Wavelet Domain Watermarking

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Wavelet Transform Domain

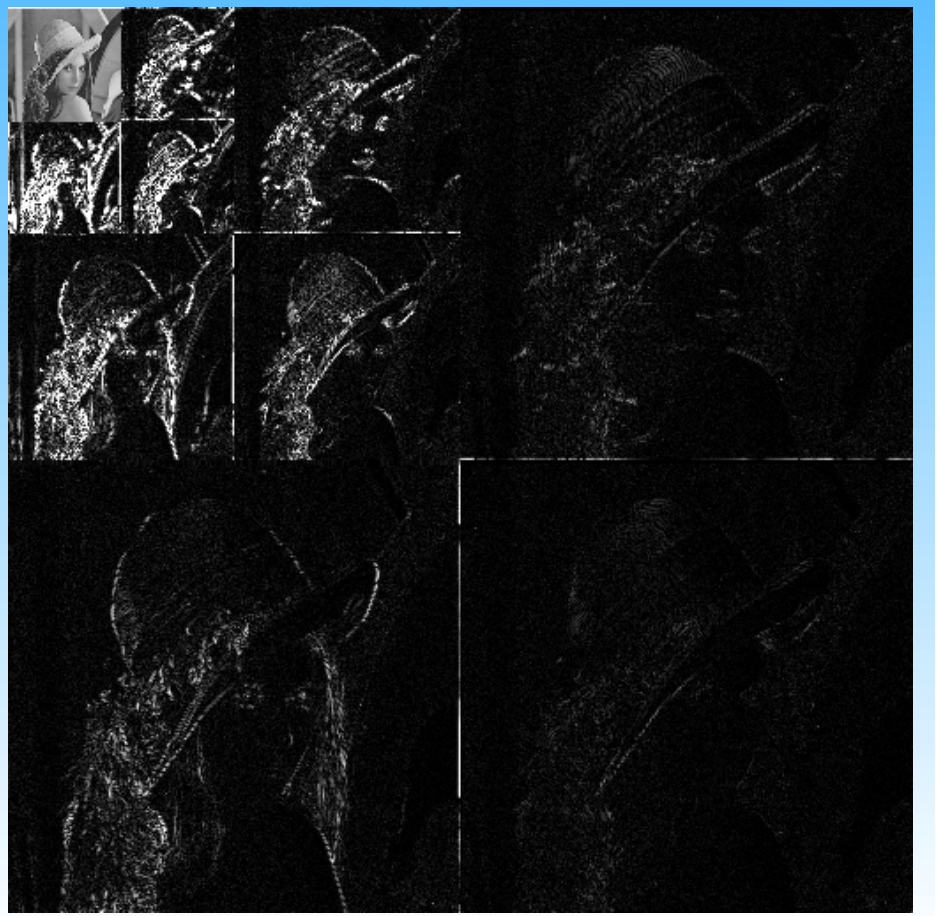
Embedding Strategies

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

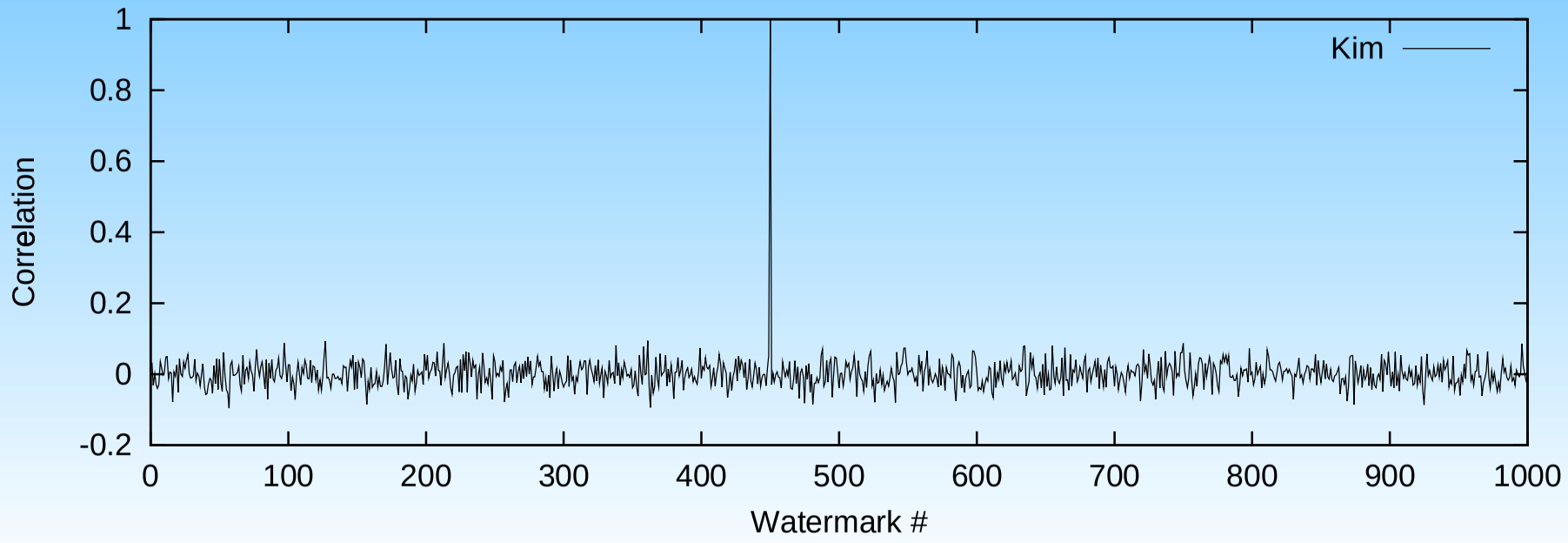
detection $d = \dfrac{1}{M} \cdot \sum^{M} f(m,n)' \cdot w_i$

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

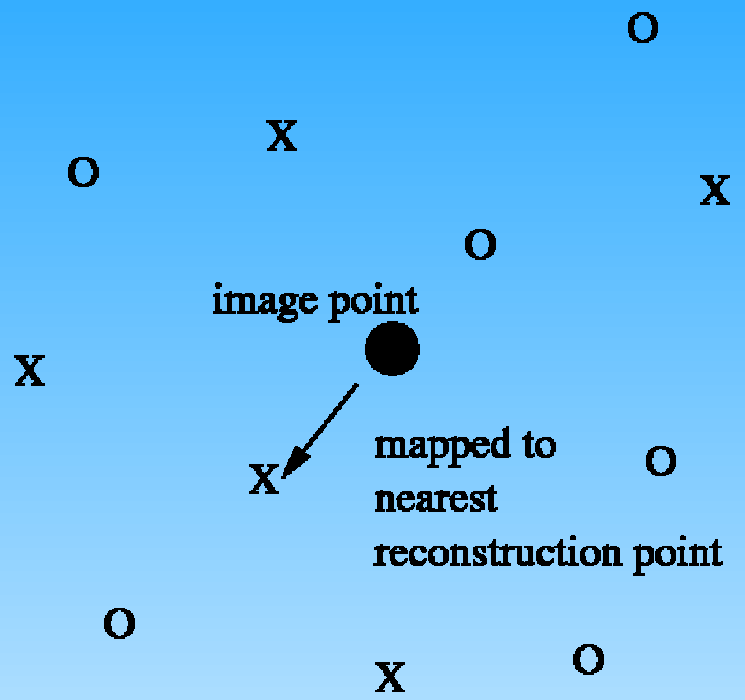
embedding function

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

x	host vector
m	message
d(.)	dither vector
Q(.)	quantization function
Δ	quantization step size

detection function

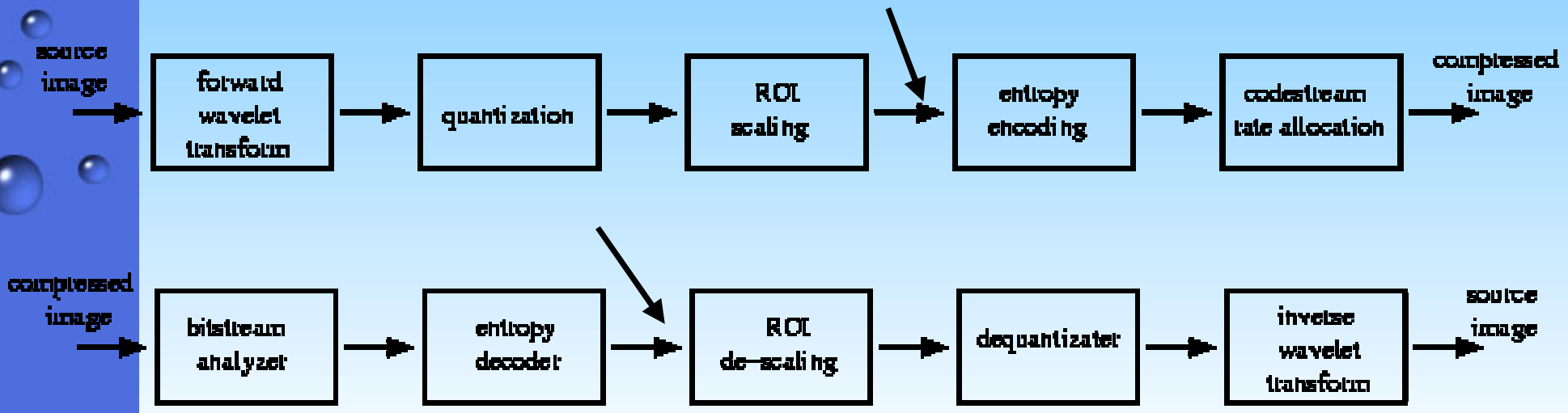
$$m=arg_m\,min(|y-s(y;m)|)$$



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

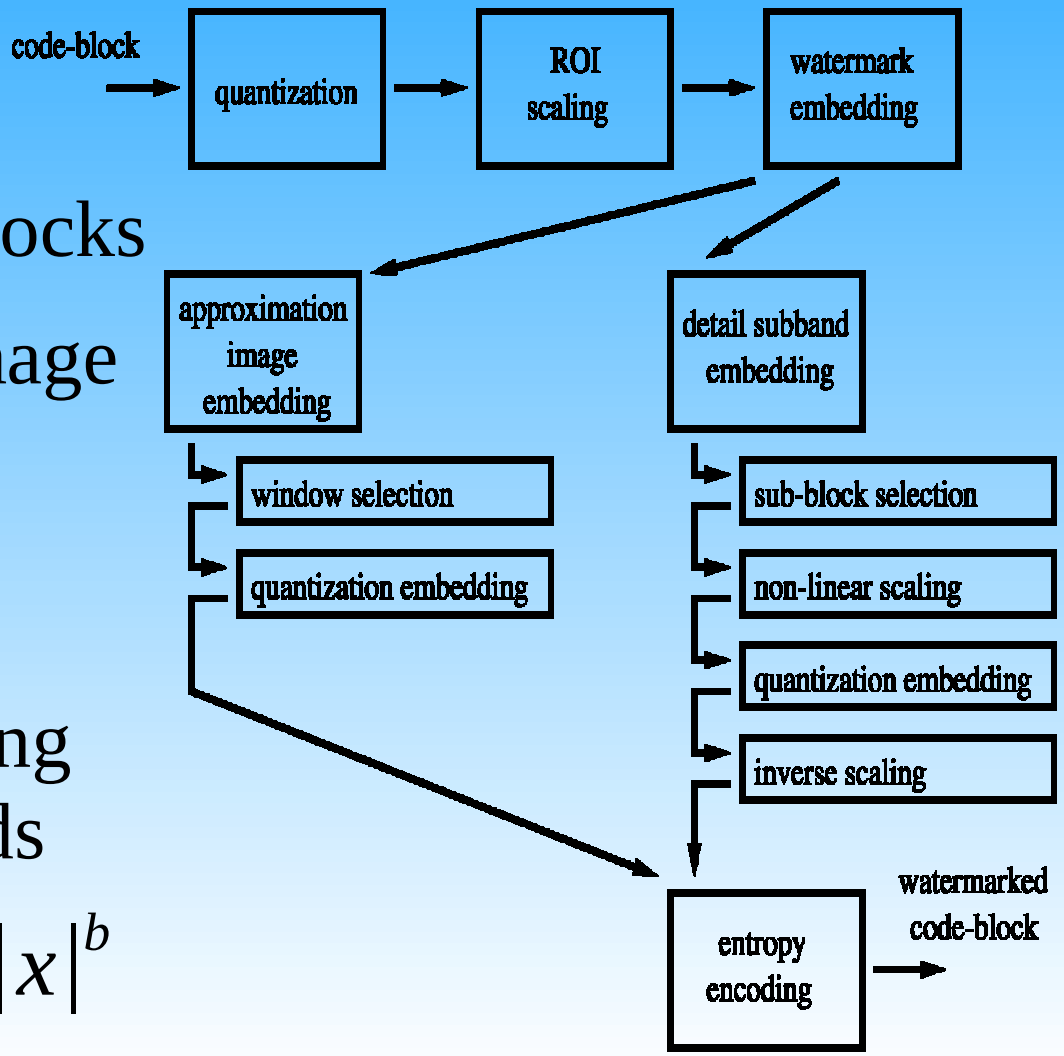
JPEG2000 Watermark Embedding

Distinguish code−blocks

- approximation image
- detail subbands

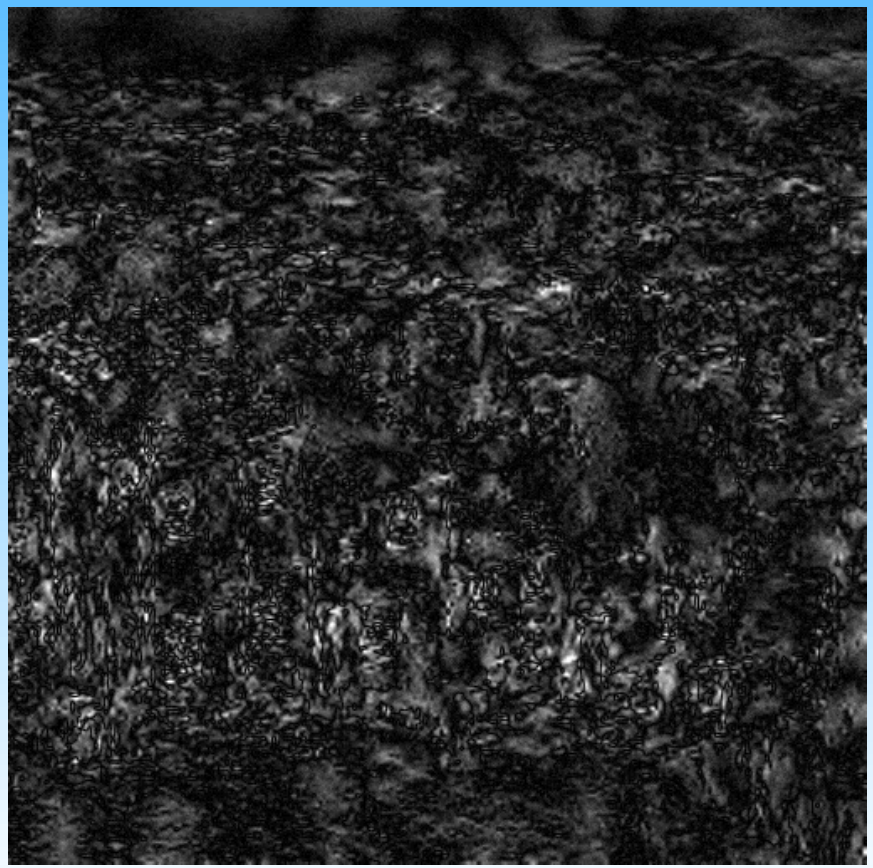
use non−linear scaling for detail subbands

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



Results: Watermarked Goldhill

capacity 383 bits, PSNR 32.09 dB



Robustness to JPEG Compression

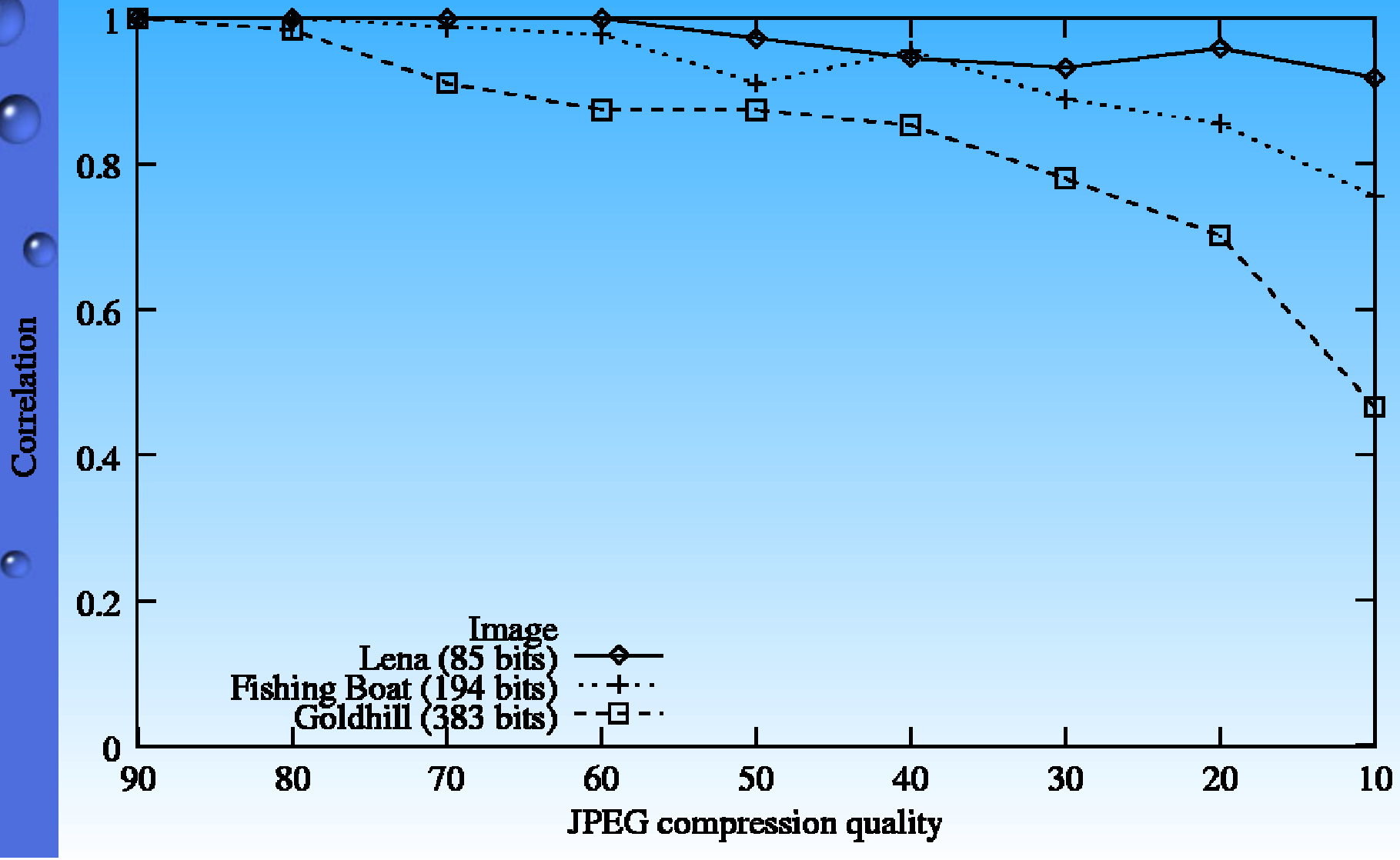


Image Authentication

watermarked and manipulated image

Tamper Detection

difference image and detected manipulation (after default JPEG compression)