Bit Plane

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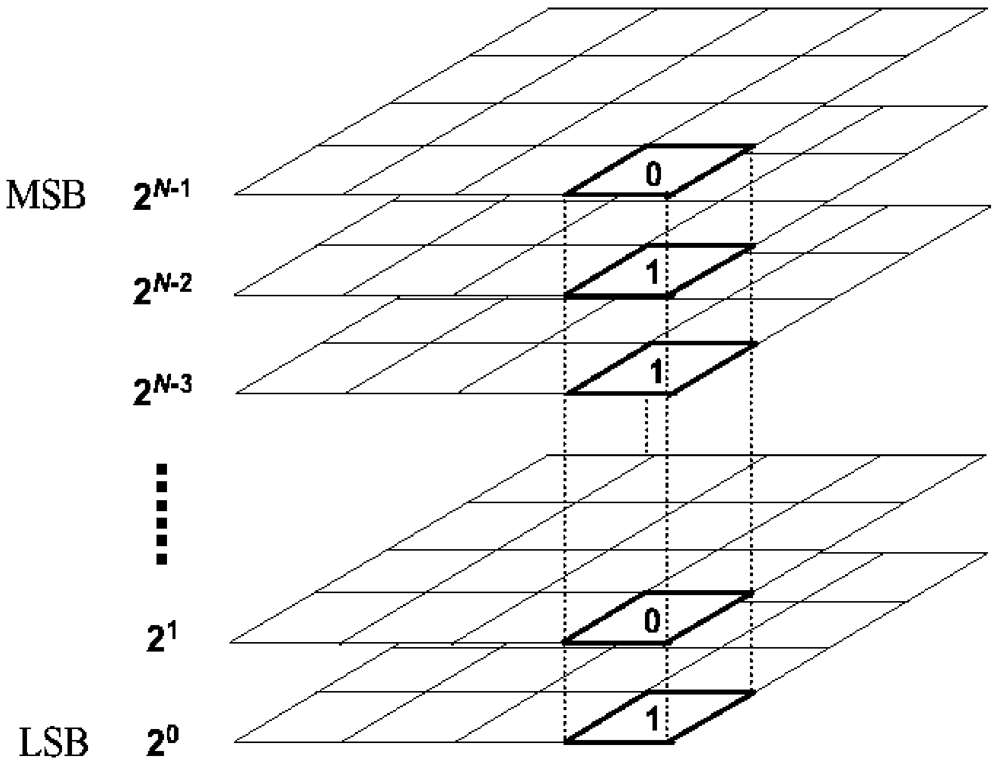
Bit-plane

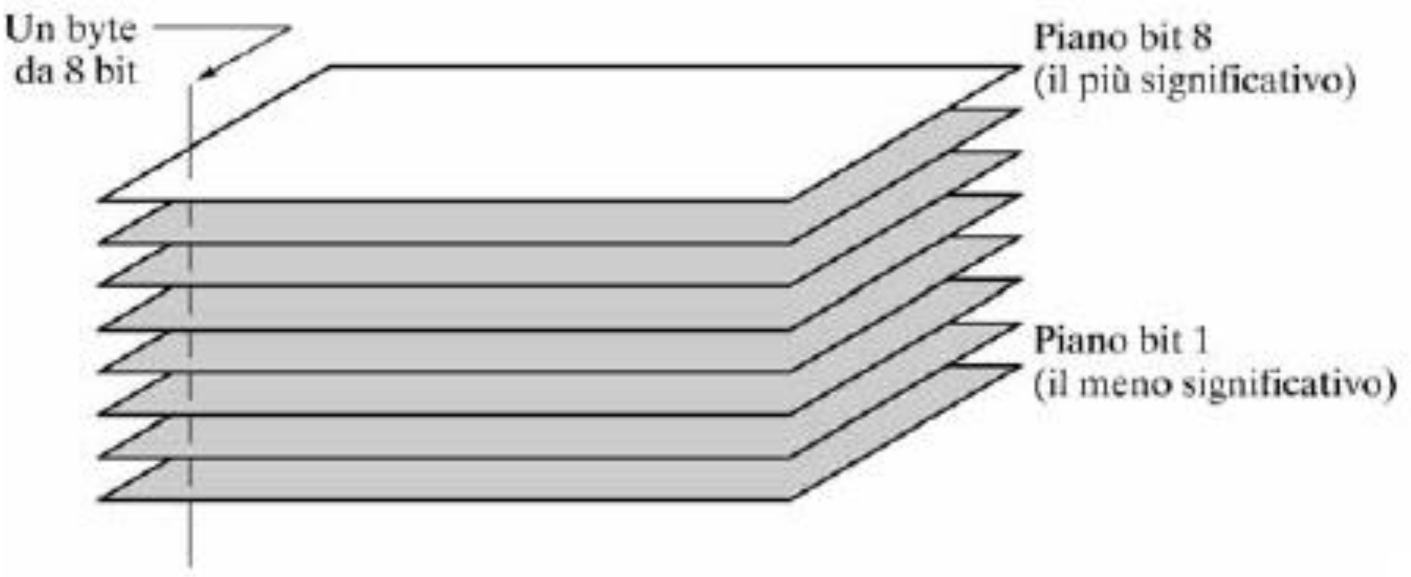
An image with a color depth of N bits can be represented by N bit planes (bit-planes), each of which can be viewed as a single binary image.

In particular, an order ranging from **Most Significant Bit** (MSB) to **Least Significant Bit** (LSB) can be induced.

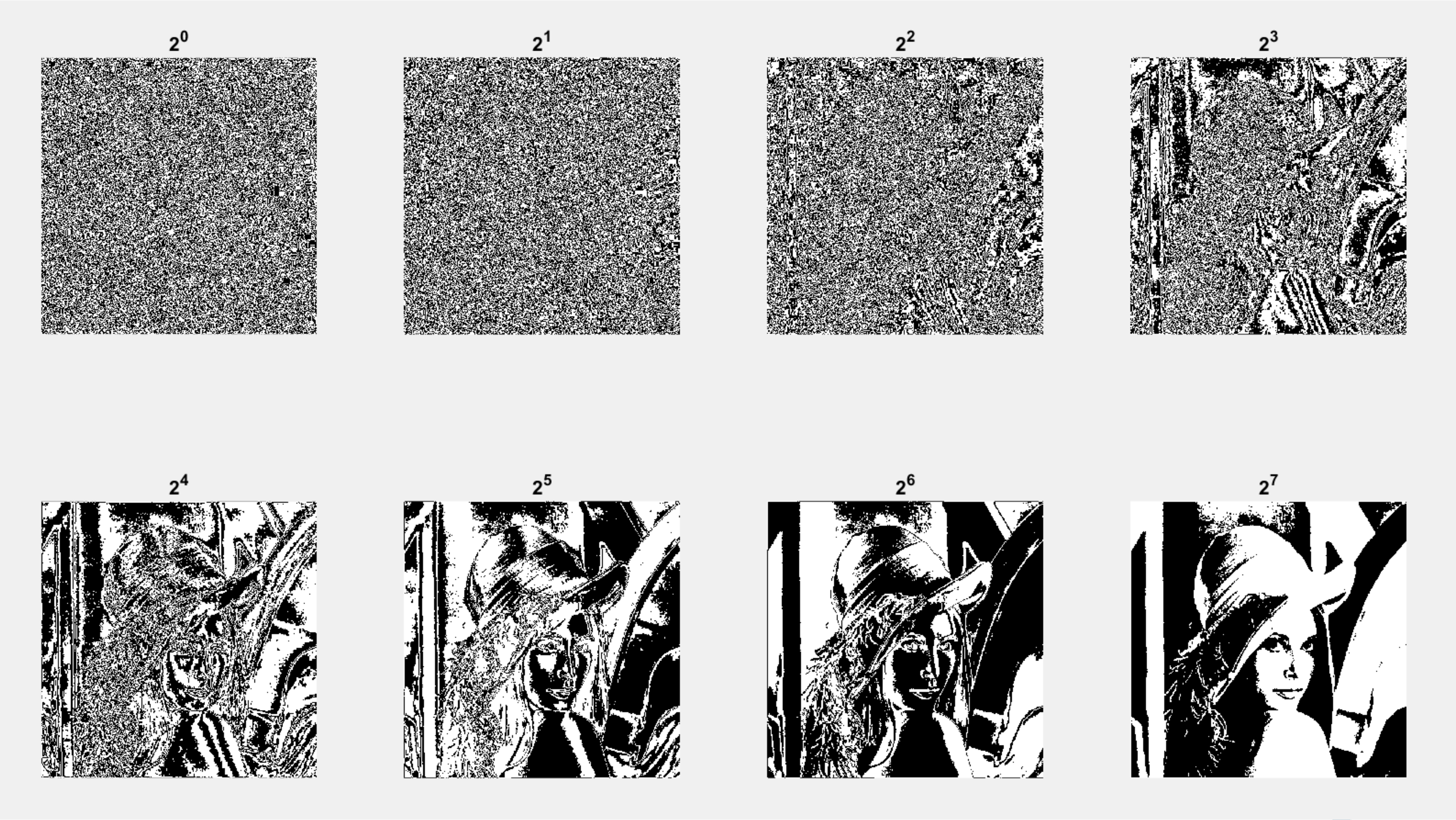


Bit-plane - Definition

The bit plane of an N-bit digital image, is a set of N binary images (planes), in which the i-th image contains the values of the i-th bit of the chosen encoding.



Lena's Bit plane



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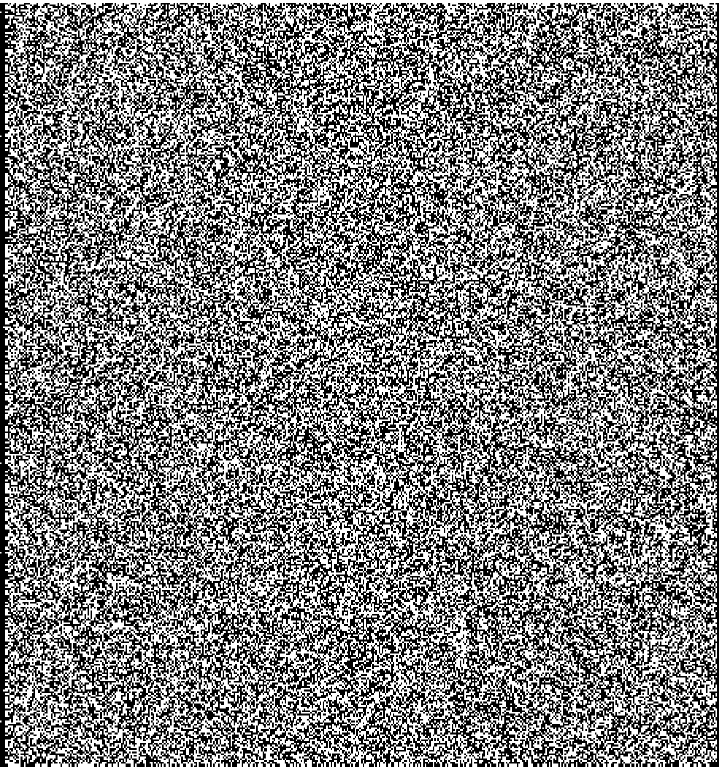
Bit-planes - binary encoding

Most Significant bit (**MSB**)



Least Significant bit (**LSB**)

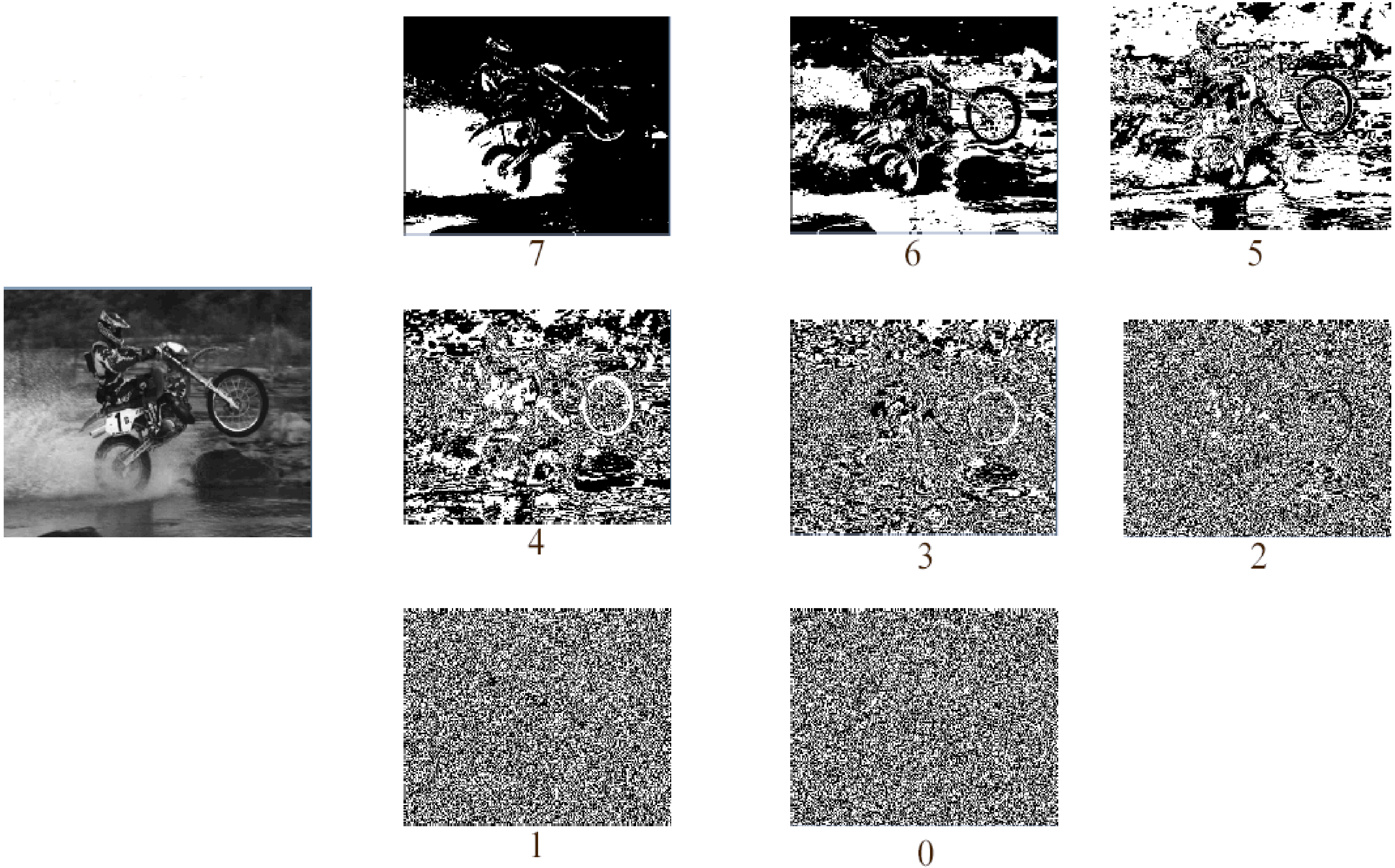
Bit-planes: Osservazioni

- The more significant bit planes contain information about the structure of the image, while the progressively less significant bit planes provide the increasingly smaller details.

- Note that only planes 7 through 3 contain visually significant data.

- Image noise and acquisition errors are most evident in the lower planes.

Bit-planes



Uses of bit-planes

- This kind of decomposition is very useful for removing all values within a certain range.

- For example, if one wants to remove all grays between 32 and 64, it is necessary to set the fifth bit to 0, and thus all of plane 5.

Bit-plane - Example

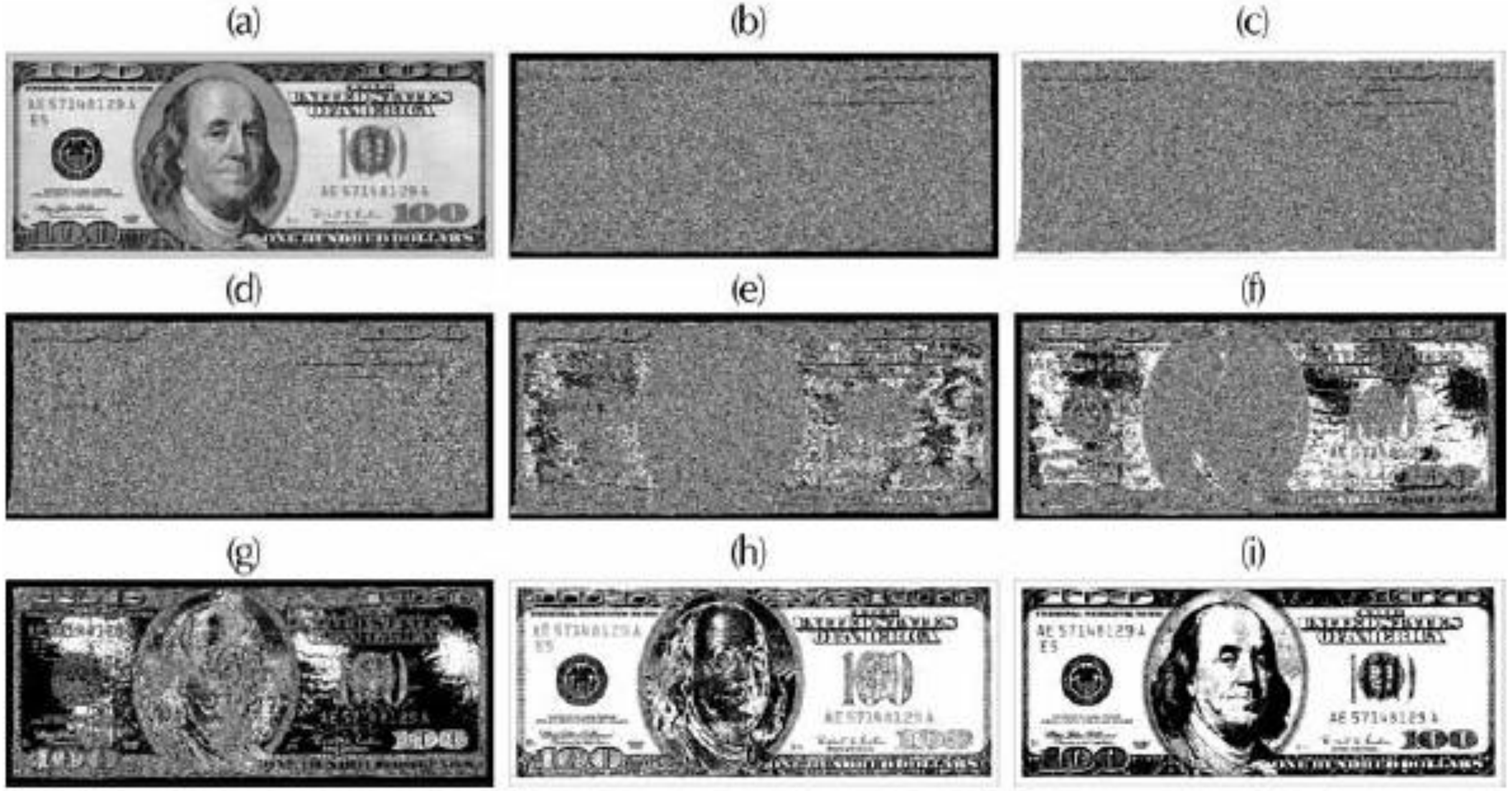


Figura 3.14 (a) Immagine a 8 bit in scala di grigio di 500×1192 pixel. Da (b) a (i) i piani di bit da 1 a 8; il piano 1 corrispondente al bit meno significativo. Ogni piano è un'immagine binaria.

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Bit-plane binario puro - Esempio

Figura 3.15 Immagini ricostruite usando (a) i piani di bit 8 e 7; (b) i piani di bit 8, 7 e 6; (c) i piani di bit 8, 7, 6 e 5. Si confronti (c) con la Figura 3.14a.

Reconstruction without a bit plan

Bit-Plane - Problem

- If the encoding used is pure binary, then a disadvantage becomes apparent: a small variation can affect all planes.

- Example: If a pixel has, for example, intensity 127 (01111111) and its neighbor has intensity 128 (10000000) then the transition between 0 and 1 affects all bit planes.

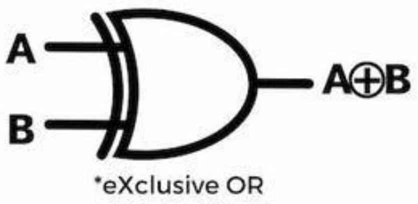
- You need a code in which very close values have very similar binary encodings!

Solution - Code Gray

The m-bit Gray code $g_{m-1} \dots g_1 g_0$ which corresponds to the number in pure binary $a_{m-1} \dots a_1 a_0$ can be calculated by the formula

$$g_i = a_i \oplus a_{i+1} \qquad 0 \leq i \leq m-2$$
$$g_{m-1} = a_{m-1}$$

where $\oplus$ denotes the XOR (exclusive OR) operator.



2 input XOR gate

A	B	A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

Gray code enjoys the property that each codeword differs from the previous one by only one bit.

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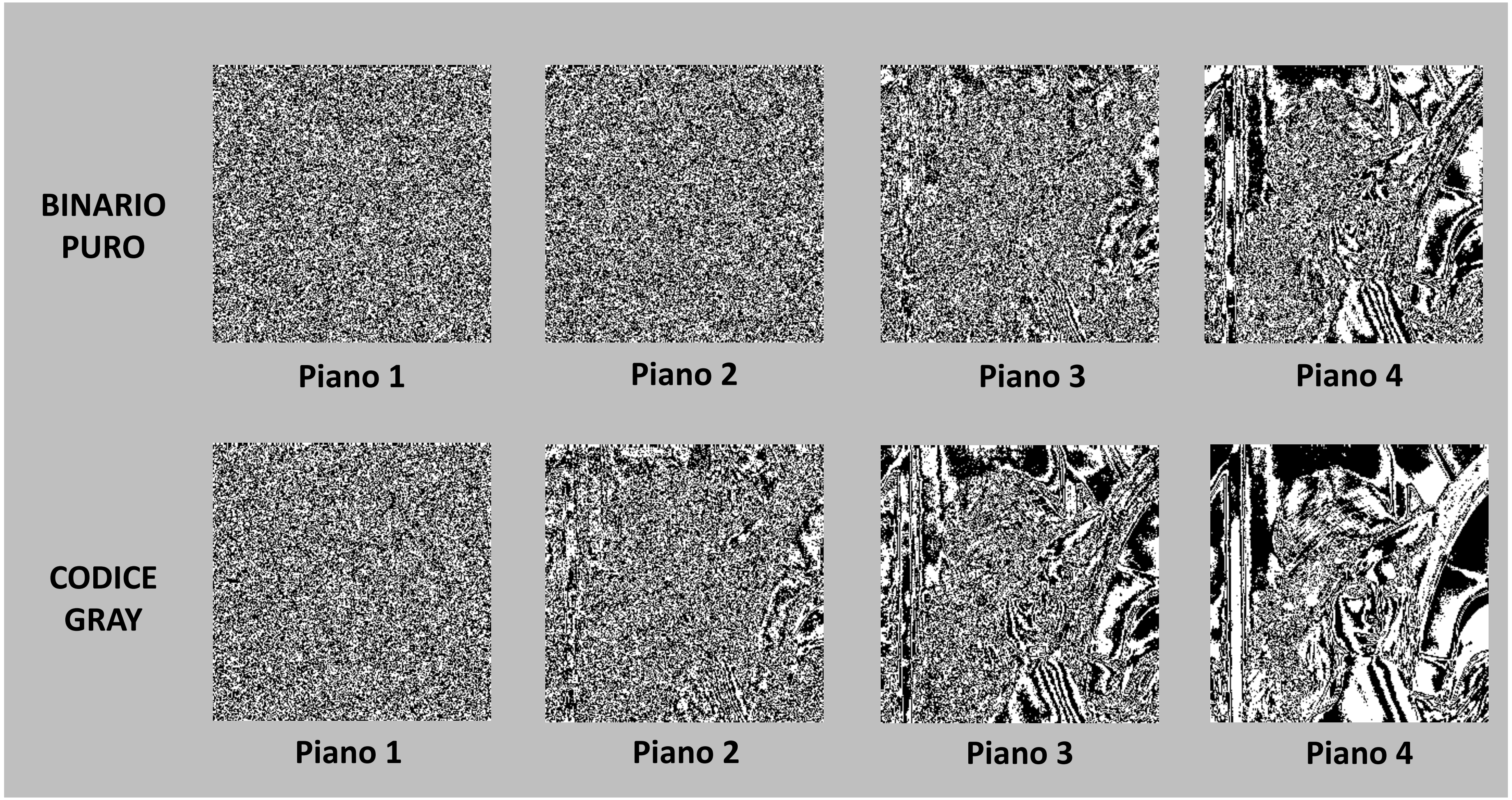
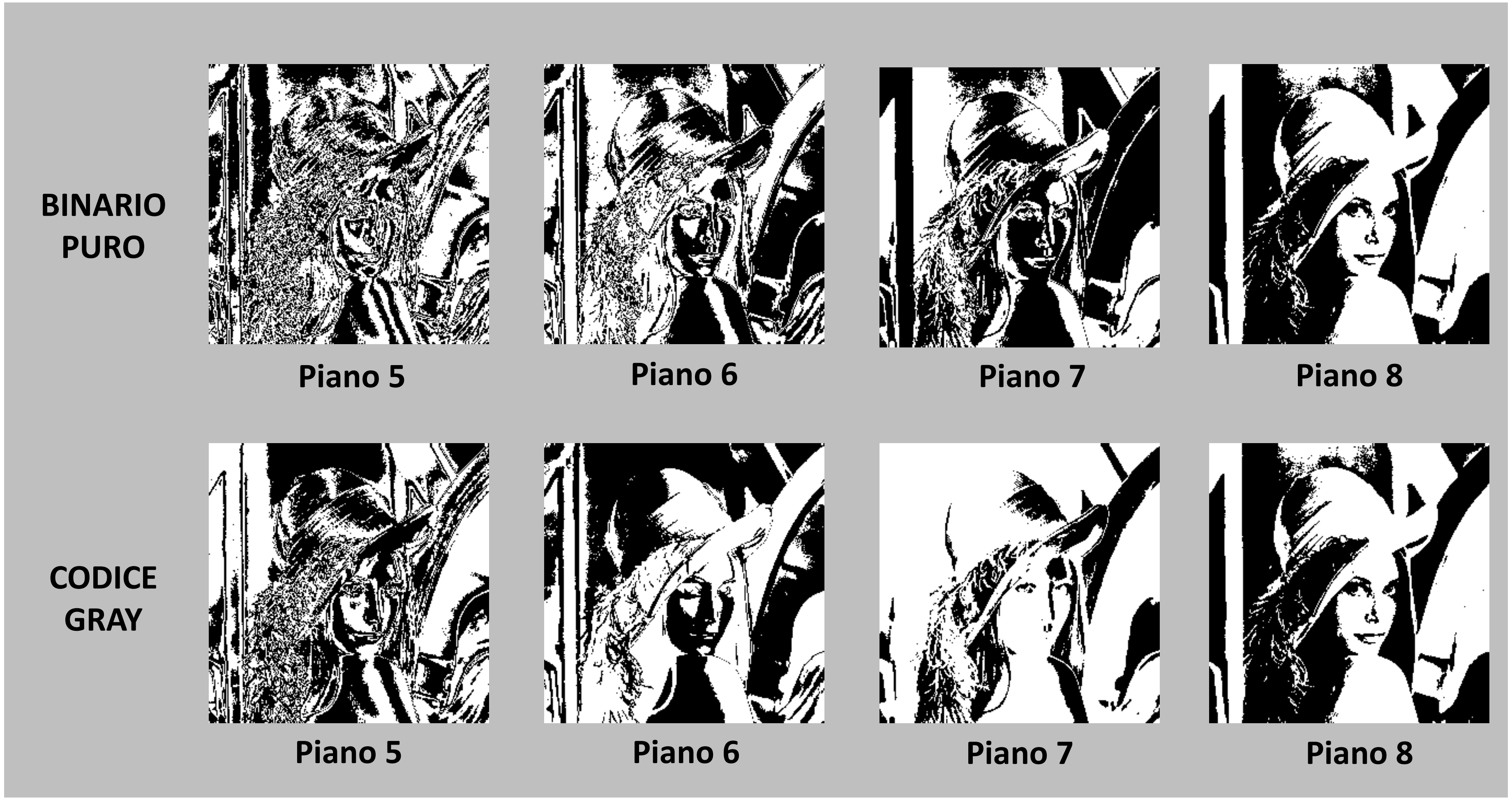
Pure Binary VS Gray Code



Pure Binary VS Gray Code



Pure Binary VS Gray Code

- As can be seen in the above example, depending on the encoding the bit-planes show differences.

- In particular, the bit-planes of Gray-coded images turn out to be more ''consistent'' with each other when compared with their respective ones in pure binary. In fact, if I increase the pixel intensity by 1 only one bit (i.e., only one plane) will vary.

- In addition, the number of black-white transitions in the single plane (descriptive complexity) are lower if Gray code is used (e.g., compare Lena's hair between planes 6).

- These features indicate lower entropy (higher redundancy) if Gray code is used. This means that it becomes easier to compress from such coded images.

Pure Binary VS Gray Code

WARNING.

- Since the meaning associated with bits is different between the two encodings, some properties of one do not apply to the other!
- If you reset bit planes in Gray code, you eliminate different (and less significant) ranges of values than in pure binary.
- Although details and noise will tend to be concentrated in the lower planes even with Gray code, directly eliminating such planes could introduce unwanted artifacts.