DPCM - Overview

- Principle of Differential Pulse Code Modulation (DPCM)
- Characteristics of DPCM quantization errors
- Adaptive intra-interframe DPCM
- Conditional Replenishment

Principle of DPCM

\[ e = s - \hat{s} \]
\[ s' = e' + \hat{s} \]
\[ s' - s = e' - e = q \]
Quantization error feedback in the DPCM coder

- Assuming a linear predictor, the DPCM coder is equivalent to the following structure:

\[ \tilde{E}(\Omega) = [1 - P(\Omega)]S(\Omega) \]

- Transfer function of the prefilter:

\[ E'(\Omega) = \tilde{E}(\Omega) + [1 - P(\Omega)]Q(\Omega) \]

Power spectrum of the DPCM quantization error

- Power spectral density of the quantization error \( q \) measured for intraframe DPCM with a 16 level quantizer
Signal distortions due to intraframe DPCM coding

- **Granular noise**: random noise in flat areas of the picture
- **Edge busyness**: jittery appearance of edges (for video)
- **Slope overload**: blur of high-contrast edges, Moire patterns in periodic structures.

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Example of intraframe DPCM coding

- Linear predictor:
  - 0
  - 1/4
  - 1/4
  - 1/2
- Lloyd-Max quantizers
- Fixed-length coding
Interframe coding of video signals

- Interframe coding exploits:
  - similarity of temporally successive pictures
  - temporal properties of human vision
- Important interframe coding methods:
  - Adaptive intra-interframe coding
  - Conditional replenishment
  - Motion-compensated prediction
  - Motion-compensated interpolation

Principle of adaptive intra-interframe DPCM

- Predictor is switched between two states:
  A: Intraframe prediction for moving or changed areas.
  B: Interframe prediction (previous frame prediction) for still areas of the picture.

\[
\hat{S}_{\text{intra}} = a_1 S_1 + a_2 S_2 + a_3 S_3 + a_4 S_4
\]
\[
\hat{S}_{\text{inter}} = S_{20}
\]
Intra-interframe DPCM: feedback adaptation

Coder

Decoder

Intra-interframe DPCM: feedforward adaptation

Coder

Decoder
Conditional replenishment

- Still areas: repeat from frame store
- Moving areas: encode and transmit address and waveform

Change detection

- Example of a pixel-wise change detector
- Example of a block-wise change detector
The “Dirty Window” effect

- Conditional replenishment scheme with change detection threshold set too high leads to the subjective impression of looking through a dirty window.

Crawford noise reduction filter
DPCM - Summary

- DPCM: Prediction from previously coded/transmitted samples (known at transmitter and receiver)
- Typical signal distortions for intraframe DPCM: granular noise, edge busyness, slope overload
- Adaptive Intra-Interframe-DPCM: forward adaptation vs. backward adaptation
- Conditional replenishment: only transmit frame-to-frame changes
- Temporal noise reduction by nonlinear, recursive frame differencing