**Modeling and Optimization of a Systematic Lossy Error Protection System Based on H.264/AVC Redundant Slices**

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**Systematic Lossy Error Protection (SLEP)**

- Analogous to systematic lossy source/channel coding
  - [Shamai, Verdú, Zamir, 1998]
- Wyner-Ziv coding by applying Reed-Solomon codes across H.264/AVC redundant slices
  - [Rane, Baccichet, Girod, 19th JVT mtg, Geneva 2006]

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**Outline**

- SLEP implementation using H.264/AVC redundant slices
- Model for end-to-end rate-distortion performance
- Resilience vs. quality trade-off in SLEP

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**SLEP Using Redundant Slices**

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**RS Encoding Across Redundant Slices**

- Transmit only SLEP slices in Wyner-Ziv bit stream

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RS Decoding Across Redundant Slices

Decode and display in place of lost primary slice

{\text{Regenerated Redundant Slice}}

Recovered Redundant Slice

k

\ldots

n

Distortion in Received Video Packet

After taking expectations of pixel-wise squared errors,

\[ D[i] = (1 - p)D[i - 1] + p \cdot p_{WZ}(D[i - 1] + D_{r} - D_{p}) + p \cdot p_{BC}(D[i - 1] + MSE[i, i - 1]) \]

Model Vs. Experimental Simulation

Resilience vs. Quality Trade-Off in SLEP

For a packet loss probability \( p_{e} \)

- Bit rate of the "best" redundant description:
  
  \[ R_{t} = \min \left( (C - R_{p}) \frac{1 - p_{e}}{p_{e}}, R_{p} \right) \]

- Quality loss due to best redundant description:
  
  \[ \Delta = \frac{R_{t} - R_{p}}{R_{p}} \]
Conclusions

- SLEP achieves graceful trade-off between error resilience and video quality, and mitigates FEC cliff.
- Quality loss from WZ decoding modeled as function of quantization mismatch and extent of error propagation.

Backup (1): Optimization of a SLEP System

For maximum packet loss probability $p_e$, find bit rates for encoding the primary and redundant slices, i.e., $R_p$ and $R_r$, that maximize output picture quality.

Let $R_{FEC}^p, R_{FEC}^r$ be the source coding bit rate and distortion for the optimal FEC scheme.

Maximize $R_p$

subject to

$R_p + \frac{R_r}{1 - p_e} R_r \leq C$

$D_p + \frac{2}{N + 1} R_r (\Delta e - \Delta p) = D_{FEC}$

$0 \leq R_r \leq R_{FEC}^r \leq R_p \leq C$

Backup (2): Resilience vs. Quality Trade-Off

Optimum bit rate of redundant slice [kbps]

Loss from WZ decoding [dB]

Backup (2): Resilience vs. Quality Trade-Off

Maximize $R_p$

subject to

$R_p + \frac{R_r}{1 - p_e} R_r \leq C$

$D_p + \frac{2}{N + 1} R_r (\Delta e - \Delta p) = D_{FEC}$

$0 \leq R_r \leq R_{FEC}^r \leq R_p \leq C$