Digital Watermarking and Steganography

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Chapter 9. Robust Watermarking

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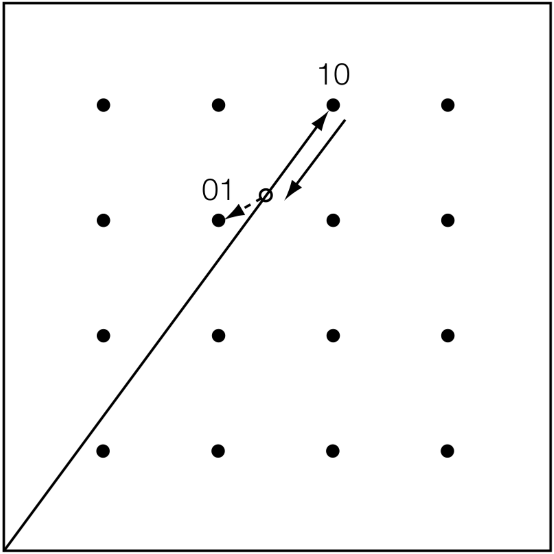
Valumetric Scaling

$\mathbf{c} * 0.8$

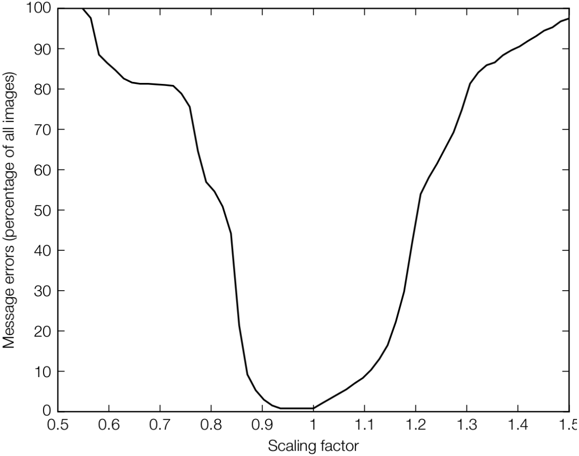
$\mathbf{c} * 1.0$

$\mathbf{c} * 1.2$

QIM is not Robust



Error Illustration



Valumetric scaling on the E_LATTICE/D_LATTICE system.

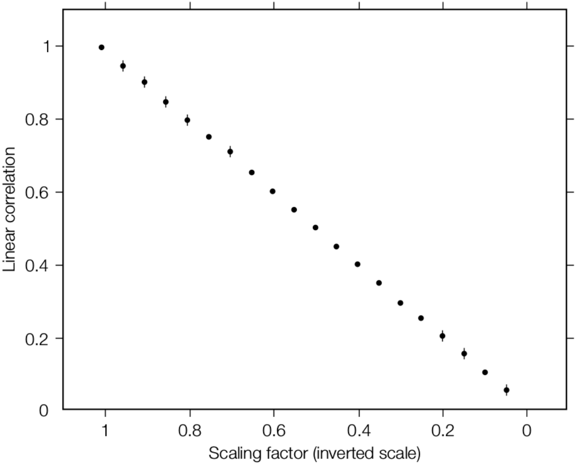
Reason

$$\begin{aligned} z_{lc}(s) &= (s\mathbf{c_w}) \cdot \mathbf{w_r} \\ &= s(\mathbf{c_w}) \cdot \mathbf{w_r}) \\ &= s \cdot z_{lc}. \end{aligned}$$

Possible solution?

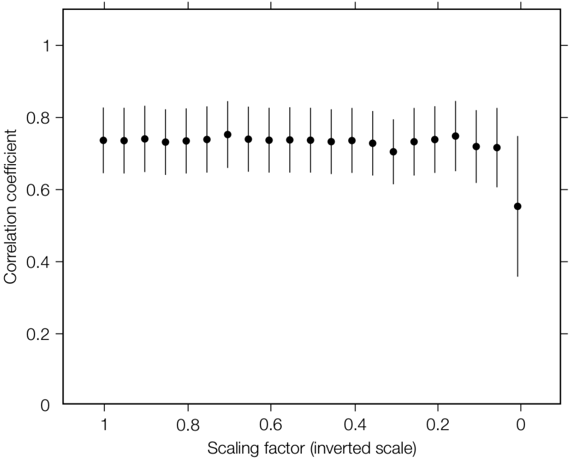
$$\begin{aligned} z_{nc}(s) &= \frac{s\mathbf{c_w}}{\|s\mathbf{c_w}\|} \cdot \mathbf{w_r} \\ &= \frac{\mathbf{c_w}}{\|\mathbf{c_w}\|} \cdot \mathbf{w_r} \\ &= \cos(\theta(\mathbf{c_w}, \mathbf{w_r})). \end{aligned}$$

Linear Correlation



E_FIXED_LC/D_LC.

Correlation Coefficients

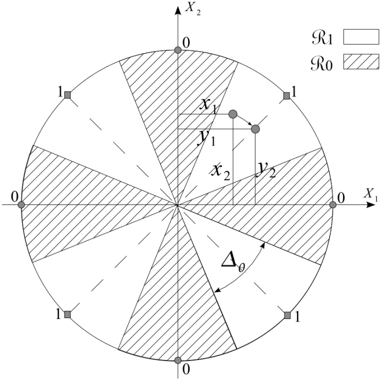


E_BLK_FIXED_R/D_BLK_CC.

z_{nc} with Dirty Paper

Angle QIM (Ourique et al. ICASSP 2005.):

- Snap work to the closest "grid angle".



2-Dimensional Case

- Choosing two bases $\mathbf{X}_1, \mathbf{X}_2$.
- Get coordinates x_1, x_2.
- Evaluate the length and angle:

$$r = \sqrt{x_1^2 + x_2^2}, \quad \theta = \arctan(x_2/x_2).$$

- Angle QIM:

$$\theta^Q = Q_{m,\Delta}(\theta) = \left\lfloor \frac{\theta + m\Delta}{2\Delta} \right\rfloor 2\Delta + m\Delta.$$

- Restore:

$$x_1' = r\cos(\theta^Q), \quad x_2' = r\sin(\theta^Q).$$

L-Dimensional Case

- L bases: $\mathbf{X}_i, i = 1, \cdots, L$.
- L coordinates: $\mathbf{x}_i, i = 1, \cdots, L$.
- $L - 1$ angles: $\mathbf{x}_i, i = 1, \cdots, L - 1$.

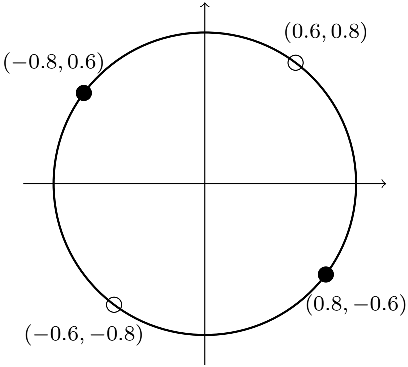
$$\theta_1 = \arctan(x_2/x_1)$$
$$\theta_i = \arctan \frac{x_{i+1}}{\sqrt{\sum_{k=1}^{i} x_k^2}}, i = 2, \cdots L - 1.$$

- Restore:

$$x'_1 = r \Pi_{k=1}^{L-1} \cos \theta_k^Q$$
$$x'_i = r \sin \theta_{i-1}^Q \Pi_{k=i}^{L-1} \cos \theta_k^Q, i = 2, \cdots, L.$$

Question: AQIM

	$(\sqrt{5}, 2)$	$(\sqrt{7}, -3)$
0		
1		



Circle is for 0*, dot is for* 1*.*