Multiple description coding for noisy-varying channels

Manuela Pereira, Marc Antonini, Michel Barlaud
I3S Laboratory of CNRS, University of Nice Sophia Antipolis, {pereira, am, barlaud} @ i3s.unice.fr

Problem: efficient image/video transmission over wireless channels.

Goal: good compression rates and effectiveness in presence of channel failures.

Method: Multiple Description Coding (MDC) scheme based on the 2D/3D scan-based Discrete Wavelet Transform (DWT).

Advantages:
- The transform used allows the generation of a stripe-based MDC that takes into account channel changes in time.
- An efficient model-based bit allocation procedure that dispatches the source redundancy between different channels in function of channel model and state (BER).

MD Bit Allocation and \( r_N \) Estimation

Minimize the central distortion \( D_0 \) for a central rate \( 2R \) while keeping the side distortion \( D_1 < D_s \) and \( D_2 < D_s \).

Formulation with Lagrangian operators proposed in [Ref 1]:

\[
J_{r_1, r_2, 0, 0} (\{q_j\}, R_1, R_2, \mu) = \sum_{n \in N} A \sigma_n (D_0 (q_{n-1}, q_n) + \lambda (R_1 (q_{n-1}) \leq R_1 + \mu) (D_1 (q_{n-1}, q_n) \leq D_1))
\]

\[
D_0 (q_{n-1}, q_n) = \frac{1}{\sigma_n} \left( \min (\sigma_1, \sigma_2) \right) \left( \max (\sigma_1, \sigma_2) \right)
\]

Challenge: design the MDC coder that can automatically adapt the amount of added redundancy according to underlying channel error characteristics.

Proposed solution: adapt redundancy \( r_N \) between the descriptors in function of channel model and state (BER).

Method: Considering the Shannon channel capacity defined as \( C = \max (H(x) - H_s (x)) \), where \( H_s (x) \) is the amount of redundancy that the decoder needs to correct the received message. We define the redundancy parameter as

\[
r_N = \frac{H_s (x)}{\max (H (x))}, \quad r_N \in [0, 1]
\]

- BSC channel: \( r_N = - p \log_2 p - (1 - p) \log_2 (1 - p) \) bits/symbol.
- Gaussian channel (QPSK): \( r_N = 2 \log_2 (1 + \gamma) \) bits/symbol, \( \gamma = S/N \), where \( S \) is the received signal power and \( N \) is the AWGN power within the channel bandwidth.

Results

<table>
<thead>
<tr>
<th>Frame</th>
<th>PSNR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29.41</td>
</tr>
<tr>
<td>11</td>
<td>31.27</td>
</tr>
<tr>
<td>21</td>
<td>34.90</td>
</tr>
</tbody>
</table>

Conclusions

We develop an MDC for noisy-varying channels. The proposed method uses a 3D scan-based DWT that allows the development of a stripe-based MDC. This one is useful to adapt the coder to time varying states.

We introduce a redundancy parameter defining the amount of redundancy that the decoder needs to correct the received message. This redundancy parameter is adapted to the a priori channel model and the current channel state.

We consider BSC and Gaussian channels, but the method is extensible to other channels when its model is known. Most interesting results are found when using channels with memory, where our MDC becomes an alternative to methods using error control schemes as FEC or ARQ.

Ref 1: M. Pereira, M. Antonini, M. Barlaud, “Channel Adapted Multiple Description Coding using Wavelet Transform”, in IEEE ICIP, Rochester, USA, Sept. 2002.

BSC channel at 0.001 BER:
- \( R_1 = 0.25 \) bpp, PSNR = 29.41 dB.
- \( R_2 = 0.5 \) bpp, PSNR = 33.89 dB.

Gaussian channel at 0.001 BER:
- \( R_1 = 0.25 \) bpp, PSNR = 31.27 dB.
- \( R_2 = 0.5 \) bpp, PSNR = 34.90 dB.

SDC Proposed MDC