# Wavelet Domain Watermarking

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Wavelet Transform Domain

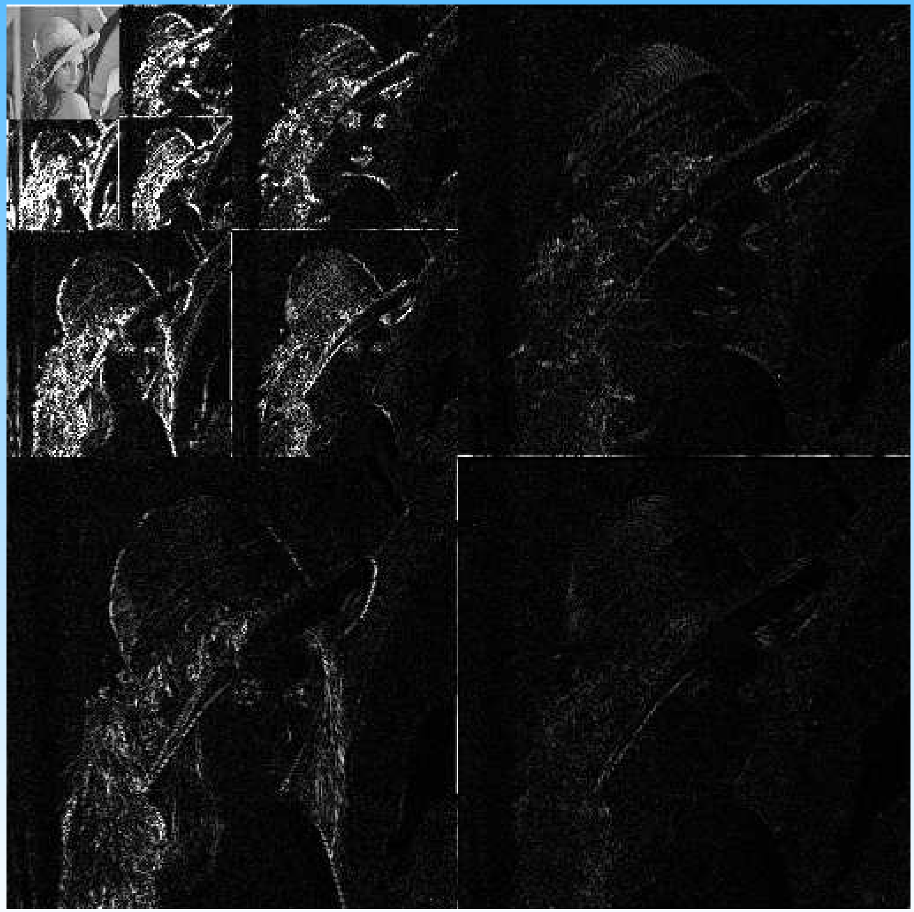
Embedding Strategies

JPEG2000 and Watermarking

Possible Application

# Wavelet Decomposition

- Successive low–pass / high–pass filtering steps
- Approximation image (low frequency comp.)
- detail subbands (sparse high frequency comp.)
- Multi–resolution representation



# Wavelet Advantages

- Robustness [Cox]
  - allows to mark significant image components
- advantages due to transform structure
  - space–frequency localization
  - multi–resolution representation
  - adaptivity [transform structure, filters, HVS]
- efficient implementation, object coding
- compatibility with JPEG2000 standard

# Classification of Embedding Schemes

- decomposition strategy
  - number of levels, adaptivity, packet basis
- coefficient selection
  - approximation image or detail subbands?
- blind / non–blind detection, avail. of original image
- embedding and extraction method
  - additive or quantization strategy
- HVS modelling
  - implicit or explicit

# Additive Watermark Embedding

embedding $f(m,n)' = f(m,n) + a \cdot |f(m,n)| \cdot w_i$

non–blind case

extraction $\bar{w}_i = \dfrac{\bar{f}(m,n) - f(m,n)}{a \cdot |f|}$

normalized correlation $c = \dfrac{\sum \bar{w}_i \cdot w_i}{\sqrt{\sum w_i^2 \cdot \sum \bar{w}_i^{\,2}}}$

$c \gg 0\,?$

blind case

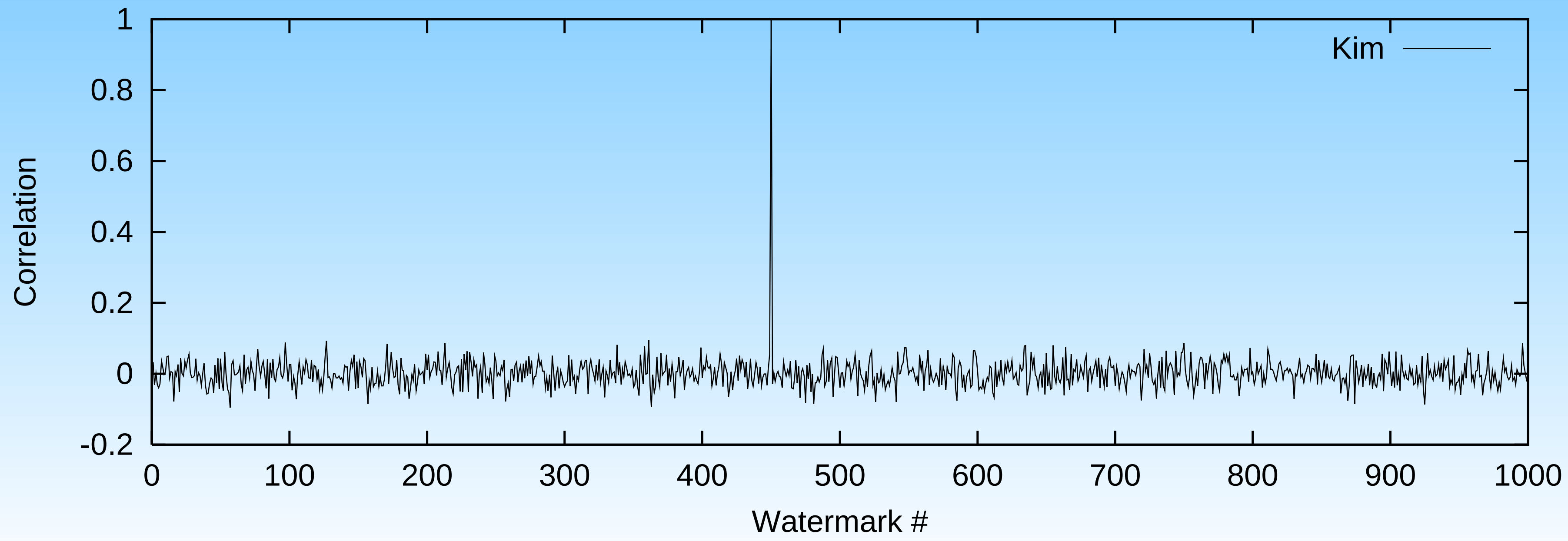
detection $d = \dfrac{1}{M} \cdot \sum^{M} f(m,n)' \cdot w_i$

detection threshold $t = \dfrac{a}{3 \cdot M} \cdot \sum^{M} |f(m,n)|$

$d \gg t\,?$

# Watermark Detection

trying to detect 1000 random watermarks,
watermark #450 was embedded



# Quantization Watermark Embedding

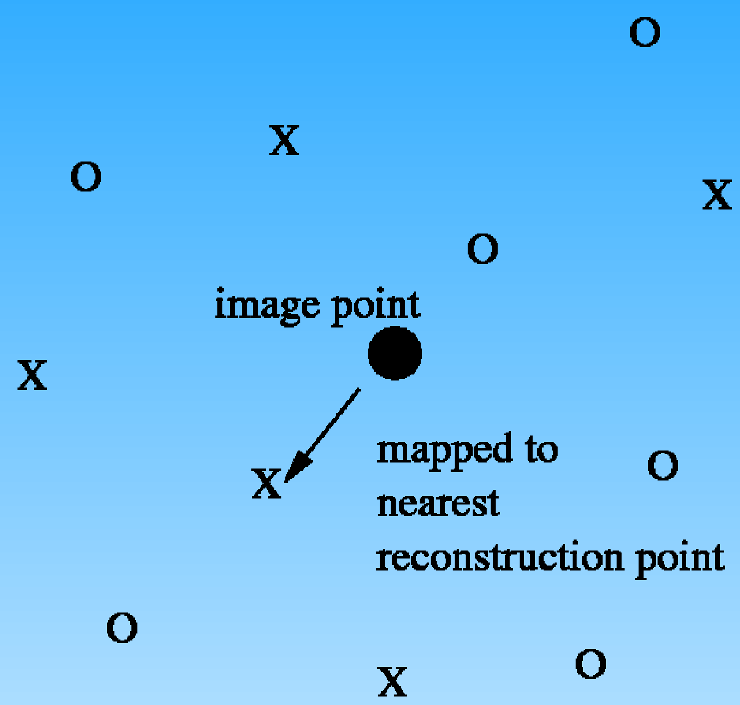
embedding function

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

| | |
|---|---|
| x | host vector |
| m | message |
| d(.) | dither vector |
| Q(.) | quantization function |
| $\Delta$ | quantization step size |

detection function

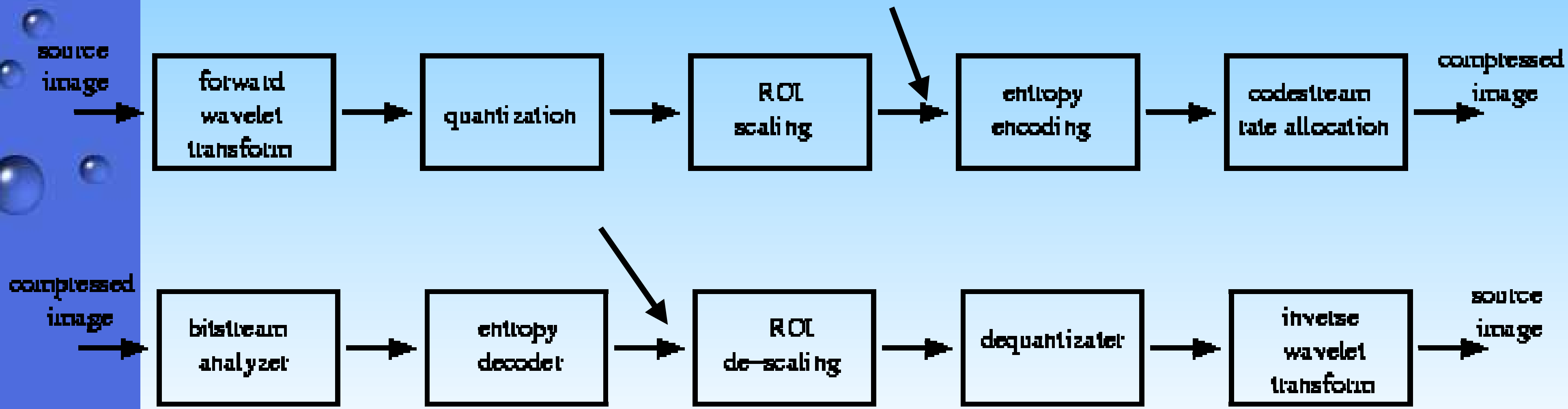
$$m=\arg_m \min(|y-s(y;m)|)$$




simple scalar quantization,
binary message

# JPEG2000 Coding

JPEG2000 is upcoming ISO standard to supplement JPEG
based on Wavelet transform, inherent progressive image transmission
many new features, independent processing of code−blocks
sophisticated rate/distortion allocation (EBCOT)



# Advantages & Constraints

- on–the–fly watermark embedding during image coding / decoding – integration with JPEG2000
- no extra DWT computation
- allows ROI and scalable watermarking
- only local information – ’scope’ is one code–block, makes perceptual model computation harder

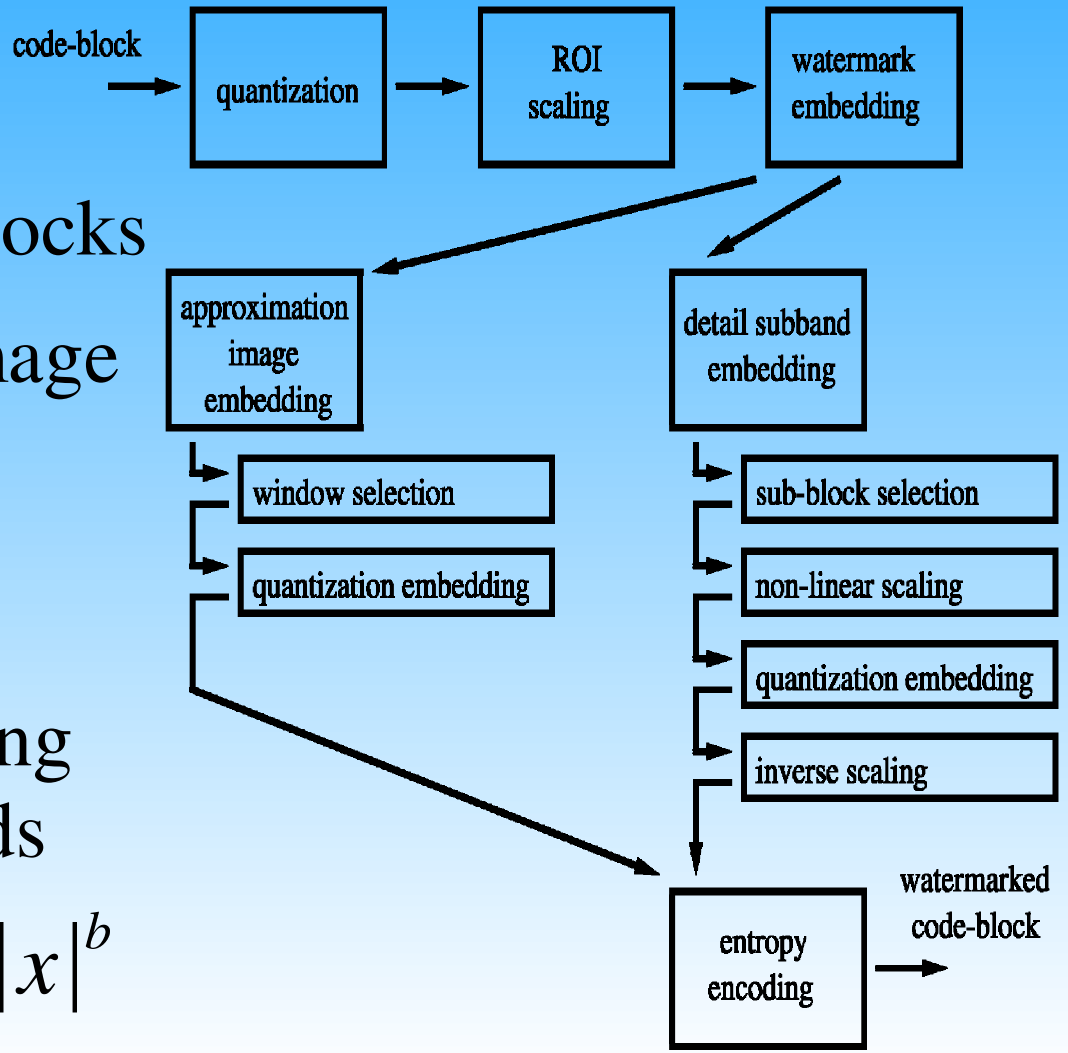
# JPEG2000 Watermark Embedding

Distinguish code–blocks

- approximation image
- detail subbands

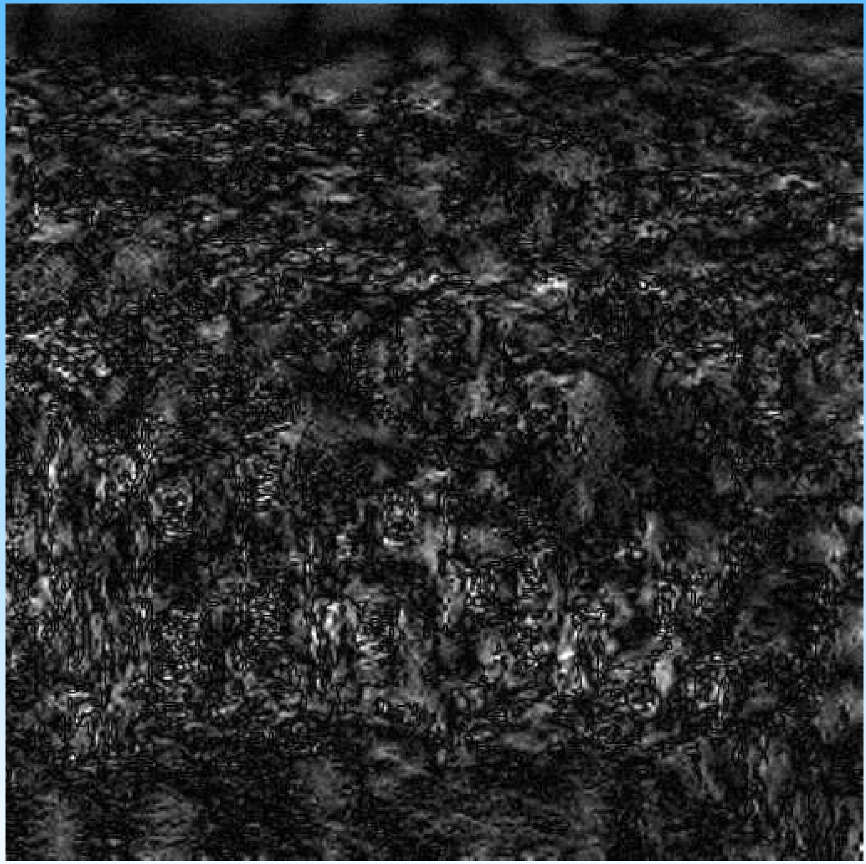
use non–linear scaling
for detail subbands

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

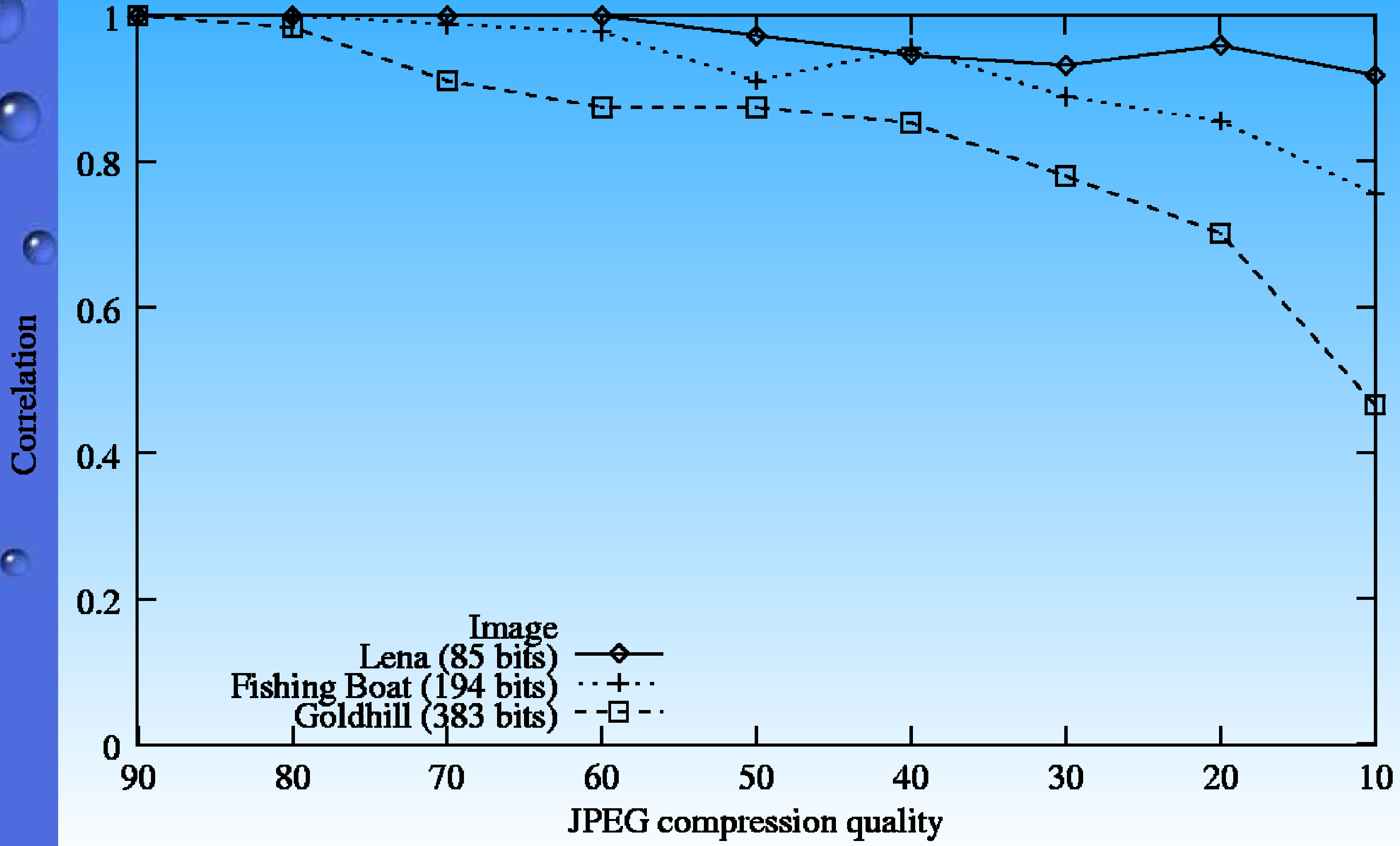


# Results: Watermarked Goldhill

capacity 383 bits, PSNR 32.09 dB



# Robustness to JPEG Compression



# Image Authentication

watermarked and manipulated image

# Tamper Detection

difference image and detected manipulation (after default JPEG compression)