Power-Rate-Distortion Analysis For Wireless Multimedia Networks - Part II

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Consider wireless transmission of an image of $R$ bits

- energy/bandwidth constraint
- unreliable channel

Goal:

- Minimize energy consumption $P$, given distortion requirement
- Minimize distortion $D$, given the power constraint.

Design parameters:

- the compressed bit rate, $R_s$
- the channel-coded bit rate $R_c$
- the transmission power $P$
Recap: Power-Rate-Distortion Analysis

PRD for compression

- focus: computation energy \( P_s \)
- parameter: \( R_s \),
  - approximate energy model for adaptable compression algorithms
- optional: simplistic model for transmission: \( P_t \propto R_s \)
Recap: Power-Rate-Distortion Analysis

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PRD for transmission
- focus: transmission energy $P_t$
- parameter: $R_c$, $P$
  - mathematical formulation for power-distortion analysis of wireless data transmission
- optional: simple model for compression energy: $P_s \propto R_s$
Recap: Power-Rate-Distortion Analysis

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PRD for joint compression-transmission
PRD for transmission:

- Goal: minimize $P_t$ for a fixed amount of data, $R_s$
- Parameter: channel code rate $R_c$, transmission power $P$

Model:

- Given channel/modulation model
  \[ P \rightarrow \text{BER} \]

- Given channel code type
  \[ \text{BER}, R_c \rightarrow P_e \text{ fail rate} \]

- Given distortion model
  \[ P_e \rightarrow E[D_t] \]

Result: $E[D_t](P, R_c)$, allows optimization of $P, R_c$
Joint source-channel matching for a wireless communications link, [Appadwedula et al., ICC98]

- **Goal**: minimize average distortion under power and rate constraint
- **Parameter**: $R_c, P$

\[
\min_{BEP, r} \mathbb{E}[D] = \sum_{\text{blocks}} D(\text{block})P_e(\text{block})
\]

\[
s.t. \quad P_{\text{tot}} \leq P \quad \text{and} \quad R_{\text{tot}} \leq R
\]
PRD formulation for joint compression-communication is obtained by combining individual components

\[ P_{tot} = P_s + P_t + \ldots \]

\[ D_{tot} = D_s + D_t \]

Various energy models for

- video coding
- channel encoding/decoding
- receiver
Total system energy minimization for wireless image transmission, [Appadwedula et al., 2001, Journal of VLSI signal processing, 2001]

- Goal: minimize total energy of encoding/transmission/receiving
- Parameter: $R_s, R_c, P, C_{rake}, \ldots$

Nonlinear optimization problem, numerical methods.
Power-minimized bit allocation for video communication over wireless channels, [Zhang et al., 2002, CVST 2002],

- **Goal:** \( \min P_{tot}, \text{s.t. } D_{tot} < D \)
- **Parameters:** \( R_c, P, R_s \)
- \( R_s \) controlled by adaptive motion estimation
- Simple model for power consumption in source/channel coding
Power efficient multimedia communication over wireless channels, [Lu et al., 2003, JSAC 2003]

- Goal: \( \min P_{tot}, \text{s.t.} D_{tot} < D \)
- Parameter: \( R_c, P, R_s \)
- \( R_s \) controlled by adaptive I-frame ratio
- Simple model for power consumption in source/channel coding
Related power-rate-distortion analysis for video coding

- More control parameters
  - Block mode selection (intra/inter), adaptive quantization [He et al., 2002]
- Advanced distortion model
  - inter-frame distortion model
  - error-concealment
- Application of PRD
  - Power allocation (frames/blocks)
- Review papers, [Katsaggelos et al., 2005][Etoh and Yoshimura, 2005]


