

Side-Informed Steganography with Additive Distortion

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Side-Informed Steganography



P

RAW

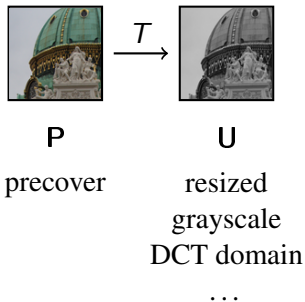
high resolution

high bit depth

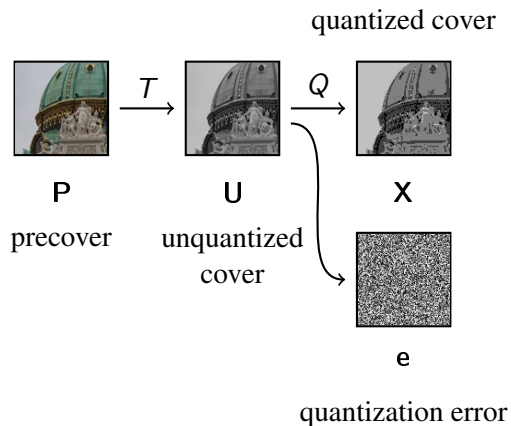
uncompressed

...

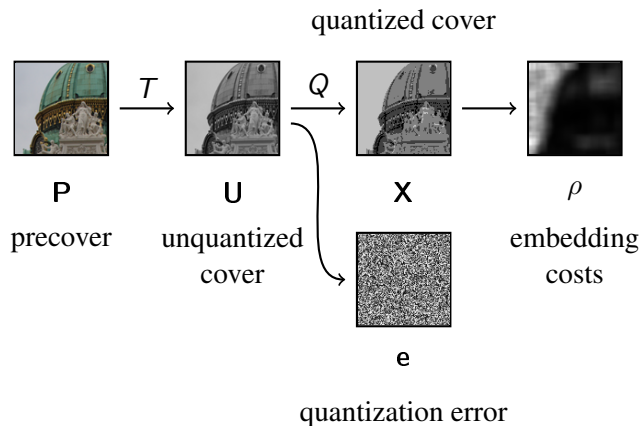
Side-Informed Steganography



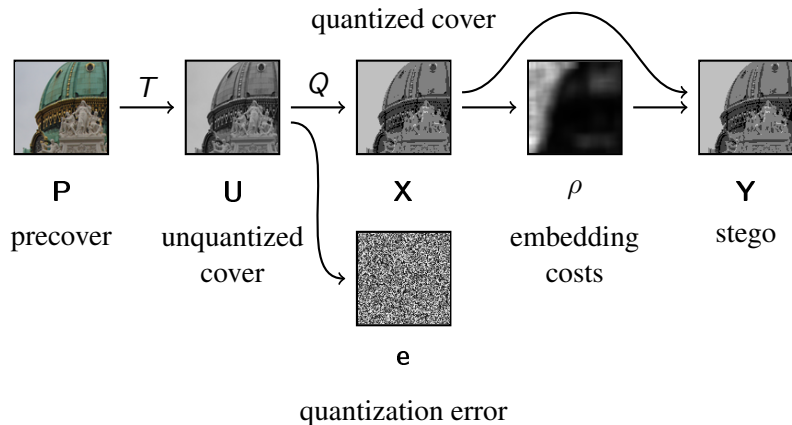
Side-Informed Steganography



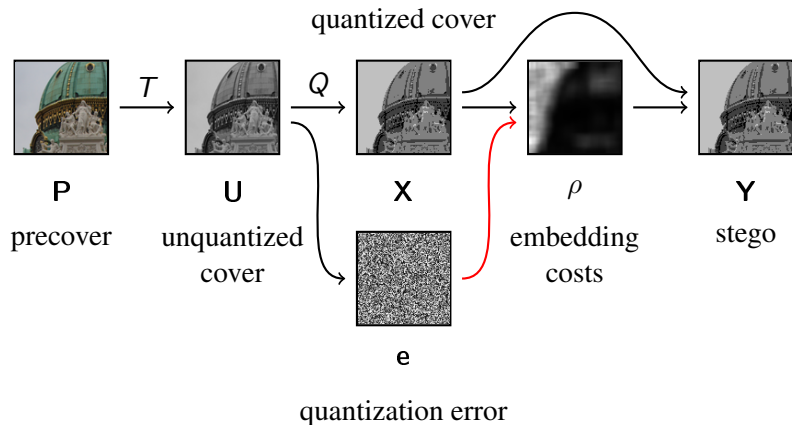
Side-Informed Steganography



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Previous Art

GIF

Embedding-while-dithering [Fridrich, IHW 1999]

JPEG

Perturbed Quantization [Fridrich, ACM MMSec 2004]

MME_x [Kim, IHW 2006]

BCHopt [Sachnev, ACM MMSec 2009]

EBS [Wang, ICASSP 2012]

NPQ [Huang, ACM IH&MMSec 2013]

SI-UNIWARD [Holub, ACM IH&MMSec 2013]

UED [Guo, TIFS 2014]

UERD [Guo, TIFS 2015]

Previous Art (cont'd)

Embedding limited to **binary** operation
Either rounding as is or "to the other side"

Changing an element "to the other side"
has positive cost

MME_x:

$$\rho_{ij} = 1 - 2|e_{ij}|$$

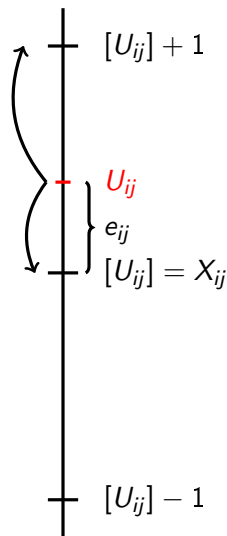
BCHopt: (simplified)

$$\rho_{ij} = (q(1 - 2|e_{ij}|)/2)^2,$$

q is the quantization step

SI-UNIWARD:

$$\rho_{ij} = (1 - 2|e_{ij}|)\rho_{ij}^{(J-\text{UNIWARD})}$$



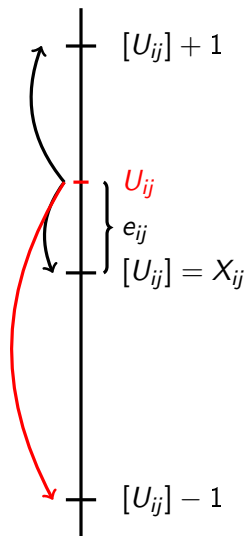
Proposed Method – Cost Modulation

Applicable to any additive stego scheme \mathcal{A}
that uses costs $\rho_{ij}^{(\mathcal{A})}$

Ternary embedding instead of binary

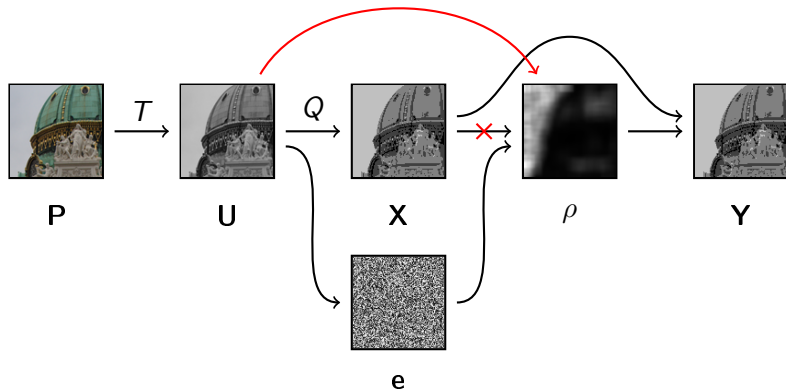
General formula for modulating the costs

$$\begin{aligned} \rho_{ij} &= (|U_{ij} - Y_{ij}| - |U_{ij} - X_{ij}|) \rho_{ij}^{(\mathcal{A})} \\ &= \begin{cases} (1 - 2|e_{ij}|) \rho_{ij}^{(\mathcal{A})} & Y_{ij} = X_{ij} + \text{sign}(e_{ij}) \\ 0 & Y_{ij} = X_{ij} \\ \rho_{ij}^{(\mathcal{A})} & Y_{ij} = X_{ij} - \text{sign}(e_{ij}) \end{cases} \end{aligned}$$



Proposed Method – Cost Generation

Costs extracted from the **unquantized** cover rather than the quantized cover



Experimental Setup

Precover source:

BOSSBase v1.01 consisting of 10000 full resolution RAW image files

Unquantized covers:

Images converted using `ufraw` to RGB TIFF. All further processing was done in Matlab rather than ImageMagick.

Feature set:

Spatial Rich Model (dim 34671) [Fridrich, TIFS 2012]

J+SRM [Kodovský, SPIE 2012]

Classifier:

Ensemble of FLDs [Kodovský, TIFS 2012]

Performance measure:

Average out-of-bag error \bar{E}_{OOB} (estimate of $P_E = \frac{1}{2} (P_{FA} + P_{MD})$)

SI and Processing Considered

Spatial domain

HILL [Li, IEEE ICIP 2014]

S-UNIWARD [Holub, EURASIP 2014]

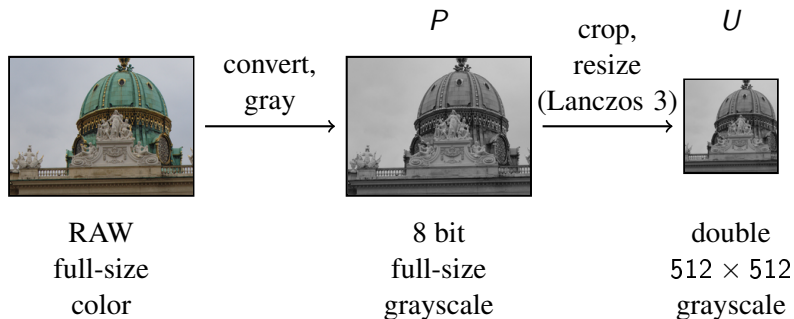
Resizing, Color Conversion, Quantization

JPEG domain

J-UNIWARD [Holub, EURASIP 2014]

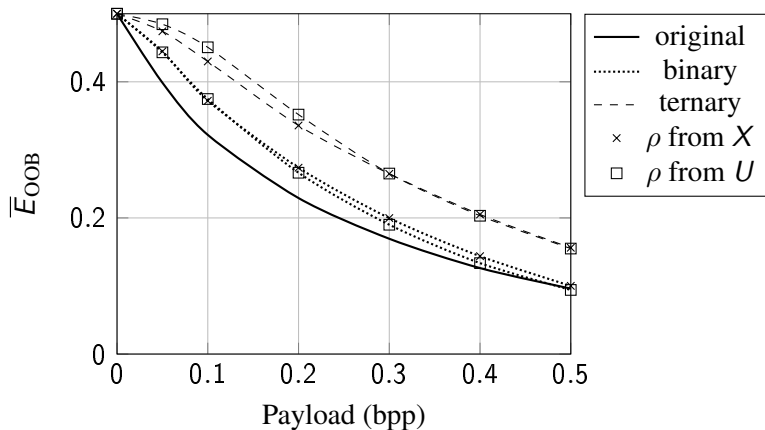
JPEG Compression

Experiment 1 - Resizing

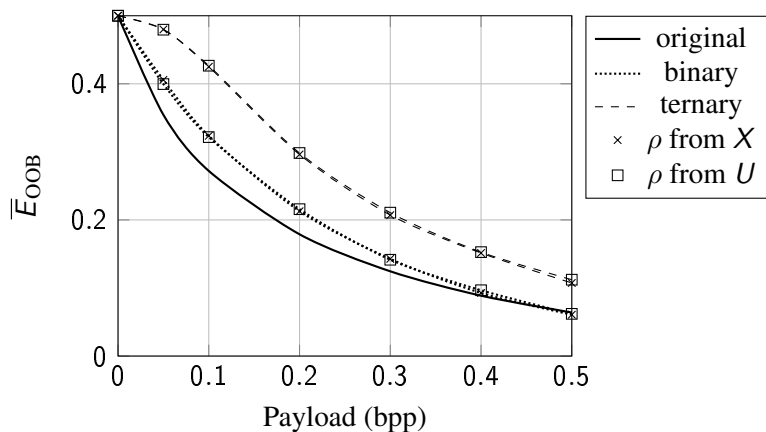


ufraw output: 24bit TIFF

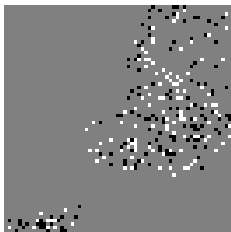
Experiment 1 – Resizing (HILL)



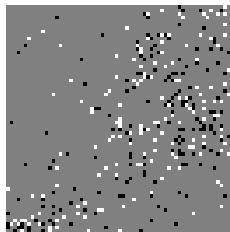
Experiment 1 – Resizing (S-UNIWARD)



Resizing – Selection Channel



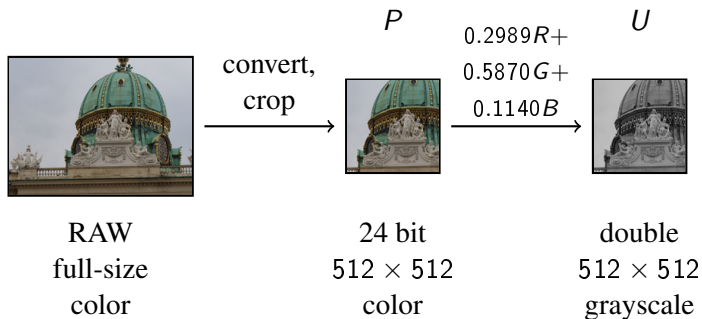
HILL 0.4 bpp



SI-HILL

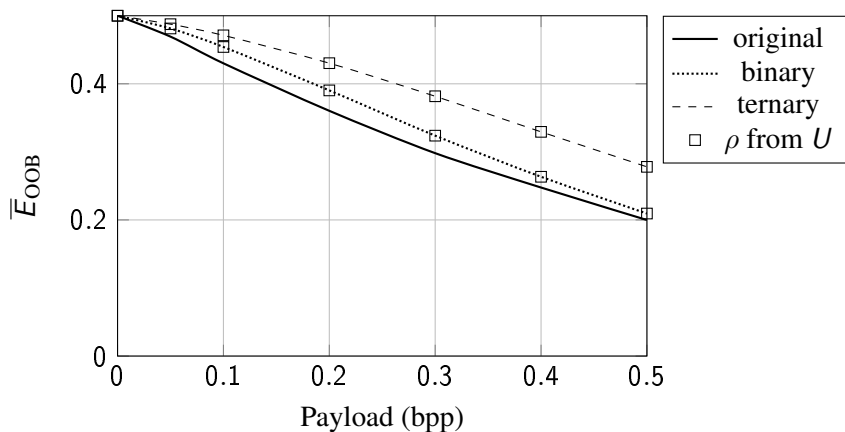
Last operation before quantizing: Resizing with Lanczos 3 in Matlab

Experiment 2 – Color Conversion

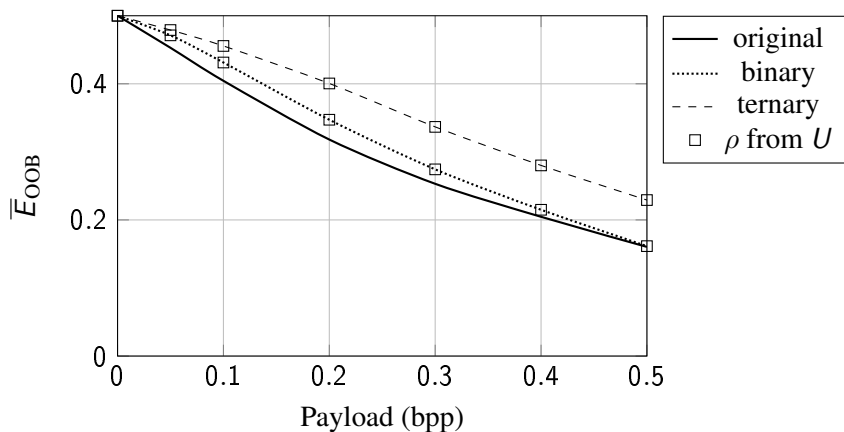


ufraw output: 24bit TIFF

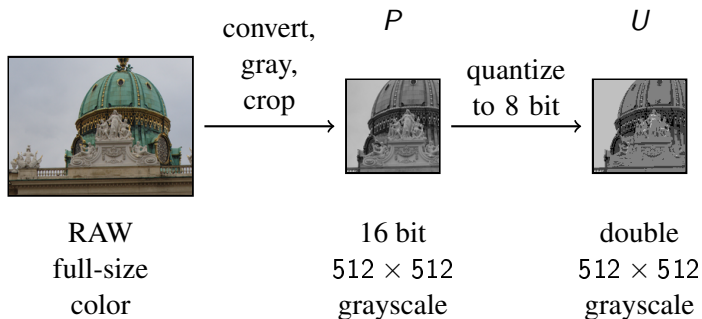
Experiment 2 – Color Conversion (HILL)



Experiment 2 – Color Conversion (S-UNIWARD)

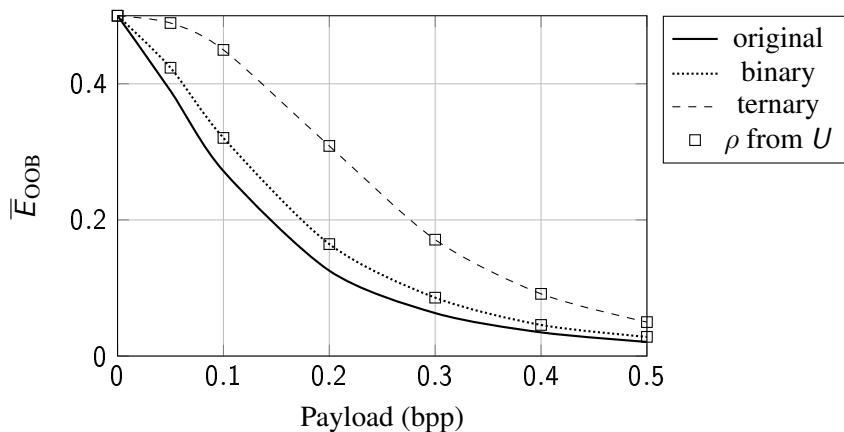


Experiment 3 – Quantization

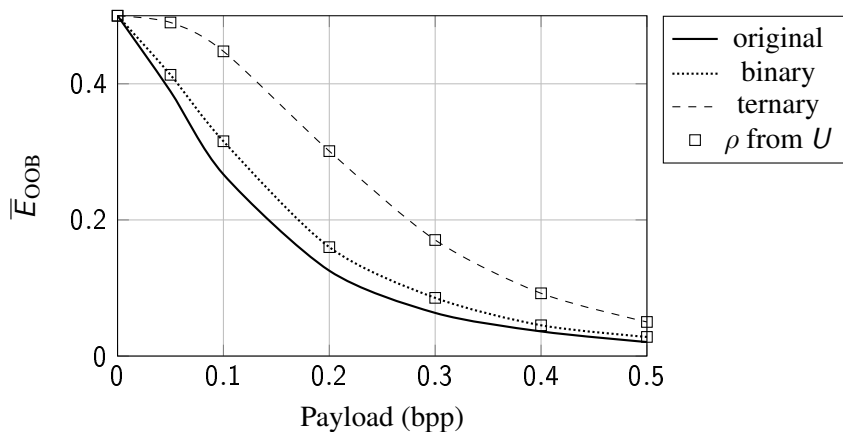


ufraw output: 48bit TIFF

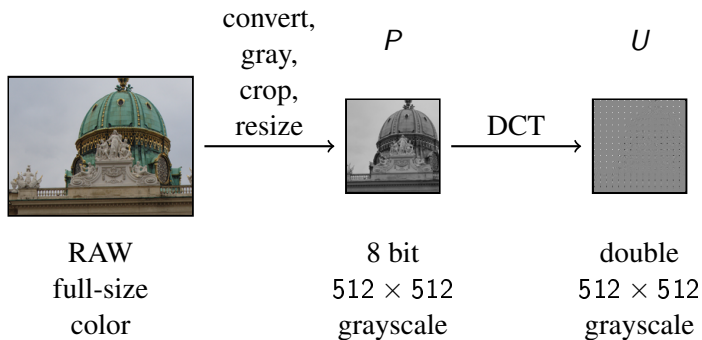
Experiment 3 – Quantization (HILL)



Experiment 3 – Quantization (S-UNIWARD)

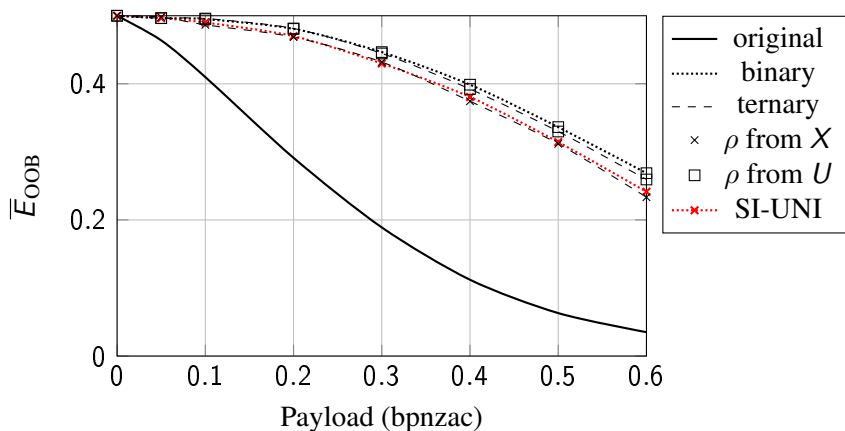


Experiment 4 – JPEG Compression



ufraw output: 24bit TIFF

Experiment 4 – JPEG Compression (J-UNIWARD, QF 75)



Conclusion

We present general steganographic method of using side-information for
any domain
any cost-based steganography
any transformation with quantization

Improves on previous state-of-the-art by
allowing ternary embedding (effective when quantization is fine)
extracting the costs from the unquantized cover (effective when
quantization is coarse)

Source codes available at dde.binghamton.edu/download