*
  - *error propagation*

waveform coding
ADPCM

- ADPCM:
  - coefficient **adaptation for every block of samples**
  - quantization step size (scale) adjusts to signal power

- **forward adaptive** implementation
  - coefficients are *calculated from the input* signal and *transmitted*
  - *robust* against transmission errors
  - requires *additional side information* (coefficients)

- **backward adaptive** implementation
  - coefficients are *calculated from the reconstructed signal*
  - *no additional side information*
  - *error propagation*

waveform coding
ADPCM

- ADPCM:
  - coefficient **adaptation for every block of samples**
  - quantization step size (scale) adjusts to signal power
- **forward adaptive** implementation
  - coefficients are *calculated from the input* signal and *transmitted*
  - *robust* against transmission errors
  - requires *additional side information* (coefficients)
- **backward adaptive** implementation
  - coefficients are *calculated from the reconstructed signal*
  - *no additional side information*
  - *error propagation*

waveform coding
summary

- waveform coding aims at efficiently representing the time domain signal
- **idea**: non-redundant parts are quantized (lossy) according to transmission bandwidth

- **advantages**:
  - low latency
  - low complexity
  - high quality at high bitrates

- **disadvantage**:
  - quality loss is attempted to minimize waveform similarity

  $\Rightarrow$ not perceptually meaningful

waveform coding
summary

- waveform coding aims at efficiently representing the time domain signal
- **idea**: non-redundant parts are quantized (lossy) according to transmission bandwidth

- **advantages**:
  - low latency
  - low complexity
  - high quality at high bitrates

- **disadvantage**:
  - quality loss is attempted to minimize waveform similarity

  $\Rightarrow$ not perceptually meaningful

waveform coding
summary

- waveform coding aims at efficiently representing the time domain signal
- **idea**: non-redundant parts are quantized (lossy) according to transmission bandwidth

- **advantages**:
  - low latency
  - low complexity
  - high quality at high bitrates

- **disadvantage**:
  - quality loss is attempted to minimize waveform similarity

  $\Rightarrow$ not perceptually meaningful