

# Side-Informed Steganography with Additive Distortion

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# Side-Informed Steganography



P

RAW

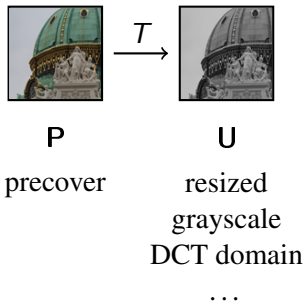
high resolution

high bit depth

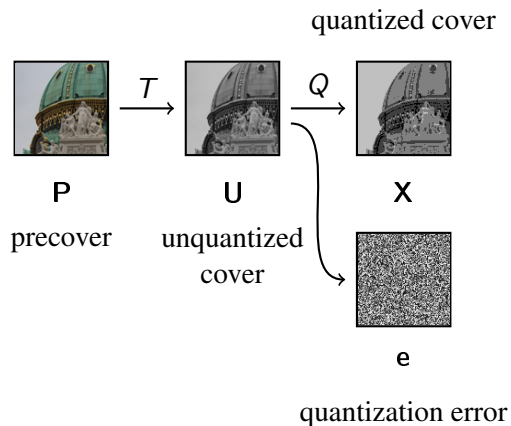
uncompressed

...

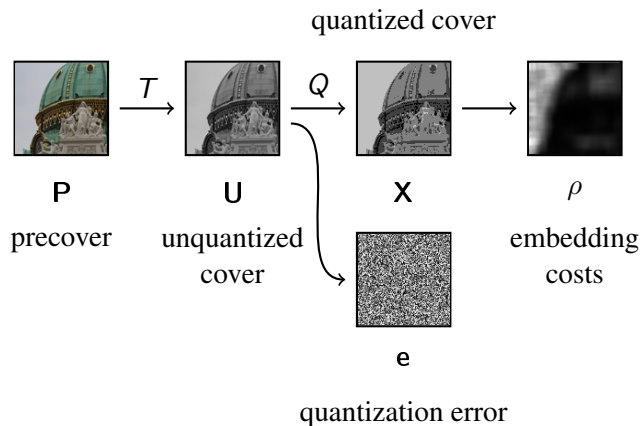
# Side-Informed Steganography



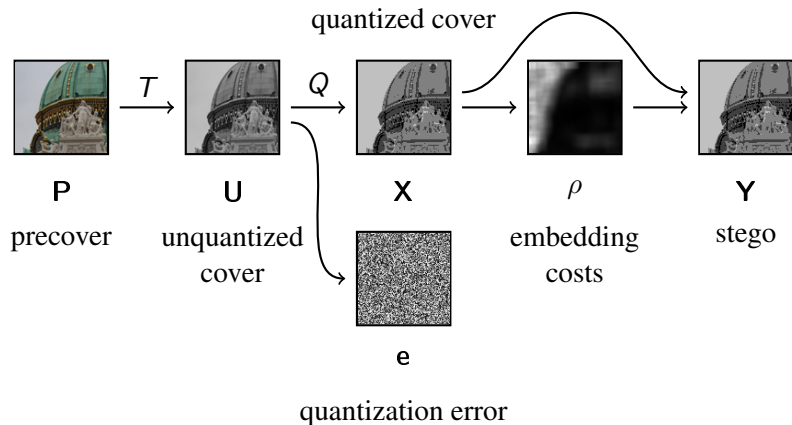
# Side-Informed Steganography



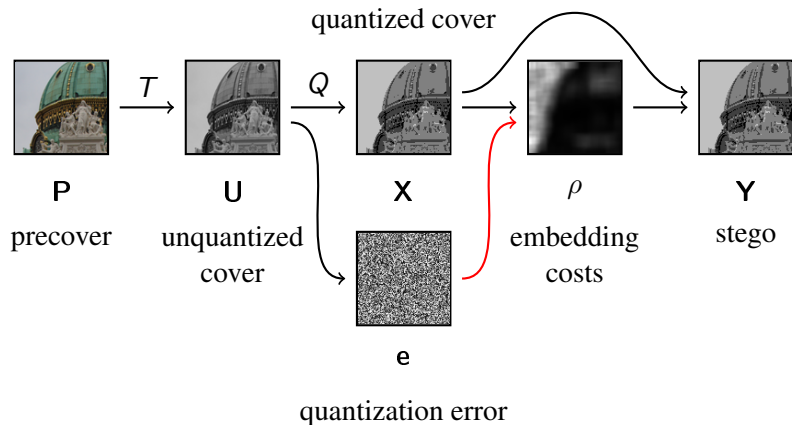
# Side-Informed Steganography



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## Previous Art

### **GIF**

Embedding-while-dithering [Fridrich, IHW 1999]

### **JPEG**

Perturbed Quantization [Fridrich, ACM MMSec 2004]

MME<sub>x</sub> [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<sub>x</sub>:

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

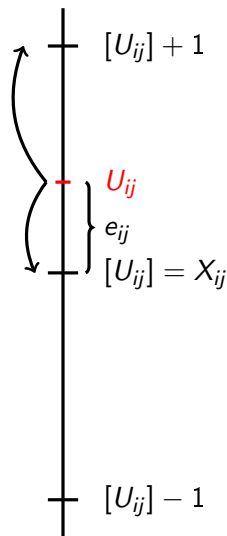
### BCHopt: (simplified)

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

$q$  is the quantization step

### SI-UNIWARD:

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



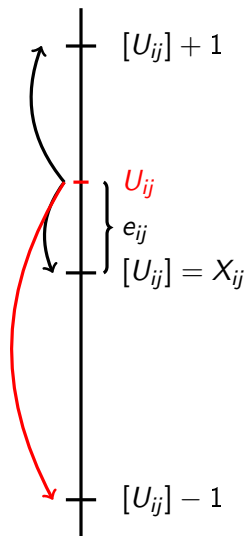
# Proposed Method – Cost Modulation

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

**Ternary** embedding instead of binary

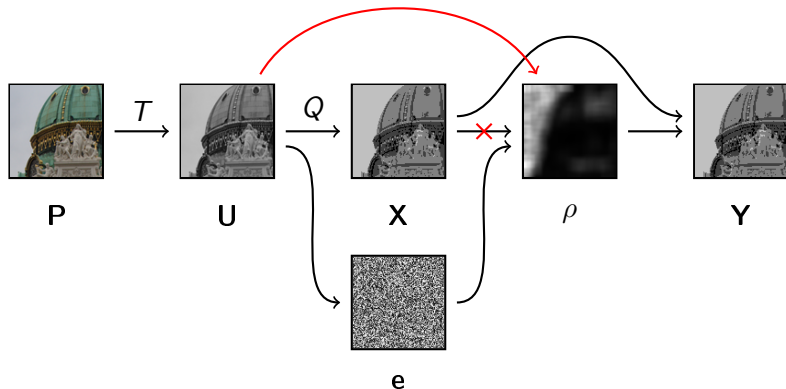
**General** formula for modulating the costs

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



## 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  $\bar{E}_{\text{OOB}}$  (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]

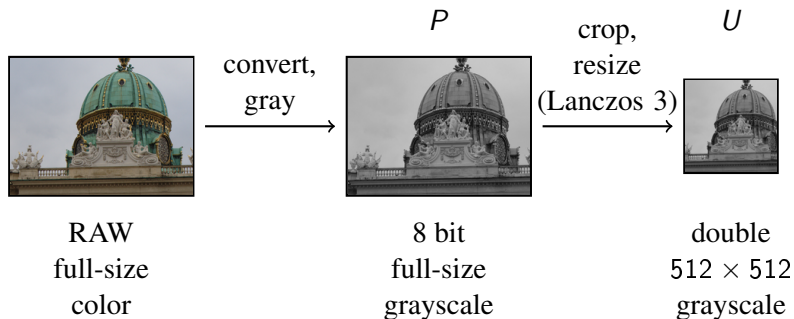
Resizing, Color Conversion, Quantization

## **JPEG domain**

J-UNIWARD [Holub, EURASIP 2014]

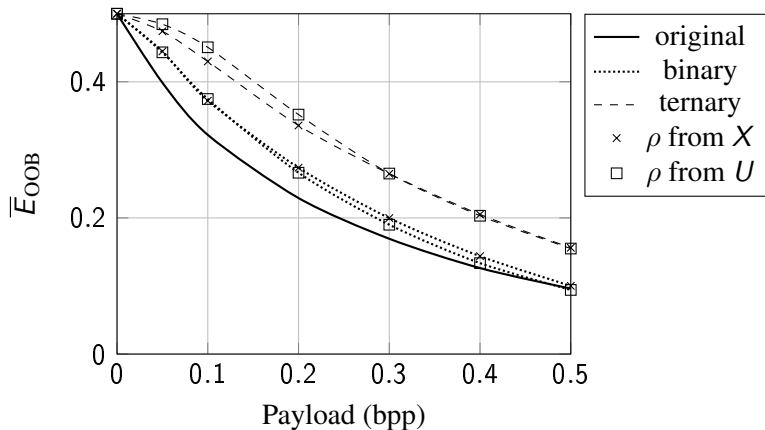
JPEG Compression

# Experiment 1 - Resizing

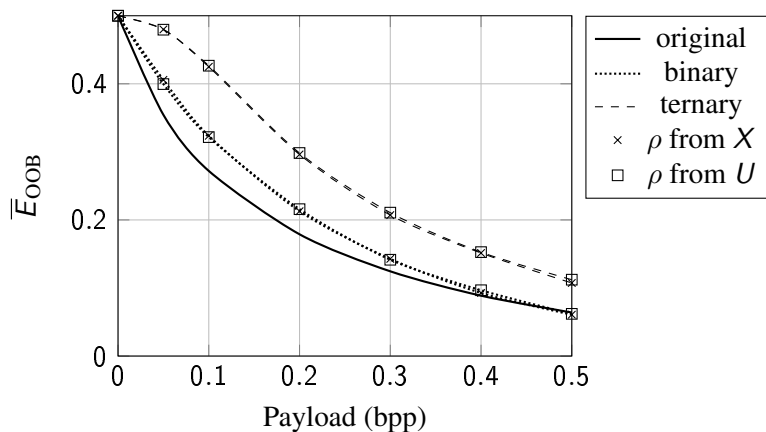


ufraw output: 24bit TIFF

# Experiment 1 – Resizing (HILL)

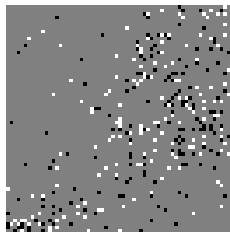
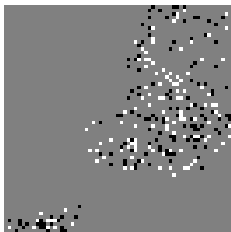
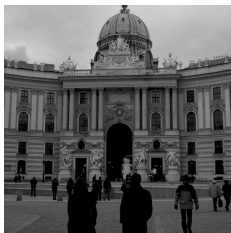


# Experiment 1 – Resizing (S-UNIWARD)





## Resizing – Selection Channel

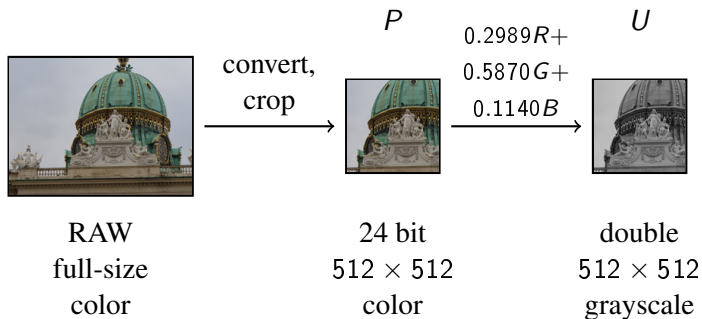


HILL 0.4 bpp

SI-HILL

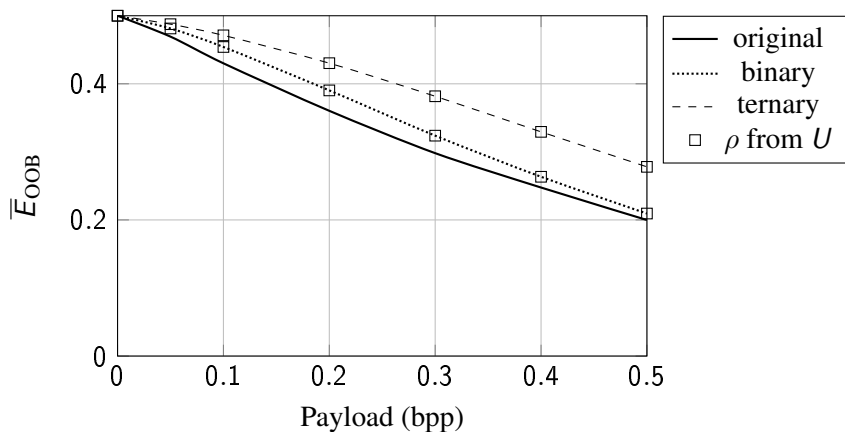
Last operation before quantizing: Resizing with Lanczos 3 in Matlab

## Experiment 2 – Color Conversion

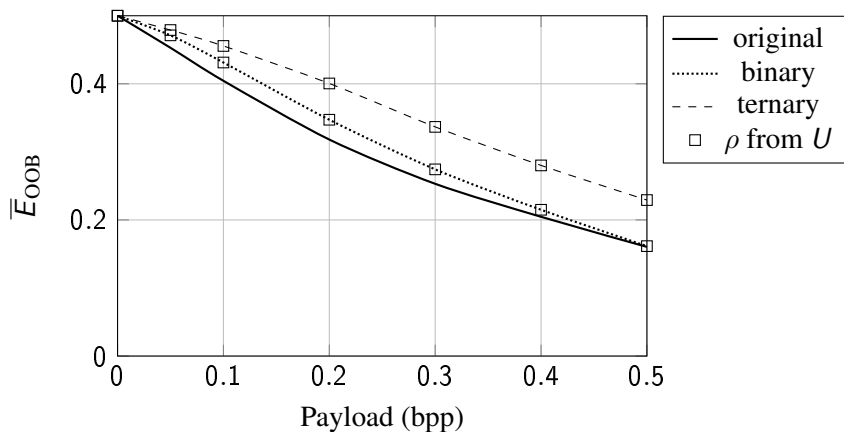


ufraw output: 24bit TIFF

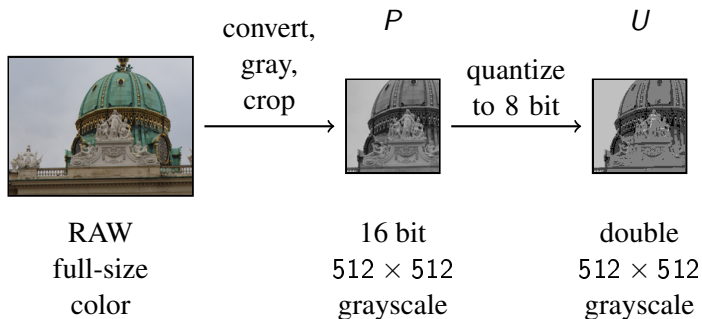
## Experiment 2 – Color Conversion (HILL)



## Experiment 2 – Color Conversion (S-UNIWARD)

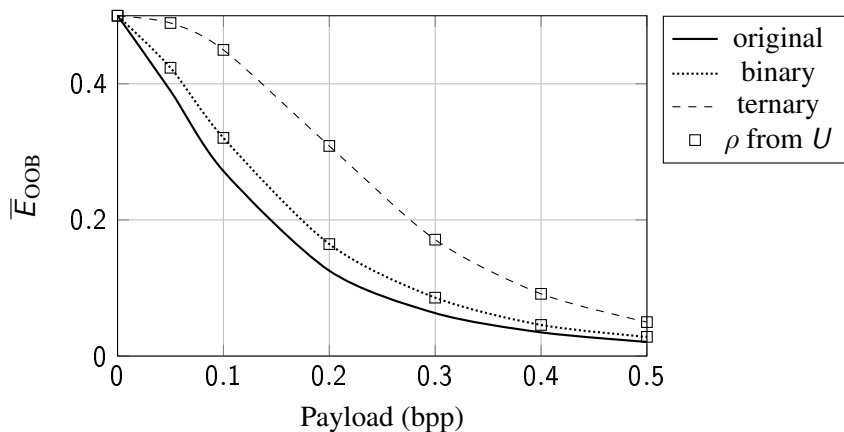


## Experiment 3 – Quantization

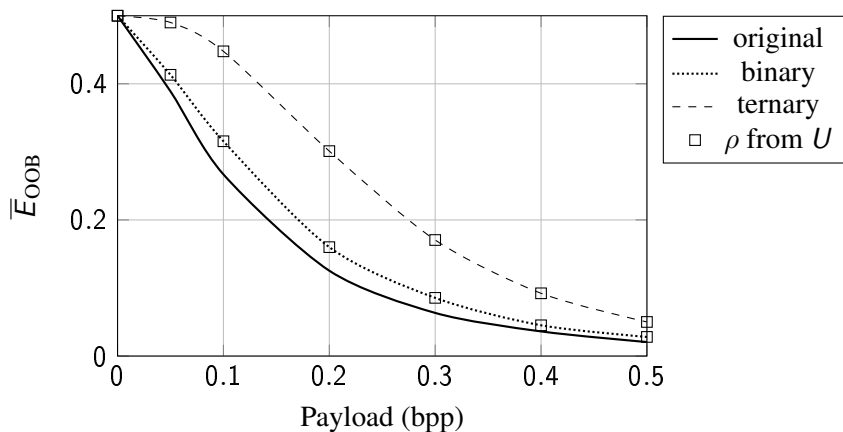


ufraw output: 48bit TIFF

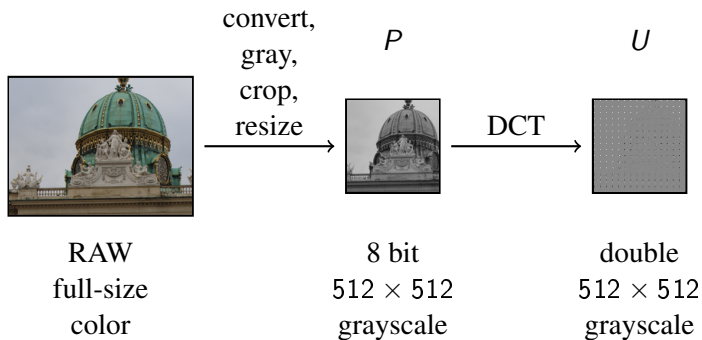
## Experiment 3 – Quantization (HILL)



## Experiment 3 – Quantization (S-UNIWARD)



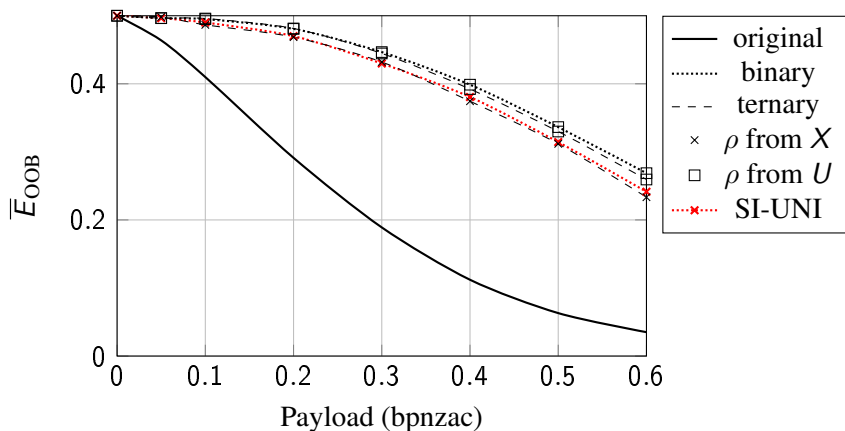
## Experiment 4 – JPEG Compression



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](http://dde.binghamton.edu/download)