Interframe coding of video signals

- Adaptive intra-interframe prediction
- Conditional replenishment
- Rate-distortion optimized mode selection
- Motion-compensated prediction
- Hybrid coding: combining interframe prediction and intraframe transform coding
Interframe coding of video signals

... exploits similarity of successive pictures
“It has been customary in the past to transmit successive complete images of the transmitted picture.”

[...]

“In accordance with this invention, this difficulty is avoided by transmitting only the difference between successive images of the object.”
Interframe DPCM

![Diagram of Interframe DPCM]

**Coder**

**Decoder**
Adaptive intra-interframe Prediction

Predictor is switched between two states:

A: Intraframe prediction for moving or changed areas.

\[
\hat{S}_{\text{intra}} = a_1 S_1 + a_2 S_2 + a_3 S_3 + a_4 S_4
\]

B: Interframe prediction (previous frame prediction) for still areas of the picture.

\[
\hat{S}_{\text{inter}} = S_{20}
\]
Intra-interframe DPCM: feedback adaptation

Coder

Decoder
Intra-interframe DPCM: feedforward adaptation

Coder

Decoder

intra-/interframe switching information
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
Example: pixel-wise change detection

Two successive video frames

Change detection mask

[Xinqiao Liu, EE368B class project, 2000]
Crawford noise reduction filter

Diagram showing a block diagram of a noise reduction system with a non-linear component labeled as $f(\delta)$ and a frame store. The input signal is denoted as "noisy video signal" and the output is "clean video signal".
“Dirty Window” effect

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

Moving area picked up by change detector

Moving areas missed by change detector
Rate-distortion optimized mode selection

- How to choose the decision threshold, if distortion $D$ shall be minimized for a given rate $R$?

- Assumptions
  - Blockwise mode selection, block index $i$
  - Additive overall distortion $D = \sum_i D_i$ and rate $R = \sum_i R_i$

- Lagrangian cost function
  \[ J = D + \lambda R = \sum_i D_i + \lambda R_i = \sum_i J_i \]

- Strategy: minimize $J_i$ for each block $i$ separately, using a common Lagrange multiplier $\lambda$
Rate-distortion optimized mode selection (cont.)

- Consider 2 blocks with $D(R) = D_1(R_1) + D_2(R_2)$
- Intra-coding only
Rate-distortion optimized mode selection (cont.)

Interframe replenishment

Intraframe coding

\[ D_1(R_1) \]

\[ D_2(R_2) \]
Motion-compensated prediction

Prediction for the luminance signal $S(x, y, t)$ within the moving object:

$$\hat{S}(x, y, t) = S(x - d_x, y - d_y, t - \Delta t)$$
Combining transform coding and prediction

Transform domain prediction

\[ T \xrightarrow{\cdot} Q \xrightarrow{\cdot} P_T \]

Space domain prediction

\[ T^{-1} \xrightarrow{\cdot} P_T \xrightarrow{\cdot} T^{-1} \]

Combining transform coding and prediction
Motion-compensated hybrid coder
Motion-compensated hybrid decoder

- Control Data
- DCT Coefficients
- Decoder
- Intra-frame Decoder
- Motion-compensated Predictor
- Intra/Inter
- Motion Data
Reading

