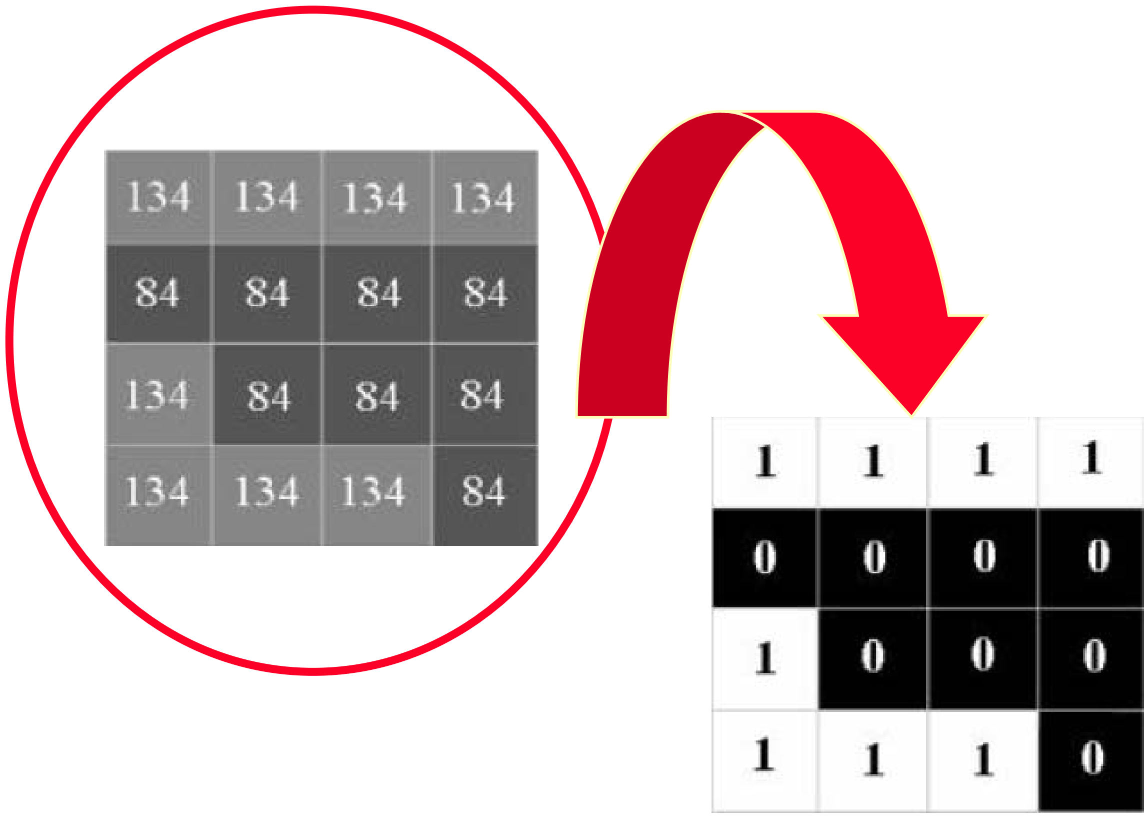
# Block Truncation Coding (BTC)

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# Basic Idea

- Originally: Preserve the first two sample moments of a small block (*n*x*n*)

Average:

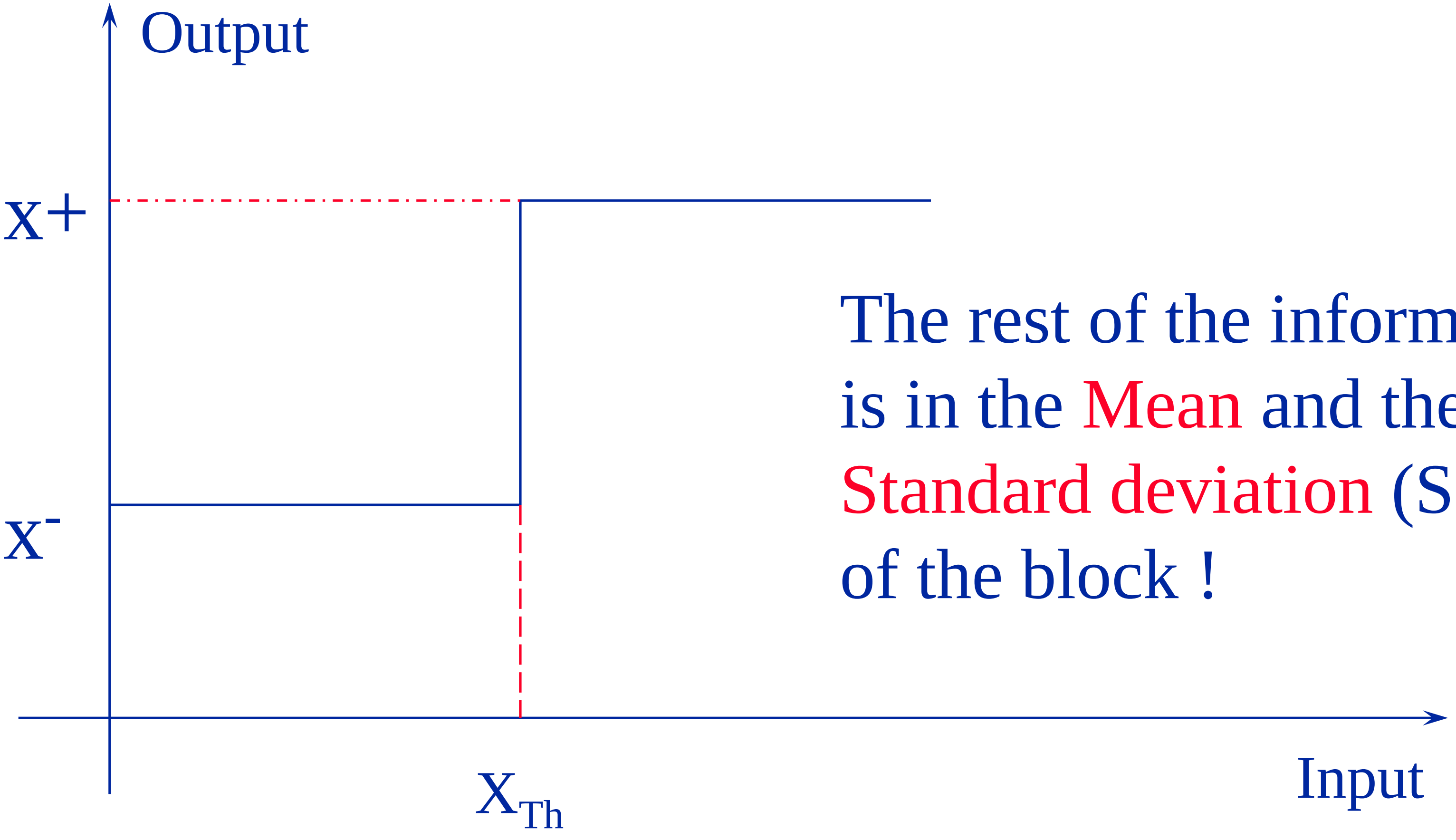
$$\overline{x} = \frac{1}{n^2}\sum_{n} x_i$$

Standard Deviation:

$$\sigma = (x^2 - \overline{x}^2)$$

Define a 1-bit (2-level quantizer: $x^+$ and $x^-$)
with $x_{Th}$, *such that preserve the two moments*

# Two Level (binary) Quantizer




The rest of the information is in the Mean and the Standard deviation (SD) of the block !

# Advantages of BTC

- Small complexity (faster than TC).
- Preserving edges.
- Each block can be compressed separately according to its variance.
- Fixed and Adaptive bit-allocation optional.

# BTC Encoding

- Assume a 512x512 image with 256 gray levels.
- The threshold will be the mean value ($x_{ave}$).
- For each block we transmit bit-level matrix, $x_{sd}$ and $x_{ave}$ .
- The levels $X^+$ and $X^-$ can be determined by setting up the expressions that equate (preserve) the moments before and after quantization.

# Levels Selection

$$n^2 \overline{x} = n^- x^- - n^+ x^+$$

$$n^2 \overline{x^2} = n^- (x^-)^2 - n^+ (x^+)^2$$

Where n+ and n- are the number of pixels above and below the threshold (mean)

$$x^- = \overline{x} - \sigma \sqrt{\frac{n^+}{n^-}} \qquad x^+ = \overline{x} + \sigma \sqrt{\frac{n^-}{n^+}}$$

# Levels Selection (Cont'd)

- Output levels are biased symmetrically around the mean level
- Both positive and negative biases are proportional to the SD
- Levels are rounded to the number of allowed bits, so moment preservation is not exact

# BTC Example

$$x = \begin{bmatrix} 136 & 27 & 144 & 216 \\ 172 & 83 & 43 & 219 \\ 200 & 254 & 1 & 128 \\ 64 & 32 & 96 & 25 \end{bmatrix}$$

Mean=115 SD=77.93

Thresholding

$$x' = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$X^{+}=193$ $X^{-}=37$ $n^{+}=n^{-}=8$

# BTC Decoding

- From the moment preservation principle:

$$x_{rec} = \begin{bmatrix} 193 & 37 & 193 & 193 \\ 193 & 37 & 37 & 193 \\ 193 & 193 & 37 & 193 \\ 37 & 37 & 37 & 37 \end{bmatrix}$$

For N-level reconstruction we use a Max-Lloyd Quantization !

# Compression Ratio

- The higher the block size - the higher the compression ratio
- For $L$ bits-per-pixel we have $n^2L$ bits describing a $nxn$ image
- Assuming that the *mean* and *SD* are defined also with $b$ bits, we get a total number of $(n^2 + 2b)$ bits in the output:

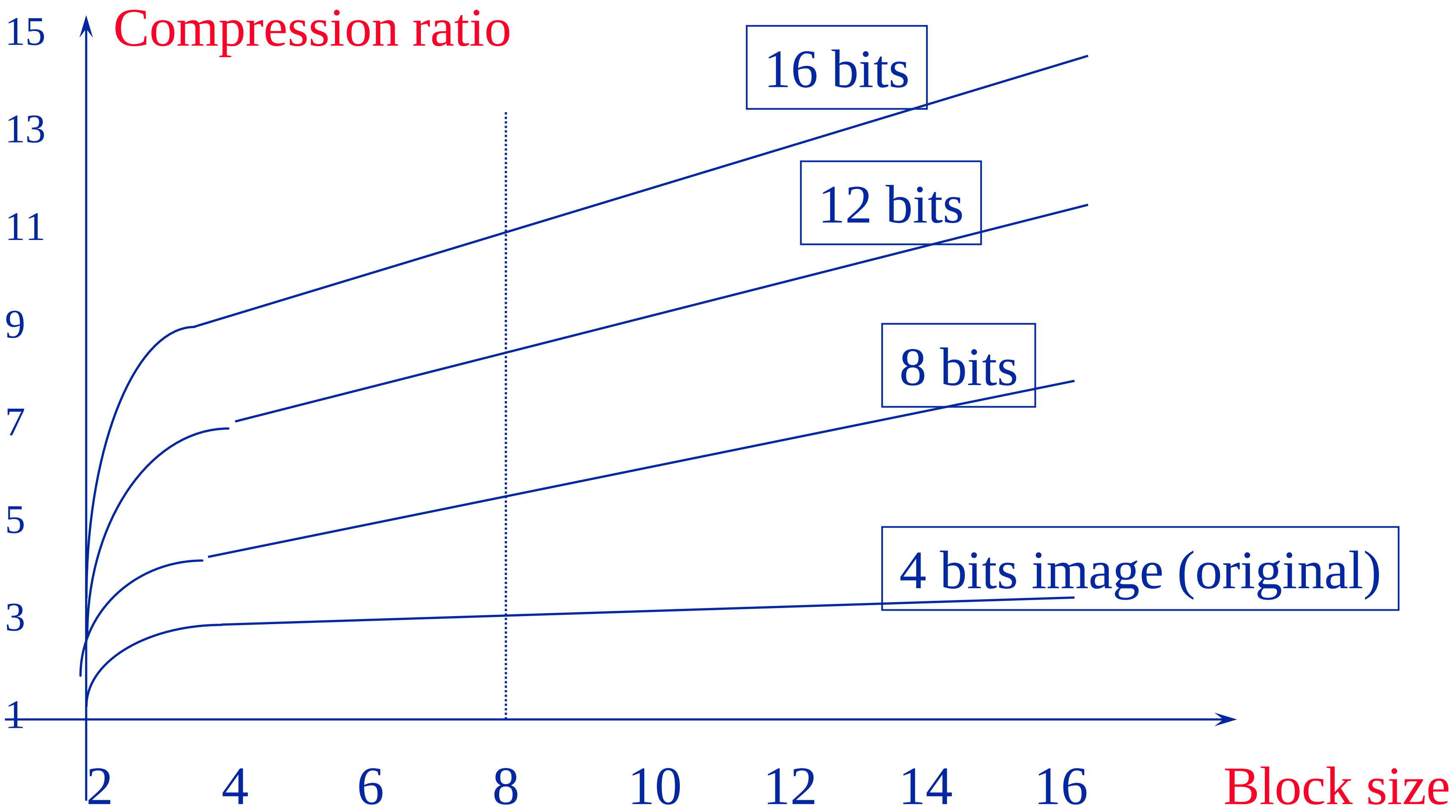
$$R_{(n)} = \frac{bn^2}{n^2 + 2b} = \frac{8*4*4}{4*4+16} = 4$$

# Increasing Compression

- Assigning only 6 bits to the mean and 4 bits to the SD: R=4.923 (1.625 bpp)

- <u>Another option</u>: assigning 10 bits together to the mean and SD, while the exact number of bits for the mean depends on the SD.

# Compression ratio Vs. Block size



# Block Size=8, Bitrate=0.935bpp, Side information=0.25bpp, SNR=30dB

# And in color

Original Image

Encoded at 1.89 bpp

Source: Handbook of Image and Video Processing,
Block Truncation Coding (BTC), Edward J. Delp, Martha Saenz, and Paul Salama

# Other BTC techniques

- Error criteria: Minimum MSE.
- Error criteria: Minimum MAE.
- Save 3rd order moment.