QIM watermarking in the JPEG2000 coding pipeline

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JPEG2000 pipeline & watermarking

blind watermarking & self−noise suppression

quantization index modulation (QIM) watermarking

results

JPEG2000 standard

- ISO/IEC standard 15444
- based on wavelet decomposition
- better quality at low bit rates than JPEG
- rich feature set (lossless, lossy operation, ROI coding, scalability, error resiliance, random access)
- optimal rate/distortion allocation, EBCOT [1] based
- flexibility to implement the coder
- patent−free
- ...

[1] D. Taubman, “High Performance Scalable Image Compression with EBCOT”, IEEE Trans. Image Proc., v9, n7, pp1158−1170, July 2000

JPEG2000 coding pipeline

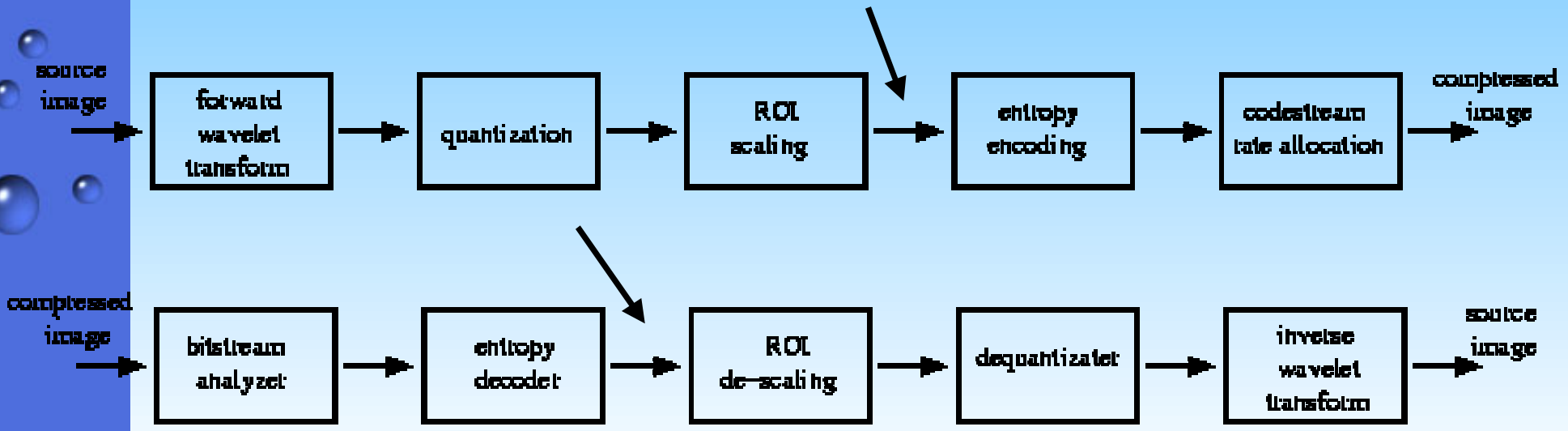
trying to maximize number of truncation points

independent processing of 64x64 code block

watermark

➔ embedding before entrophy coding

➔ detection after entrophy decoder



On−the−fly Watermarking

Advantages

- saves extra computation of image transform
- suitable for mobile devices, eg. digital camera
- can support ROI− and scalable watermarking

Disadvantages

- uses same transform domain as coding
- independent code−blocks limit scope for perceptual watermarking
- restricts application of previously proposed watermarking schemes
- hard to deal with geometric attacks

Possible Application

integrated image coding and watermarking
eg. digital camera, digital library, ...

for

- image authentication
- image annotations
- copyright protection

➔ different requirement, focus on

➔ blind detection, binary messages

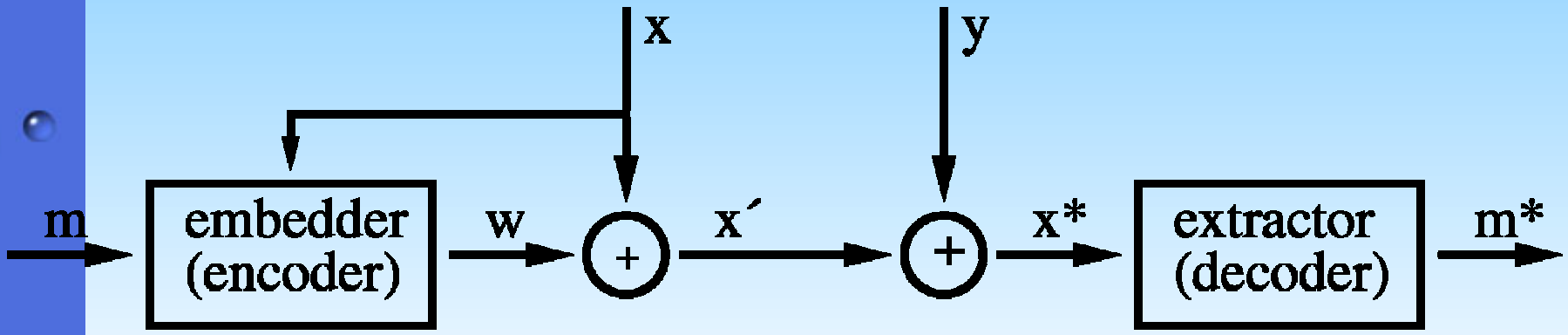
Communication model (Ramkumar)

received signal = host image (x), “self noise”

+ embedded watermark (w)

+ processing noise / attacks (y)

➔ extraction possible?



M. Ramkumar, “Self−noise suppression schemes for blind image steganography, Proc. SPIE, Multimedia Sys. and App. II, v3845, Sept. 1999

Image components

- image transformed to frequency representation (DCT, DWT, ...) − energy compaction
- low frequency component ~ “self noise”, most energy of the host image
- mid− and high frequency component ~ processing or attack noise

Where to place watermark?

- blind additive (linear) watermarking: tradeoff between low− and high−frequency components due to “self−noise”
- blind quantization (non−linear) watermarking: theoretically same performance as non−blind scheme (Costa’s proof)

➔ can suppress self noise

work by Chen & Wornell, Eggers, Ramakumar

Quantization index modulation (QIM)

embedding function s(x;m)

message $m \in \{1...M\}$

host signal x

approximate−identity function $s(x;m) \approx x$

➔ can be realized with dither modulation and quantization

$$s(x;m) = Q(x + d(m), \Delta) - d(m)$$

Watermarking with JJ2000

➔ using JJ2000 3.2.2, http://jj2000.epfl.ch

modular implementation of JPEG2000 VM in Java

5 level wavelet decomposition (7/9−biorthogonal)

pipeline interface: 64x64 code−blocks of 32bit integers (normalized)

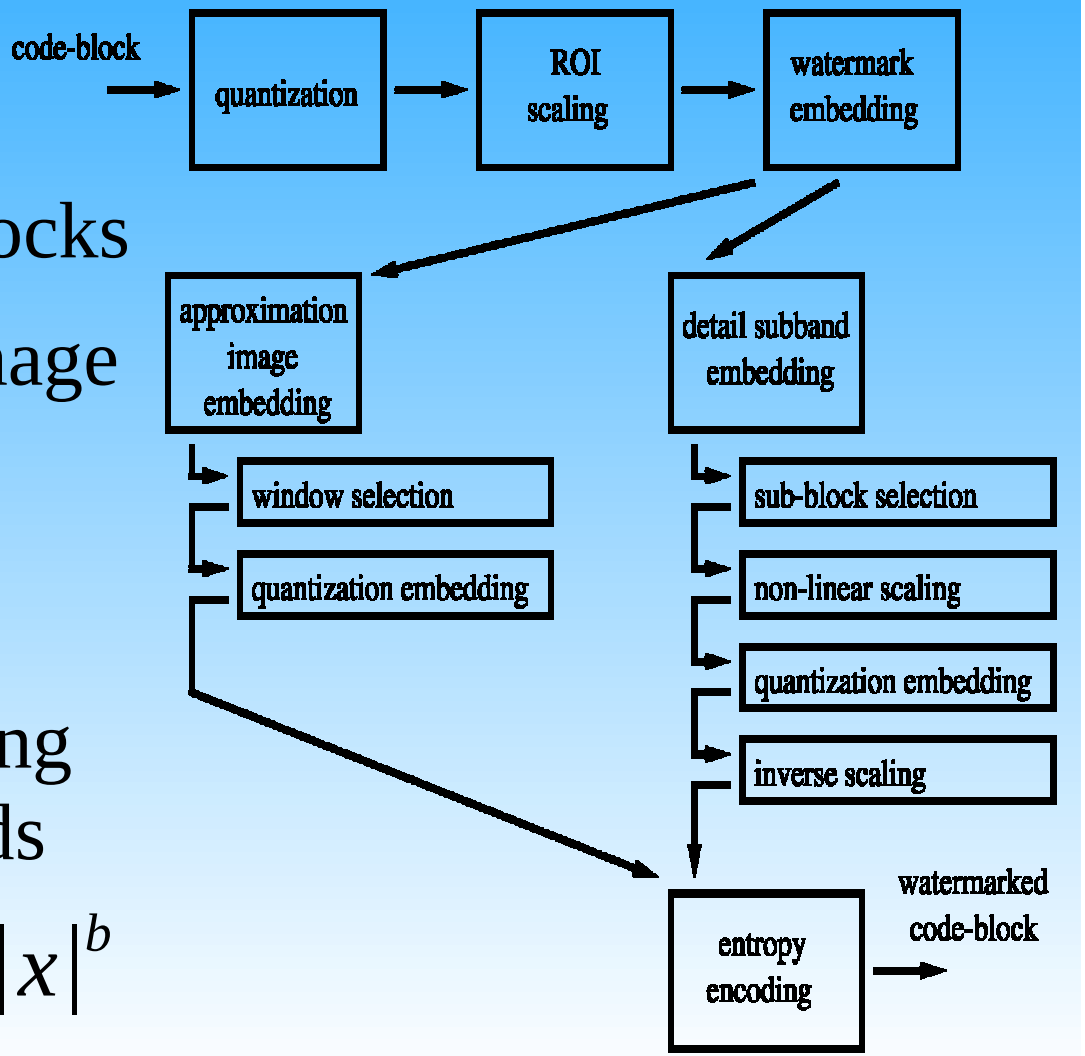
Watermark Embedder

distinguish code−blocks

- approximation image
- detail subbands

use non−linear scaling for detail subbands

$$f(x) = sign(x) \cdot |x|^{b}$$



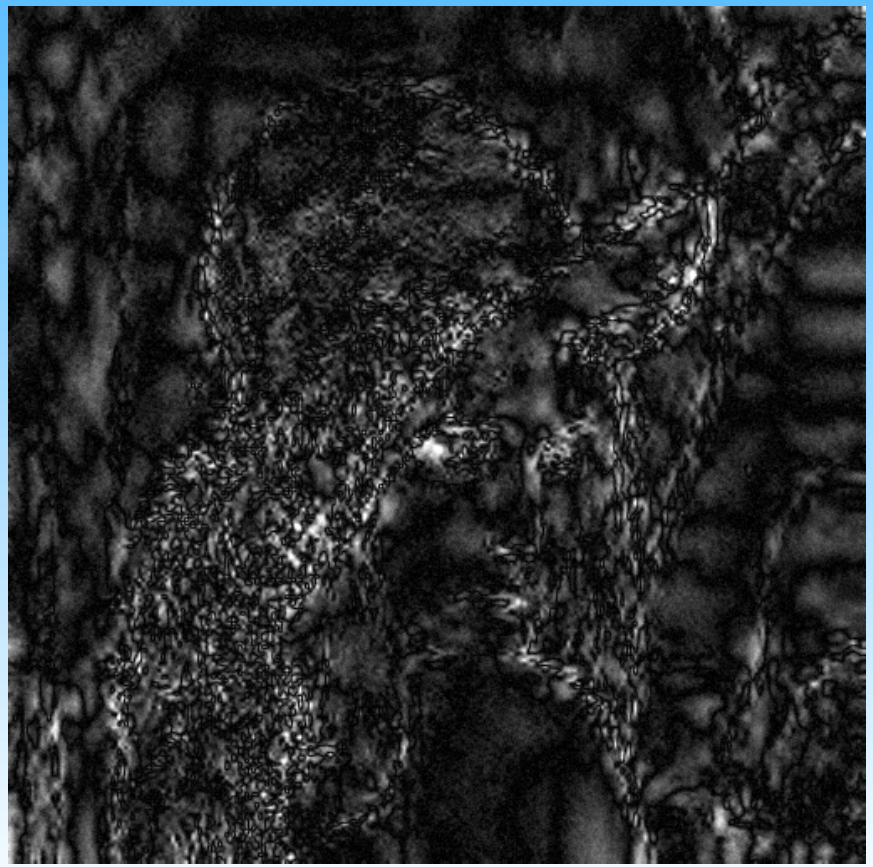
Embedding Parameters

- decomposition level (usually 3 − 6)
- code−block size (32 x 32 or 64 x 64)
- approximation or detail subband embedding
- window or sub−block size for quantization vector
- scaling factor to approximate perceptual coding (Zeng [2])
- key to generate dither vectors

[2] W. Zeng, “Digital watermarking in a perceptually normalized domain, 33rd ASILOMAR Conf. Sig., Sys. Comp., October 1999

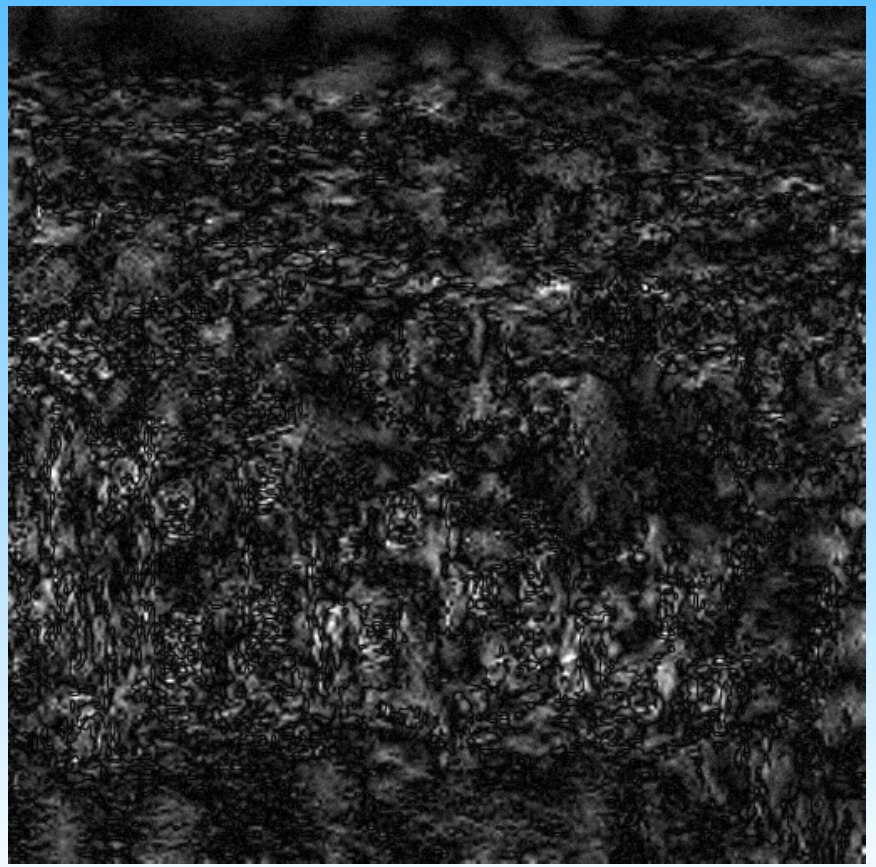
Results: Watermarked Lena

capacity 85 bits, PSNR 32.05 dB

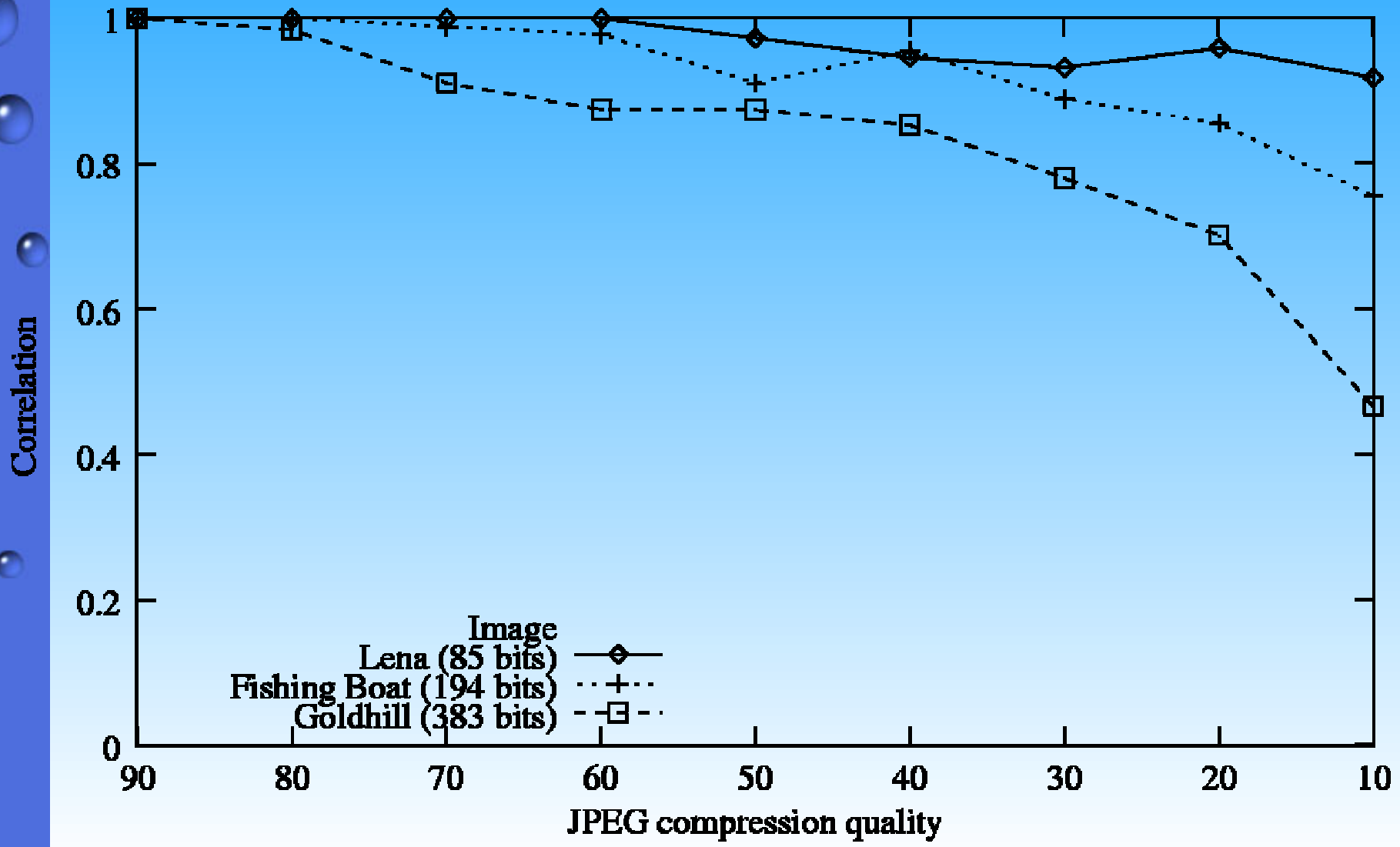


Results: Watermarked Goldhill

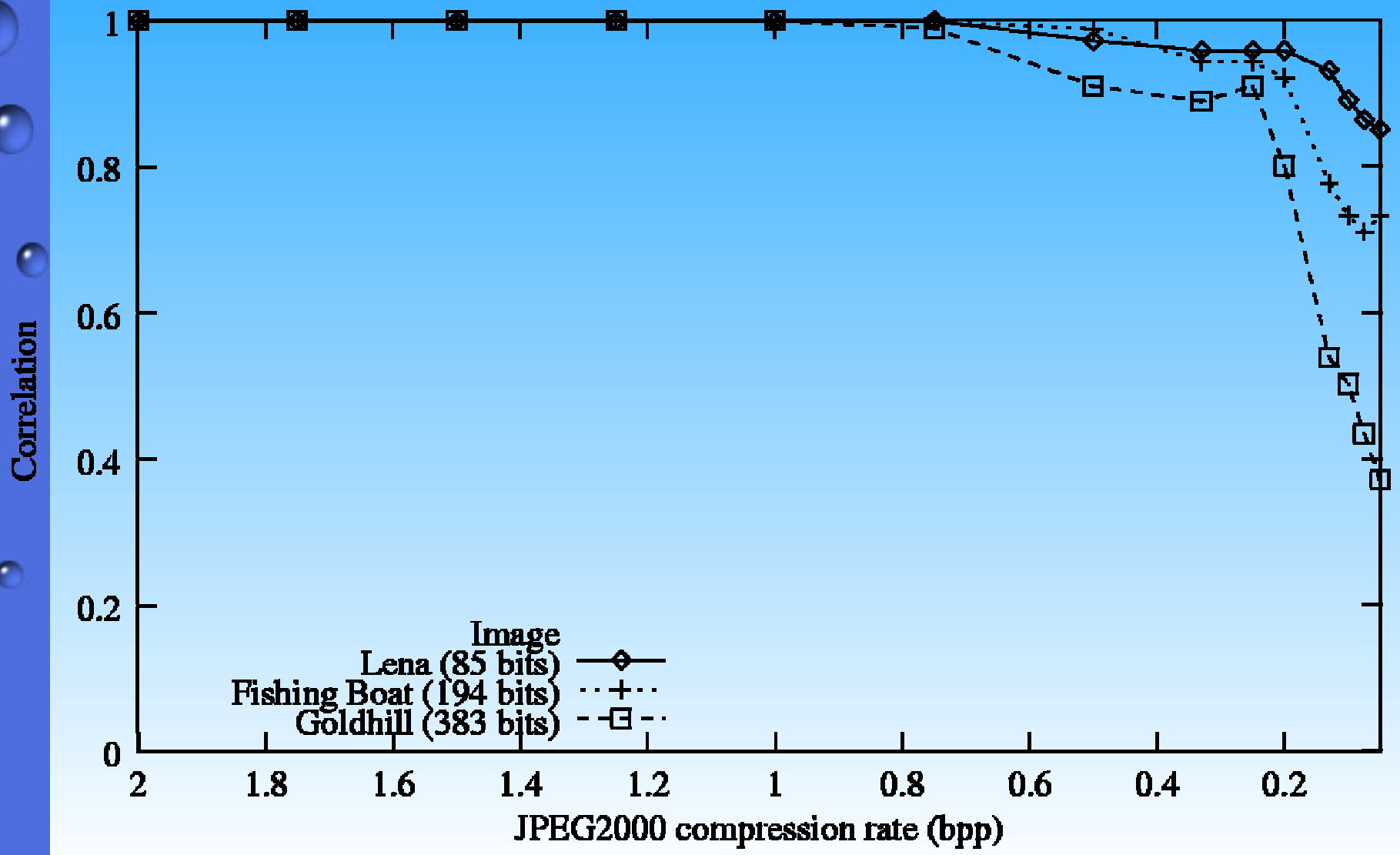
capacity 383 bits, PSNR 32.09 dB



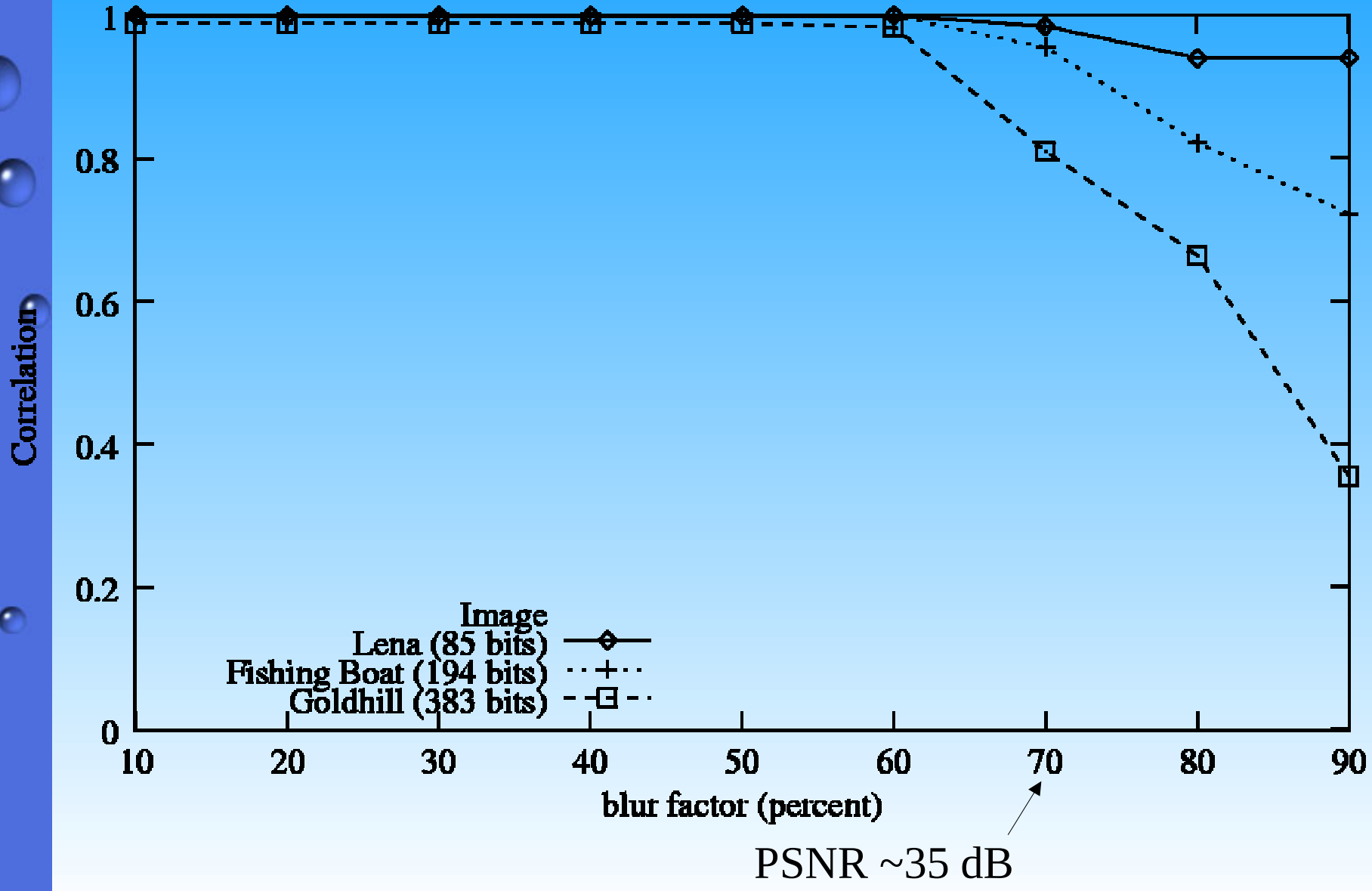
Robustness to JPEG Compression



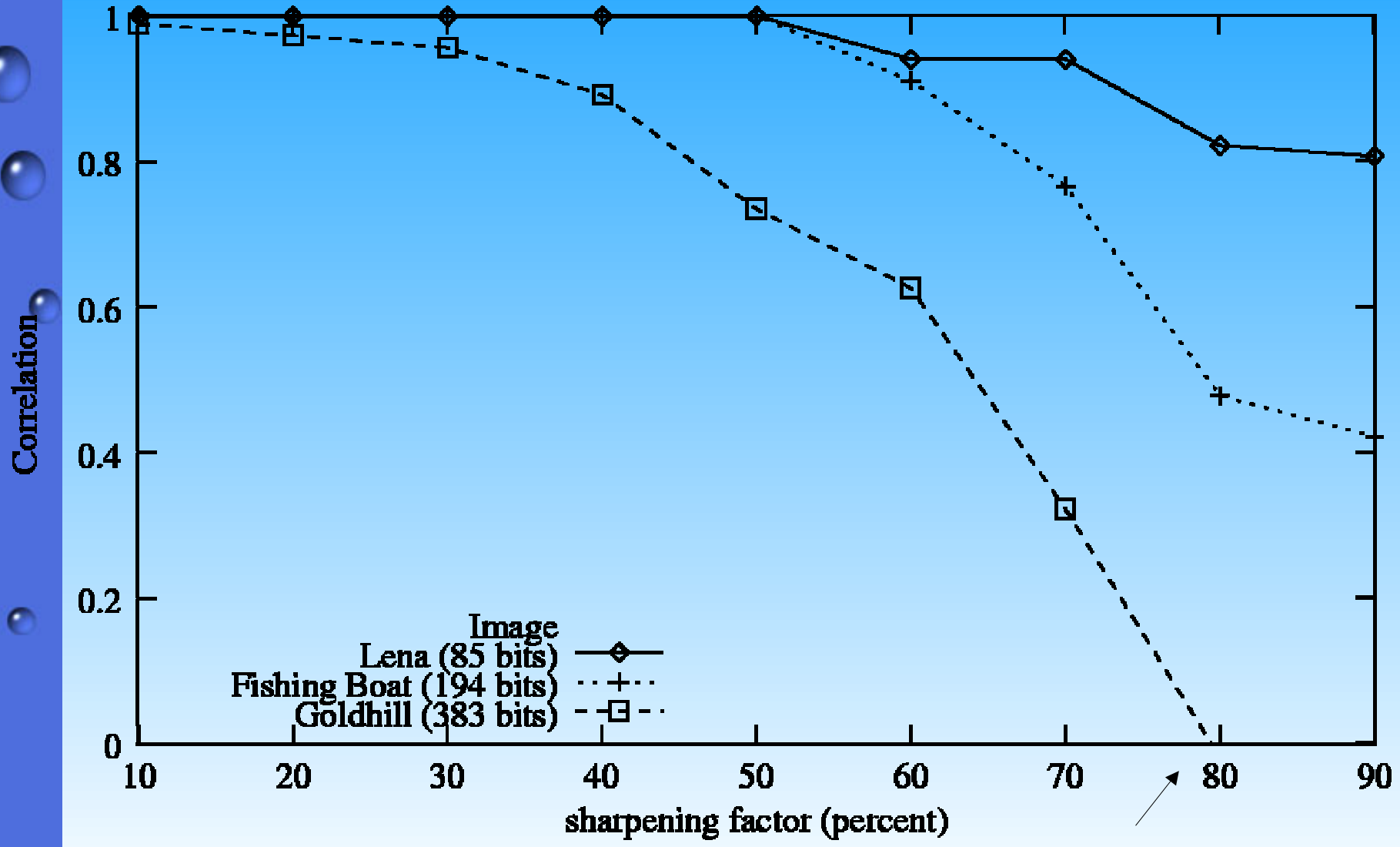
Robustness to JPEG2000 Compression



Robustness To Blurring



Robustness to Sharpening



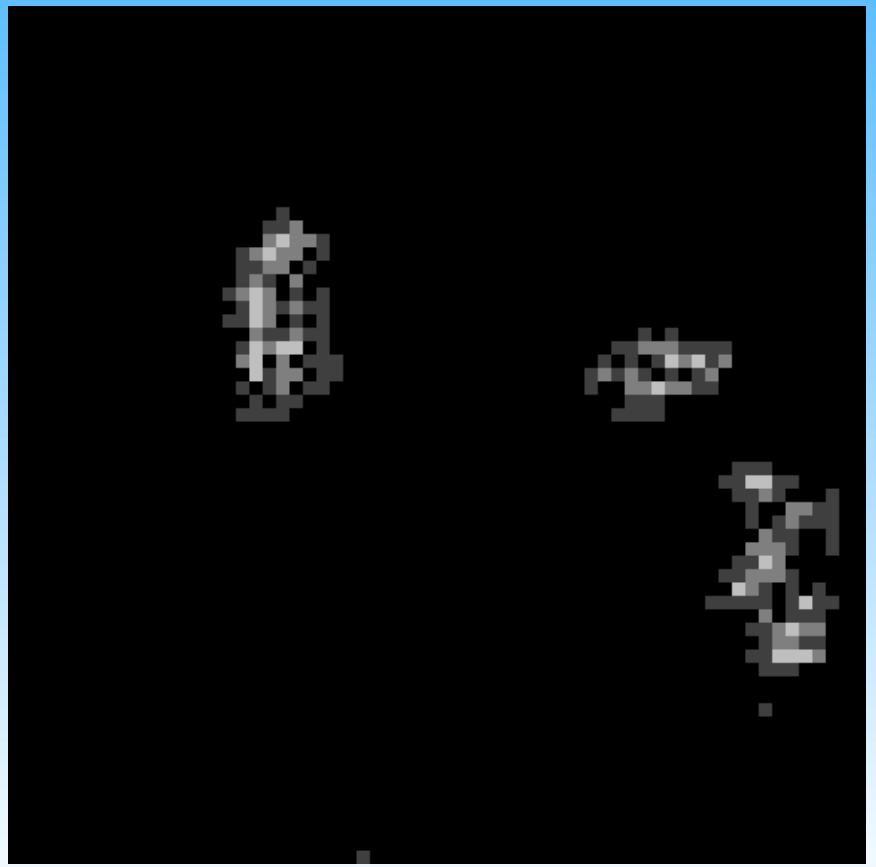
PSNR ~27 dB

Image Authentication

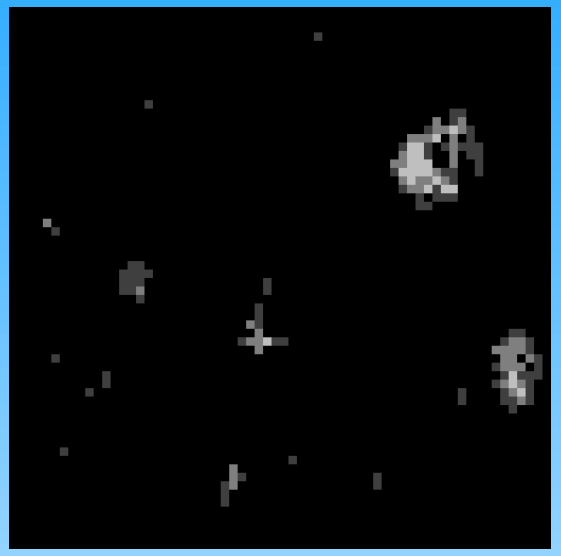
watermarked and manipulated image

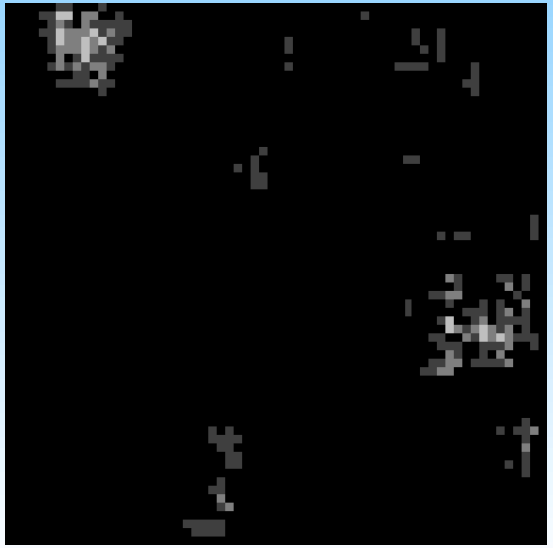
Tamper Detection

difference image and detected manipulation (after default JPEG compression)



Tamper Detection, cont.





Future Work

- better embedding method, results of Chen, Eggers and Ramkumar
- color images
- more human visual system (HVS) modelling
- region−of−interest coding (ROI)