Scalable Video Watermarking

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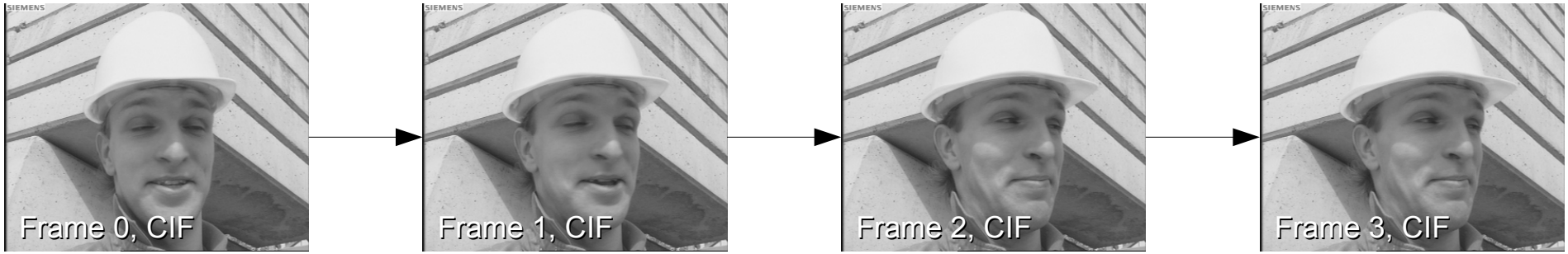
Watermarking

- Watermarking is imperceptible embedding of information into multimedia data [Cox02a]
- Applications: copyright protection, data authentication, fingerprinting, …
- Video pecularities:
  - Need perceptual model for temporal dimension [Watson, Koz05a]
  - Highly correlated data gives rise to collusion attack [Su05a, Doerr05b]
  - Data volume favors compressed-domain embedding, real-time processing

Scalable Video

- Capability to adapt video bitstream to presentation device or transmission conditions
  - SNR or quality scalability
  - Resolution scalability, eg. CIF → QCIF
  - Spatial scalability
  - Temporal scalability, eg. 30 → 15 frames/s

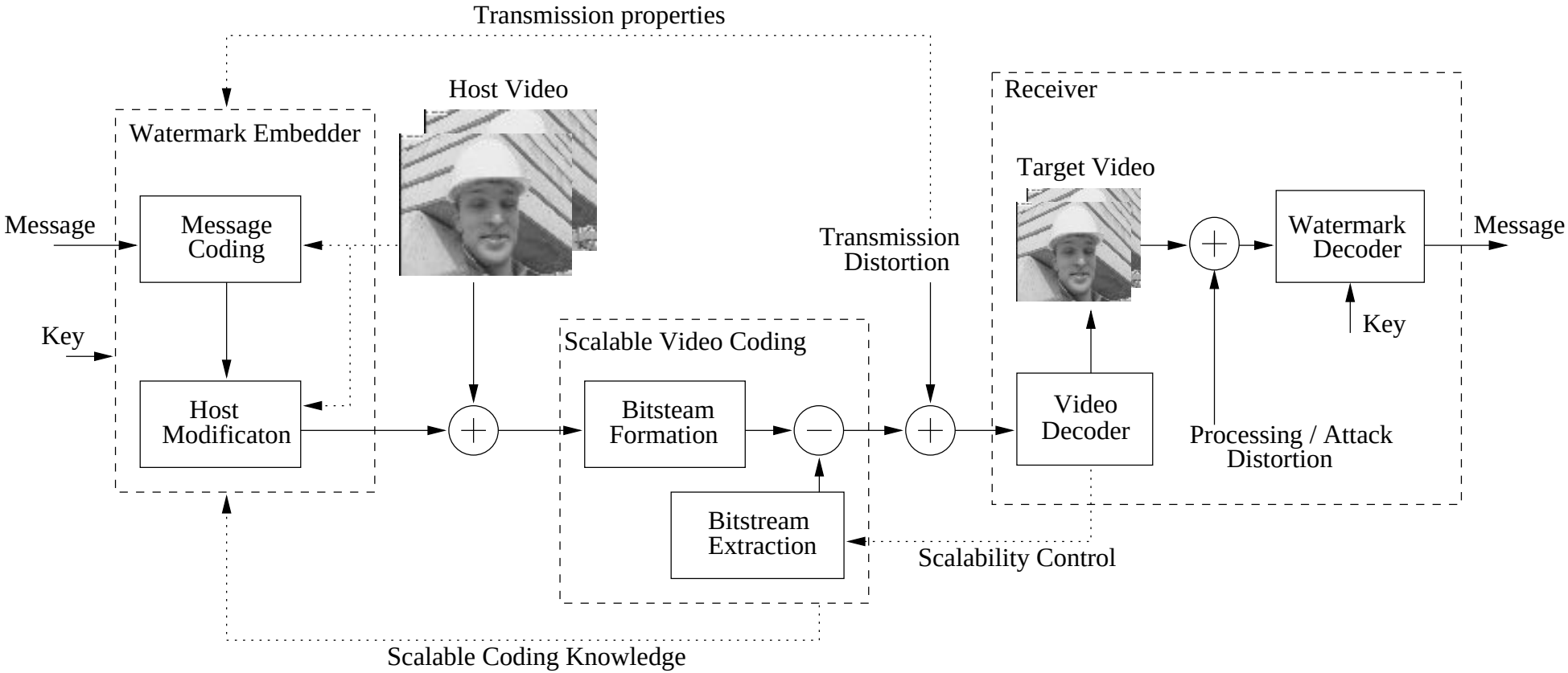


Scalabe Video Codecs

- H.264 SVC extension based on hybrid H.264/AVC codec [Schwarz06a]
  - Resolution layers, quantization refinement (FGS)
  - GOP structure
- MC-EZBC builds on motion-compensated temporal filtering (MCTF) followed by spatial subband decomposition [Ohm05a]
  - Embedded bitstream

Scalable Video Watermarking

Communication channel, detection or decoding problem



Scalable Watermark Properties

[Piper05a]

- Detectability: Watermark is detectable in any portions of the scaled content which is of 'acceptable' quality.
- Graceful Improvement: Increased portions of the scaled content provide reduced error in watermark detection.

A Simple Watermarking Scheme (1)

- Pseudo-random, bipolar sequence (same key for all frames)

$$w_i \in \{-1, 1\}$$

- 3-level spatial DWT decomposition
- Embedding: Perceptually shaped (Watson) embedding in detail subbands

$$v_i = v_i + \alpha s_i w_i$$

- Detection: whitening filter (3x3, high-pass), correlation per decomposition level

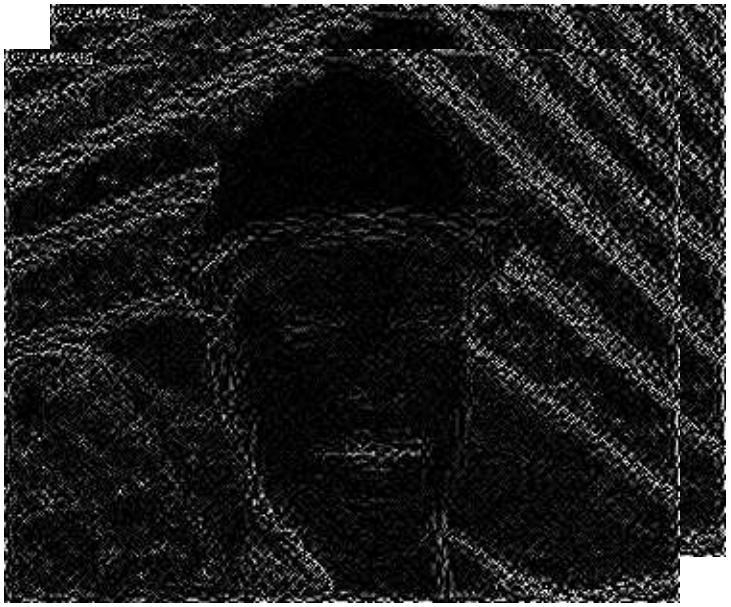
$$c_l = \frac{\tilde{v}\,\tilde{w}}{\|\tilde{v}\|\|\tilde{w}\|} \qquad c = max_l c_l$$

A Simple Watermarking Scheme (2)

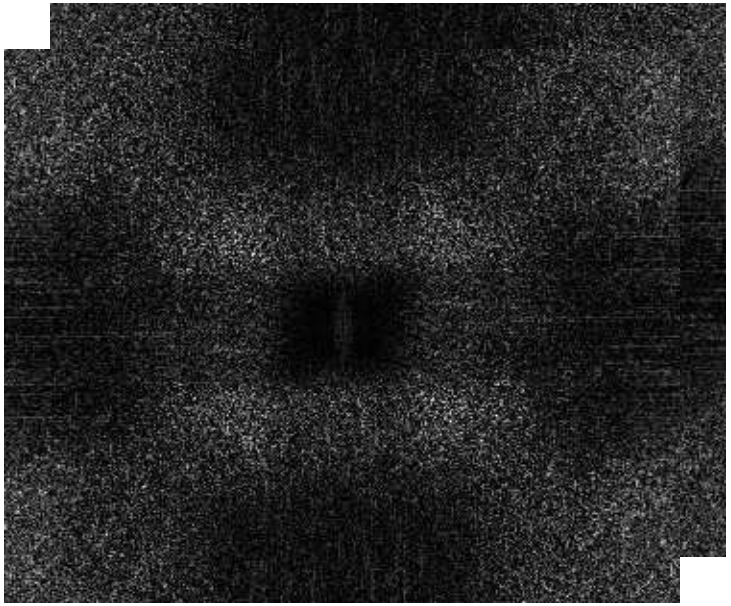
Watermarked Foreman sequence
CIF (352x288, 4:2:0)

PSNR ~35.5 dB

Scheme is called 'DWT'



Spatial domain
difference image



DFT domain
difference image

Scalability Distortion On Watermark

SNR

Quantization

Block Replacement Attack due to motion-compensation (?)

Resolution

Downsampling, synchronization problem

Reduced data rate

Temporal

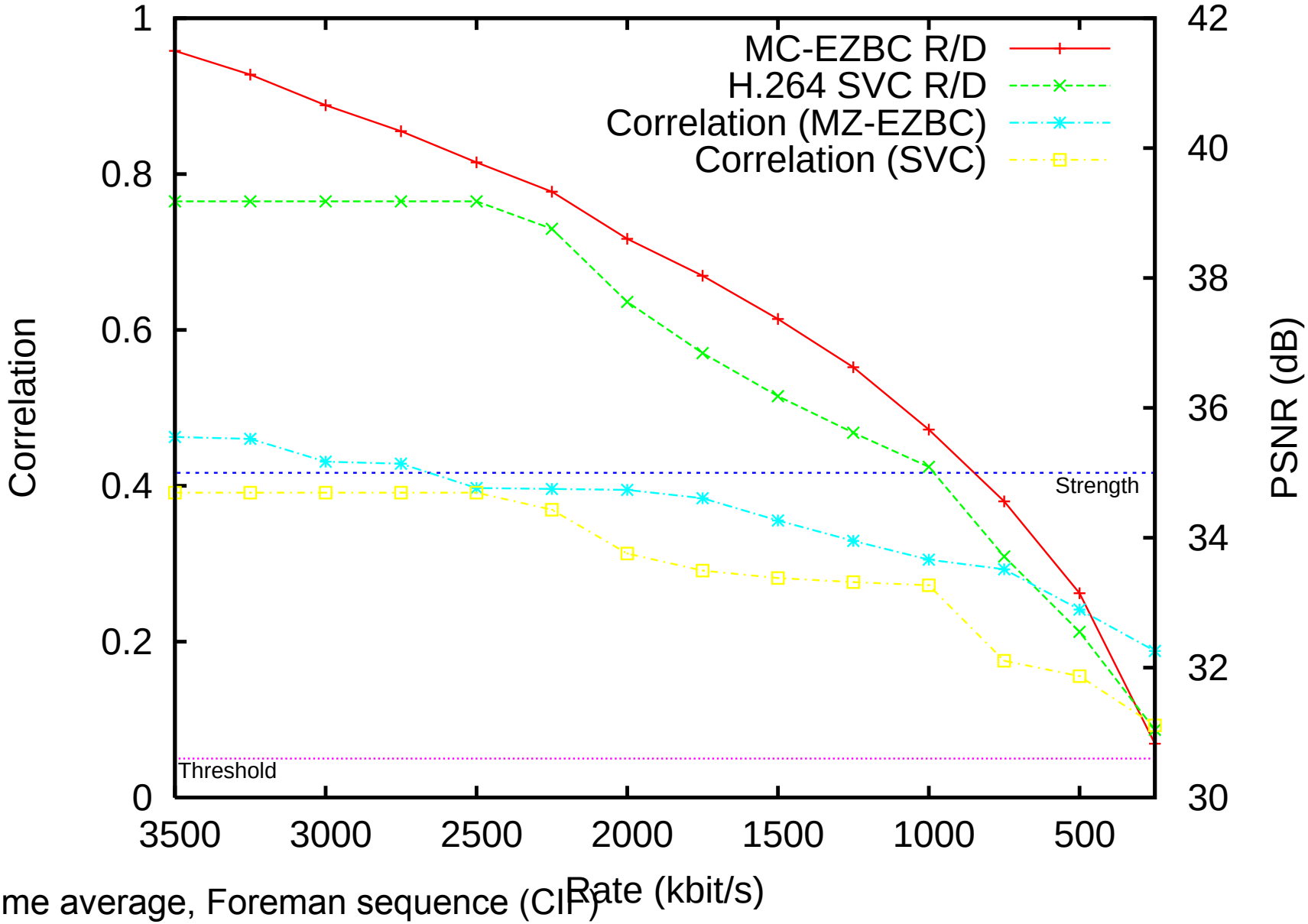
Resynchronization, depending on key-schedule

Reduced data rate

Experiment

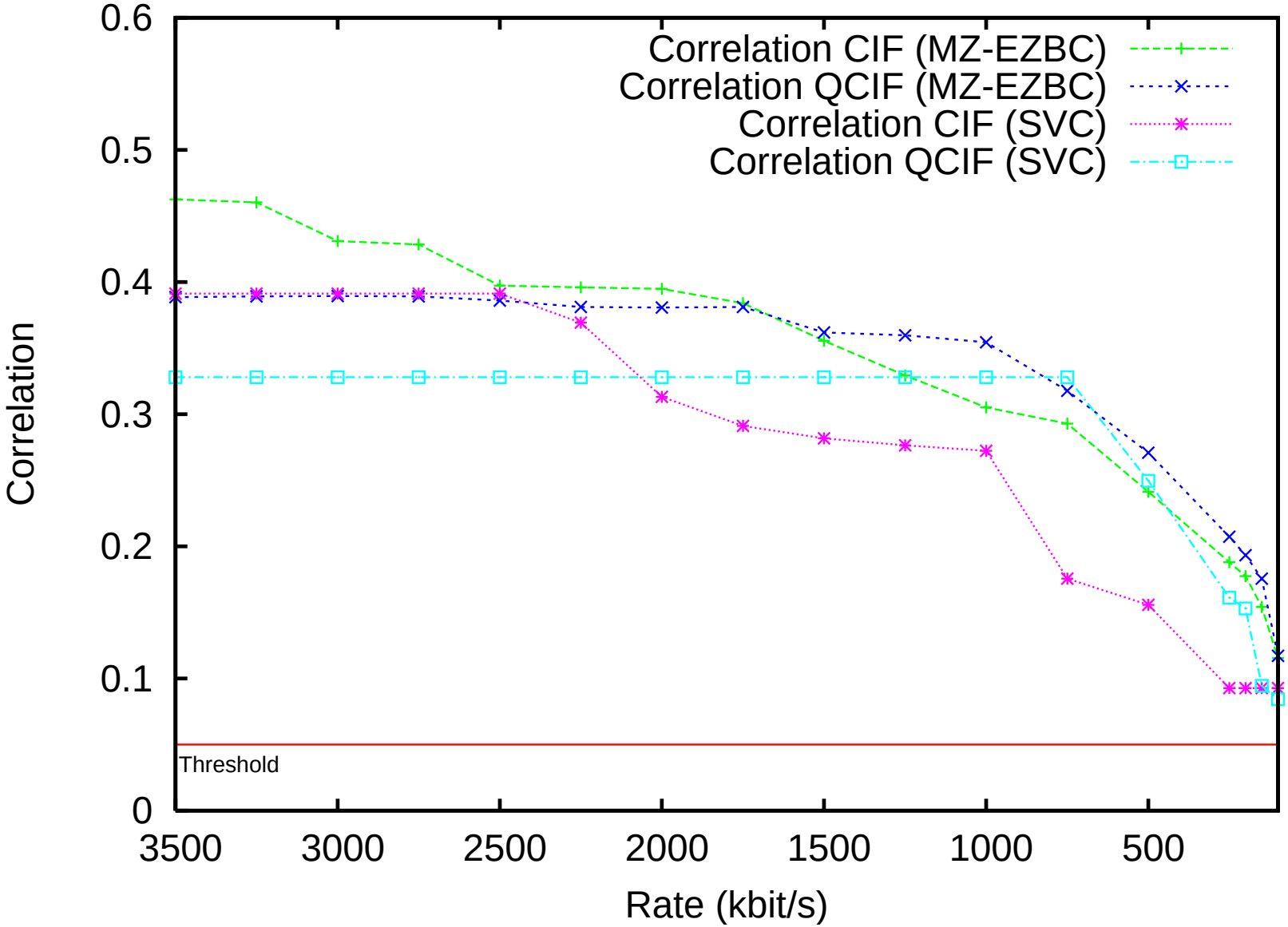
- Embed DWT watermark in first 8 frames of Foreman, PSNR ~35 dB
- Form scalable bitstream
  - H.264/SVC: GOP size 8, 2 resolution layers (QCIF, CIF), 3 FGS layers, QP 40
  - MC-EZBC: 4 level decomposition
- Extract bitstream:
  - `BitStreamExtract <fname> -e <res.>@<frate>:<brate>` (SVC)
  - `pull <fname> -s <res. layer> -r <brate>` (MC-EZBC)
- Decode bitstream & detect watermark

SNR Scalability



8 frame average, Foreman sequence (CIF)

Resolution Scalability



8 frame average, Foreman sequence

Further Investigations

- Implement collusion attacks (TFA, etc.)
- Motion compensation as Block Replacement Attack (BRA) (?)
- Temporal scalability vs. synchronization with key-schedule
- Try quantization-based schemes (QIM, ST-SCS, TCQ)
- Consider authentication application & compressed-domain embedding
- Use temporal transform: 3D-DCT, 3D-DFT, DFT-2D-DCT, t+2D DWT
- Exploit temporal masking, motion-coherent watermarking
- Employ ROC, BER measure instead of correlation

References

- Cox02a, Digital watermarking, Morgan Kaufman, 2002.
- Su05a, Statistical invisibility for collusion-resistant digital video watermarking, IEEE Tr. MM, 7(1):43-51, 2005.
- Koz05a, Oblivious video watermarking using temporal sensitivity of HVS, 961-964, ICIP '05.
- Schwarz06a, Overview of the scalable H.264/MPEG4-AVC extension, ICIP '06.
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- Piper05a, Resolution and quality scalable spread spectrum image watermarking, 79-89, MM-SEC '05.
- Doerr05b, Security issue and collusion attacks in video watermarking, PhD thesis, Univ. of Nice at Sophia-Antipolis, France. 2005.