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

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Wireless Transmission of Image/Video

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: $P_t \propto R_s$

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- 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: $P_s \propto R_s$

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PRD for joint compression-transmission

Power-Rate-Distortion for 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

$$P \longrightarrow \text{BER}$$

- Given channel code type

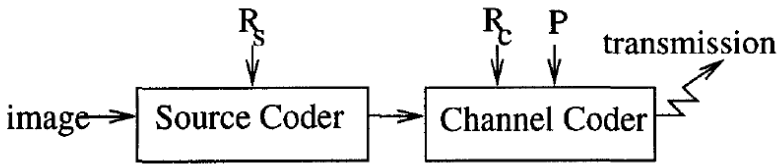
$$\text{BER}, R_c \longrightarrow P_\epsilon \text{fail rate}$$

- Given distortion model

$$P_\epsilon \longrightarrow \text{E}[D_t]$$

Result: $\text{E}[D_t](P, R_c)$, 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

$$\min_{BEP,r} \mathrm{E}[D] = \sum_{blocks} D(block) P_{\epsilon}(block)$$

$$s.t. P_{tot} \leq P$$

$$R_{tot} \leq R$$

Power-Rate-Distortion for compression-communication

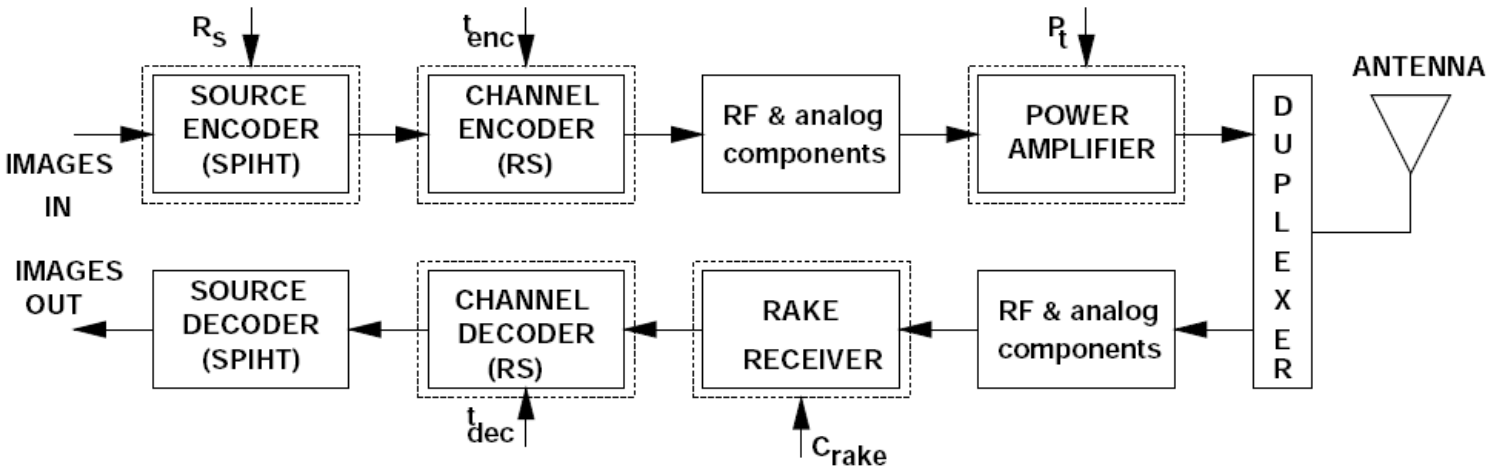
PRD formulation for joint compression-communication is obtained by combining individual components

- $P_{tot} = P_s + P_t + \ldots$
- $D_{tot} = D_s + D_t$

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]



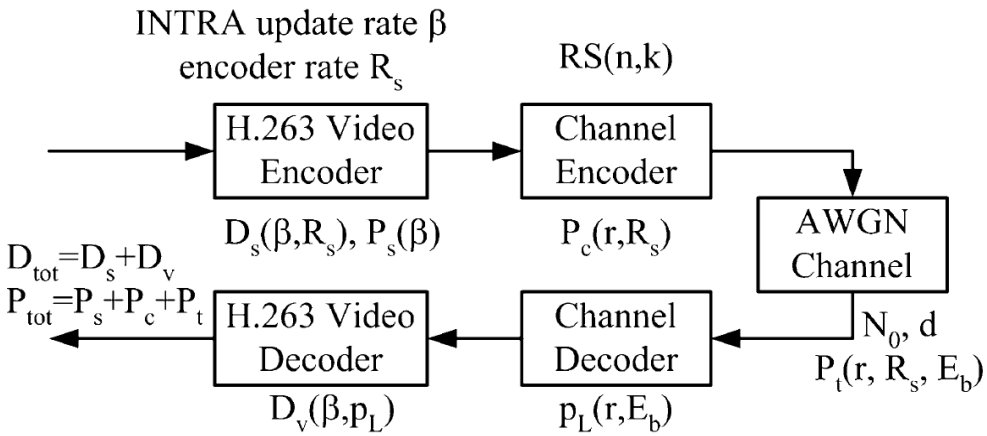
- Goal: minimize total energy of encoding/transmission/receiving
- Parameter: $R_s, R_c, P, C_{rake}, \ldots$

Nonlinear optimization problem, numerical methods.

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

- Goal: $\min P_{tot}, s.t. D_{tot} < D$
- 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 $P_{tot}, s.t. D_{tot} < D$
- 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 paramters
  - 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]

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