Multiple Description Image and Video Coding for Noisy Channels

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Supervisor: Prof. Michel Barlaud and Prof. Marc Antonini
1. Multimedia communications

Outline

Problems and requirements;
Classical approaches;
Alternative solution - Multiple Descriptions;
Channel splitting scheme;
MDC: implicit redundancy;
New approach: explicit redundancy;
MDC advantages
MDC problem
Multimedia communications
Problems and requirements

- High bit rates involved with multimedia;
- The scarcity of wireless bandwidth;
- Transmission delay;

Requirement: good compression rates.

- Unreliable channels;
- The time-varying characteristics of the channel;

Requirement: effectiveness in presence of channel failures.
Multimedia communications
Classical approaches

- ARQ - Automatic Repeat reQuest (ensure error-free delivery).
  - introduces additional delay.

- FEC - Forward Error Correction
  - difficulty dealing with burst errors;
  - difficulty adapting to time-varying channel.
Multimedia communications
Alternative solution - Multiple Descriptions

• MD problem was posed by Gersho, Witsenhausen, Wolf, Wyner, Ziv and Ozarow in 1979

“Suppose we wish to send a description of a stochastic process to a destination through a communication network. Assume that there is a chance that the description will be lost. Therefore we send two descriptions and hope that one of them will get through. Each description should be individually good. However, if both get through, then we wish the combined descriptive information to be as large as possible.”

• First theoretical results
  
Multimedia communications
Channel splitting scheme

Trade-off: single description quality - joint descriptions quality
Multimedia communications

MDC: implicit redundancy

- For speech
  - Jayant and Christensen 1981.

- For image
  - Multiple Description Scalar Quantization (1993 - Vaishampayan).
  - Multiple Description Transform Coding.
    * Square-Transform Based (1997 - Wang, Orchard, and Reibman).

These approaches are limited in their ability to adapt to changing transmission conditions.
Multimedia communications


- Level of redundancy can be selected by determining:
  - the number of times a given sample (or wavelet coefficient) is transmitted;
  - how many bits should be used for each of the redundant representations;

- Advantages using bit allocation:
  - the encoder can adjust itself in a simple manner;
  - the decoder do not require any significant changes to its structure;

Provides a very simple mechanisms for adaptation to changing network conditions.
Multimedia communications

MDC advantages

- MDC is robust due to the redundancy of the MD of the same source;
- MDC is scalable as each correctly received description improves the decoder performance;
- MDC does not require prioritized transmission, as each description is independently decodable;
- The new MDC approach provides a very simple mechanisms for adaptation to changing network conditions.
Multimedia communications

MDC problem

- The MDC were created to solve a problem related with packet losses.

“A challenging task is how to design the MDC coder that can automatically adapt the amount of added redundancy according to underlying channel error characteristics”. Y. Wang and Q. Zhu

It is this challenge we consider in the present work.
2. Proposed MDC

Outline

General scheme;
Proposed bit allocation for MDC;
Proposed model based algorithm;
Complete Coding Scheme;
Results - Central PSNR vs. side PSNR for still image;
Conclusions.
Proposed MDC

General scheme
Proposed MDC
MDC scheme

r_N

MDC

Scalar Quantization

Entropy Coder

( R_1 , D_1 )

Wavelet coefficients

MD Bit Allocation

{q_{l,1}}

{q_{l,2}}

Scalar Quantization

Entropy Coder

( R_2 , D_2 )

( R_i , D_m )
Proposed MDC

Proposed bit allocation for MDC

- Problem statement:
  - Two channels MDC,
  - and balanced MDC.

\[
\begin{align*}
\min & \quad D_0 (\{q_{i,1}, q_{i,2}\}) \\
\text{(P)} & \quad \text{Constraints } R_1 \leq \frac{R_T}{2} \text{ and } R_2 \leq \frac{R_T}{2} \\
& \quad \text{Penalty } D_1 \leq D_M \text{ and } D_2 \leq D_M
\end{align*}
\]

Resolution using Lagrange operators
Proposed MDC

Side rate and distortion modeling

\[
J(\{q_{i,1}, q_{i,2}\}) = D_0 + \sum_{j=1}^{2} \lambda_j f(R_j) + \sum_{j=1}^{2} \mu_j g(D_j).
\]

For a source with generalized Gaussian distribution, Parisot 2003 shows

\[
R_j = \sum_{i=1}^{N} a_i R_{i,j}(\tilde{q}_{i,j}), \text{ for all } j \in \{1, 2\}
\]

\[
D_j = \sum_{i=1}^{N} w_i \sigma^2_{i,j} D_{i,j}(\tilde{q}_{i,j}), \text{ for all } j \in \{1, 2\}
\]

with \(\tilde{q}_i = \frac{q_i}{\sigma_i}\).
Proposed MDC

Central distortion modeling

\[ J \left( \{q_{i,1}, q_{i,2}\} \right) = D_0 + \sum_{j=1}^{2} \lambda_j f(R_j) + \sum_{j=1}^{2} \mu_j g(D_j). \]

\[ D_0 = \sum_{i=1}^{N} w_i \sigma_{i,0}^2 D_{i,0} \left( \tilde{q}_{i,1}, \tilde{q}_{i,2} \right). \]

We propose

\[ D_{i,0} \left( \tilde{q}_{i,1}, \tilde{q}_{i,2} \right) = \frac{1}{\sigma_{i,0}^2 r_N + 1} \left[ \min \left( \sigma_{i,1}^2 D_{i,1} \left( \tilde{q}_{i,1} \right), \sigma_{i,2}^2 D_{i,2} \left( \tilde{q}_{i,2} \right) \right) \right. \]
\[ \left. + r_N \times \max \left( \sigma_{i,1}^2 D_{i,1} \left( \tilde{q}_{i,1} \right), \sigma_{i,2}^2 D_{i,2} \left( \tilde{q}_{i,2} \right) \right) \right] \]
Proposed MDC Illustration

Description 1

Description 2

Finely coded subband
Coarsely coded subband
Proposed MDC

Proposed criterion

\[ J \left( \{q_{i,1}, q_{i,2}\} \right) = \sum_{i=1}^{N} w_i \sigma_{i,0}^2 D_{i,0} \left( \tilde{q}_{i,1}, \tilde{q}_{i,2} \right) \]

\[ + \sum_{j=1}^{2} \lambda_j \left( \sum_{i=1}^{N} a_i R_{i,j} \left( \tilde{q}_{i,j} \right) - \frac{R_T}{2} \right) \]

\[ + \sum_{j=1}^{2} \mu_j P_j \]

Side distortion penalty

\[ P_j = \left[ \frac{|D_j - D_M| + (D_j - D_M)}{2} \right]^2, \text{ for all } j \in \{1, 2\} \]
Proposed MDC
Solution of the problem

First order conditions

\[
\begin{align*}
\frac{\partial J(\{q_{i,1},q_{i,2}\})}{\partial q_{i,1}} &= 0, \\
\frac{\partial J(\{q_{i,1},q_{i,2}\})}{\partial q_{i,2}} &= 0, \\
\frac{\partial J(\{q_{i,1},q_{i,2}\})}{\partial \lambda_1} &= 0, \\
\frac{\partial J(\{q_{i,1},q_{i,2}\})}{\partial \lambda_2} &= 0.
\end{align*}
\]
Proposed MDC

System a $2 \times (N + 1)$ equations and $2 \times (N + 1)$ unknowns

\[
\begin{align*}
\frac{\partial D_{i,1}}{\partial R_{i,1}} (\tilde{q}_{i,1}) &= \frac{-\lambda_1 a_i}{w_i \sigma_{i,1}^2 \left( \frac{C_{i,1}}{1+r_N} + \mu_1 E_1 \right)}, \\
\frac{\partial D_{i,2}}{\partial R_{i,2}} (\tilde{q}_{i,2}) &= \frac{-\lambda_2 a_i}{w_i \sigma_{i,2}^2 \left( \frac{C_{i,2}}{1+r_N} + \mu_2 E_2 \right)}, \\
\sum_{i=1}^{N} a_i R_{i,1}(\tilde{q}_{i,1}) - R_T/2 &= 0, \\
\sum_{i=1}^{N} a_i R_{i,2}(\tilde{q}_{i,2}) - R_T/2 &= 0.
\end{align*}
\]

\[C_{i,j} = \begin{cases} 
1, & \text{if } \min(\sigma_{i,1}^2 D_{i,1}(\tilde{q}_{i,1}), \sigma_{i,2}^2 D_{i,2}(\tilde{q}_{i,1})) = \sigma_{i,j}^2 D_{i,j}(\tilde{q}_{i,j}) \\
r_N, & \text{otherwise.}
\end{cases}\]

\[E_j = \begin{cases} 
2 \times (D_j - D_M), & \text{if } D_j > D_M \\
0, & \text{otherwise}
\end{cases}\]
Proposed MDC

C parameter - optimal solution

- Compute the MDBA for all possible combinations;
- Choose the combination that results in the minimal central distortion.

- $N = 10$: $\text{Nb}_{\text{iterations}} = 1024$;
- $N = 40$: $\text{Nb}_{\text{iterations}} = 1099511627776$. 
Proposed MDC

Proposed algorithm for C parameter

Define $\mathcal{S}$ as the set of all possible subbands of description 1 and 2. Perform the following steps:

1. Initialization $C_{i,j} = 1$, for $i = 1..N$ and $j = 1, 2$;
2. $q_{i,j}$, for $i = 1..N$ and $j = 1, 2$;
3. $D_{i,j}(\tilde{q}_{i,j})$, for $i = 1..N$ and $j = 1, 2$;
4. search the subband $k$ in $\mathcal{S}$ with the highest distortion.
5. set the correspondent $C_{k,j}$ value to $r_N$.
6. redefine the set $\mathcal{S}$ as $\mathcal{S} \setminus k$.
7. if $\mathcal{S}$ is not empty, go to step 2.
Proposed MDC

Comparison: Optimal solution vs. Proposed algorithm

- Optimal solution
  - \( N = 10 \): \( \text{Nb iterations} = 1024 \);
    \( \ast \text{PSNR} = 40.39 \text{ dB}, \) for Lena Image at 1 bpp;
  - \( N = 40 \): \( \text{Nb iterations} = 1099511627776 \).

- Proposed algorithm
  - \( N = 10 \): \( \text{Nb iterations} = 10 \);
    \( \ast \text{PSNR} = 40.38 \text{ dB}, \) for Lena Image at 1 bpp;
  - \( N = 40 \): \( \text{Nb iterations} = 40 \).
Proposed model based algorithm

Input
- \( \{C_{i,j}, i = 1..N, j = 1,2\} \)
- \( \lambda_1, \lambda_2 \)
- \( \mu_1, \mu_2, \eta_0 \)
- \( r_N \)

Compute
- \( R_{i,j} \) using (3.40) a) and \( \frac{\partial D}{\partial R} \) function

Is \( f(R_j) \leq 0 \)
- Yes
- No

Compute
- \( q_{i,j} \) from \( R_{i,j} \) and \( R \) function
- \( D_{i,j}(\tilde{q}_{i,j}) \)
- \( D_j \) and \( C_{i,j} \) from \( D_{i,j}(\tilde{q}_{i,j}) \)

\( C_{i,j}^{new} = C_{i,j}^{old} \)
- Yes
- No

Is \( g(D_j) \leq 0? \)
- Yes
- No

Output
- \( \{q_{i,j}, i = 1..N, j = 1,2\} \)
Proposed MDC

Complete Coding Scheme
Proposed MDC

Results - Central PSNR vs. side PSNR for still image

Lena image compressed to 1 bpp
Proposed MDC

Conclusions

- We proposed a MD scheme based on the Discrete Wavelet Transform (DWT) and an efficient bit allocation technique.
- The different MD are defined when setting the bit allocation of each subband. We name it Multiple Description Bit Allocation (MDBA).
- The proposed method with $C_{i,j}$ optimization provides the best results when compared with the best MDC techniques reported to date;
- When noiseless channel the proposed MDC approximates a single description coding (SDC), without channel coding.
3. Redundancy adaptability

Outline

Complete Coding Scheme;
Redundancy parameter estimation;
Estimation of $H_y(x)$;
Channel models and associated redundancies;
MDC for Video;
Conclusions.
Redundancy adaptability
Complete Coding Scheme

\[ R_T, \left( \begin{array}{l} R_1 \\ D_1 \end{array} \right) \]

\[ \text{Scalor Quantization} \rightarrow \text{Entropy Coder} \]

\[ R_T, \left( \begin{array}{l} R_2 \\ D_2 \end{array} \right) \]

\[ \text{Side Decoder} \rightarrow \text{Central Decoder} \]

\[ R_T, \left( \begin{array}{l} R_0 \\ D_0 \end{array} \right) \]

\[ \text{Video Based Scan} \rightarrow \text{DWT} \rightarrow \text{2D / 3D} \]

\[ \text{Estimation} \]

\[ \text{BER} \]

\[ \text{Channel 1} \rightarrow \text{Channel 2} \]

\[ \text{NOISE} \]

\[ \text{Allocation} \]

\[ \text{MD Bit} \]

\[ \text{Estimation} \]

\[ \text{Allocation} \]

\[ \text{MD Bit} \]
Redundancy adaptability

Redundancy parameter estimation

We propose

\[
    r_N = \frac{H_y(x)^*}{\max_p(H(x))}.
\]

- \( r_N = 0 \) when the channel is noiseless.
- \( r_N = 1 \) when a very noisy channel is expected.

How to estimate \( H_y(x) \)?

* “The equivocation \( H_y(x) \) is the amount of redundancy that the decoder needs to correct the received message.” Shannon 1948.
Redundancy adaptability

Estimation of $H_y(x)$

Proposition 1

$$\min_{p(x)}(H_y(x)) \leq \max_{p(x)}(H(x)) - C \leq \max_{p(x)}(H_y(x))$$

$p(x)$ distribution of the input channel symbols;

$H(x)$ entropy of the input;

$C$ channel capacity: $C = \max_{p(x)}(H(x) - H_y(x))$; $0 \leq C \leq \max_{p(x)}(H(x))$.

We propose to use

$$r_N = \frac{\max_{p(x)}(H(x)) - C}{\max_{p(x)}(H(x))}.$$
Redundancy adaptability

Channel models and associated redundancies

Binary symmetric channel

\[ r_N = p \log_2 p + (1 - p) \log_2 (1 - p) \]

- \( C = 1 + p \log_2 p + (1 - p) \log_2 (1 - p) \), bits/symbol.

Additive white Gaussian noise channel

\[ r_N = 1 - \frac{B \log_2 (1 + \frac{S}{N})}{2}, \text{ for a QPSK modulation} \]

- \( \frac{C}{B} = \log_2 (1 + \gamma) \), bits/symbol; \( B \) is the channel bandwidth in symbol/s; \( \gamma = \frac{S}{N} \), where \( S \) is the received signal power and \( N \) is the AWGN power within the channel bandwidth.

Rayleigh channel

\[ r_N = 1 - \frac{B \log_2 e. e^{-\frac{N}{S}} (-e + ln \frac{S}{N} + \frac{N}{S})}{2}, \text{ for a QPSK modulation} \]

- \( \frac{C}{B} \approx \log_2 e. e^{-\frac{1}{\gamma}} (-e + ln \gamma + \frac{1}{\gamma}) \), bits/symbol  \quad \text{(Lee’s).} \]
4. MDC for video

Coder characteristics

- Add a 1D DWT in the time direction to the 2D DWT. This is named a 3D DWT.
- Without motion compensation.
- The 3D scan-based DWT transform allows us to adapt the redundancy parameter to time varying states.
MDC for video

Gaussian channel simulations - 0.001 ber

QCIF silent color video compressed to 200 kbits/s (30 frames/s).

<table>
<thead>
<tr>
<th></th>
<th>Y BER</th>
<th>U BER</th>
<th>V BER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>$10^{-3}$</td>
<td>0</td>
</tr>
<tr>
<td>Proposed Method</td>
<td>33.17</td>
<td><strong>31.50</strong></td>
<td>40.72</td>
</tr>
<tr>
<td>SDC + TC</td>
<td>-</td>
<td>28.66</td>
<td>-</td>
</tr>
</tbody>
</table>

Mean PSNR results

The proposed MDC provides a gain of 3 dB over a standard method using SDC+TC.
MDC for video

Gaussian channel simulations - 0.001 ber

QCIF silent color video compressed to 200 kbits/s (30 frames/s)

SDC + Turbo Codes.

Proposed MDC.
MDC for video

UMTS channel simulations - 0.001 ber

QCIF silent color video compressed to 200 kbits/s (30 frames/s).

<table>
<thead>
<tr>
<th>Channel</th>
<th>Method</th>
<th>Y BER</th>
<th>10^{-3}</th>
<th>U BER</th>
<th>10^{-3}</th>
<th>V BER</th>
<th>10^{-3}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor UMTS</td>
<td>SDC+TC</td>
<td>28.66</td>
<td>28.66</td>
<td>36.50</td>
<td>36.50</td>
<td>38.12</td>
<td>38.12</td>
</tr>
<tr>
<td></td>
<td>Proposed MDC</td>
<td>31.54</td>
<td>30.08</td>
<td>39.11</td>
<td>39.07</td>
<td>40.09</td>
<td>40.09</td>
</tr>
<tr>
<td>Pedestrian UMTS</td>
<td>SDC+TC</td>
<td>28.66</td>
<td>28.66</td>
<td>36.50</td>
<td>36.50</td>
<td>38.12</td>
<td>38.12</td>
</tr>
<tr>
<td></td>
<td>Proposed MDC</td>
<td>31.54</td>
<td>31.45</td>
<td>39.11</td>
<td>38.99</td>
<td>40.09</td>
<td>40.04</td>
</tr>
<tr>
<td>Vehicular UMTS</td>
<td>SDC+TC</td>
<td>28.66</td>
<td>28.66</td>
<td>36.50</td>
<td>36.50</td>
<td>38.12</td>
<td>38.12</td>
</tr>
<tr>
<td></td>
<td>Proposed MDC</td>
<td>31.54</td>
<td>31.45</td>
<td>39.11</td>
<td>39.04</td>
<td>40.09</td>
<td>40.06</td>
</tr>
</tbody>
</table>

Mean PSNR (dB) results.
MDC for video

UMTS channel simulations - 0.001 ber

QCIF silent color video compressed to 200 kbits/s (30 frames/s)

SDC + Turbo Codes.

Proposed MDC.
MDC for video

Internet channel simulations - 5 % packet loss

QCIF Foreman color video compressed at 200 Kbps (30 frames/s)

SDC.

Proposed MDC.
MDC for video

Conclusions

- Redundancy parameter estimation uses channel characteristics;
- The MDBA automatically adapt the amount redundancy to channel characteristics;
- MDBA extension to video by adding to the 2D DWT a 1D DWT in the time direction.
- The 3D scan-based DWT transform allows automatic adaptation of the coding process to time varying states.
- The proposed MDBA is suitable for video transmission over time-varying channels.
5. MDC for Quincunx

Outline

Quincunx images;

MDBA for quincunx images;

Taking account of CCD captors redundancies;

Proposed criterion;

Satellite simulator;

Results;

Conclusions.
MDC for Quincunx
Quincunx images

Combining a pair of CCD linear arrays in a quincunx arrangement to improve image resolution. Each CCD linear array generates an image sampled on a square grid.

Figure 1: Representation of the two CCD linear arrays of a SPOT5 type acquisition system.

Figure 2: Combination of a pair of CCD linear arrays in a quincunx arrangement
MDC for Quincunx
MDBA for quincunx images
MDC for Quincunx
Taking account of CCD captors redundancies

![Diagram of MDC for Quincunx]

- CCD1
- CCD2
- MD Bit Allocation
- Coder Channel 1
- Coder Residual
- Coder Channel 2
- Multiplexing
- De-multiplexing
- CHANNEL
- Decoder

**Description 1**
\( (R_1, D_1) \)

**Central description**
\( (R_0, D_0) \)

**Description 2**
\( (R_2, D_2) \)
MDC for Quincunx

Proposed Criterion

\[ J \left( \{q_{i,1}, q_{i,2}, q_{i,\epsilon}\} \right) = D_0 + \sum_{j=1}^{2} \lambda_j \left( R_j - R_T/2 \right) \]

\[ D_0 = \sum_{i=1}^{N} w_i \sigma_{i,0}^2 D_{i,0} (\tilde{q}_{i,1}, \tilde{q}_{i,2}, \tilde{q}_{i,\epsilon}) \]

We propose

\[ D_{i,0} (\tilde{q}_{i,1}, \tilde{q}_{i,2}, \tilde{q}_{i,\epsilon}) = \frac{1}{\sigma_{i,0}^2} \left[ \left( \sigma_{i,1}^2 D_{i,1} (\tilde{q}_{i,1}) + \sigma_{i,2}^2 D_{i,2} (\tilde{q}_{i,2}) \right) + \sigma_{i,\epsilon}^2 \frac{2r_N}{1 + r_N} D_{i,\epsilon} (\tilde{q}_{i,\epsilon}) \right] \]

Total side distortion for channel \( j \)

\[ D_j = \sum_{i=1}^{N} \left[ \sigma_{i,j}^2 D_{i,j} + (\sigma_{i,j}^2 D_{i,j} + \sigma_{i,\epsilon}^2 D_{i,\epsilon}) \right], \quad j = 1, 2. \]
MDC for Quincunx

Satellite simulator

- As satellite channel simulator we use the model proposed by Chee and Sweeney for LEO satellite channels, that is three-good state, single error state Frichman model.
MDC for Quincunx
Simulations

- Proposed method:
  - We use two $352 \times 352$ pixels dyadic Nimes image;
  - For spatial decomposition, the coder uses 9-7 biorthogonal filter and performs three levels of decomposition.

- MDBA method:
  - We use a $352 \times 704$ pixels quincunx Nimes image generated interleaving by two dyadic image;
  - For spatial decomposition, the coder uses (6,2) nonseparable lifting scheme and performs seven levels of decomposition.
MDC for Quincunx

Simulations - MDBA vs. proposed MDC for quincunx images

<table>
<thead>
<tr>
<th></th>
<th>Side PSNR</th>
<th>Central PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2 bpp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard method</td>
<td>32.71</td>
<td>40.26</td>
</tr>
<tr>
<td>Proposed method</td>
<td>31.29</td>
<td>38.74</td>
</tr>
<tr>
<td><strong>3 bpp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard method</td>
<td>33.04</td>
<td>42.27</td>
</tr>
<tr>
<td>Proposed method</td>
<td>31.62</td>
<td>38.82</td>
</tr>
</tbody>
</table>

Table 1: PSNR values for *Nimes* image when considering transmission at an elevation angle of 40° (0.0005 ber).

<table>
<thead>
<tr>
<th></th>
<th>Side PSNR</th>
<th>Central PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2 bpp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard method</td>
<td>33.92</td>
<td>37.76</td>
</tr>
<tr>
<td>Proposed method</td>
<td>31.88</td>
<td>39.48</td>
</tr>
<tr>
<td><strong>3 bpp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard method</td>
<td>32.77</td>
<td>39.60</td>
</tr>
<tr>
<td>Proposed method</td>
<td>31.84</td>
<td>40.12</td>
</tr>
</tbody>
</table>

Table 2: PSNR values for *Nimes* image when considering transmission at an elevation angle of 30° (0.001 ber).
MDC for Quincunx
Side Description

Quincunx image compressed to 2bpp. Transmission: 0.001 ber

MDBA

New MDC
MDC for Quincunx

Central Description

Quincunx image compressed to 2bpp. Transmission: 0.001 ber

MDBA

New MDC
MDC for Quincunx

Conclusions

• We proposed a MDC designed to get the best image quality after transmission over satellite channel;

• The proposed MDC take into account the redundancy between the two CCD;

• We adapted the MDBA for quincunx images.

• The proposed MDC for quincunx images over performs the MDBA for high levels of noisy channel.
6. General conclusions and perspectives

General conclusions

- We proposed a new MDC based on bit allocation - MDBA;
- The bit allocation algorithm dispatches the redundancy between the descriptions;
- MDBA can adapt automatically to time varying networks;
- MDBA show good performances for different transmission channels involving image or video: Gaussian, UMTS, Internet.
- We present an adaptation to quincunx images and applied it for satellite channels;
- MDBA is comparable to the SDC when noiseless channels;
- MDBA performances are comparable or better than other MDC;
- MDBA is comparable to Turbo Codes for stationary channels;
Perspectives

- Generalization of the MDBA to N descriptions;
  - How to dispatch redundancy in this case?

- Consider motion compensation for video;

- Take into account a real UMTS channel model;

- Video streaming.
Figure 3: *Lena* image coded at 1.0 bpp. BSC channel at 0.001 ber. PSNR=33.89 dB.

Figure 4: *Lena* image coded at 1.0 bpp. Gaussian channel at 0.001 ber. PSNR=34.90 dB.

Figure 5: Original *Lena* image.