Steganography

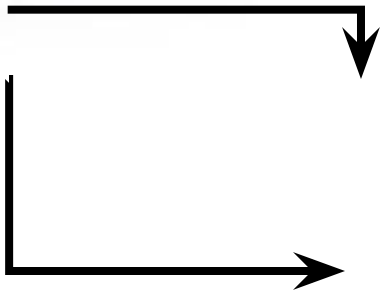
Prepared by: A H M Kamal

Multimedia Communications

What is Multimedia ?

Combination of Text, Video, Audio and other data

Multimedia



stored in digital storage

communication

Transfer of message, information is Called Multimedia Communication

Multimedia Communication Security

Multimedia Security

- Preventing unauthorized interceptors

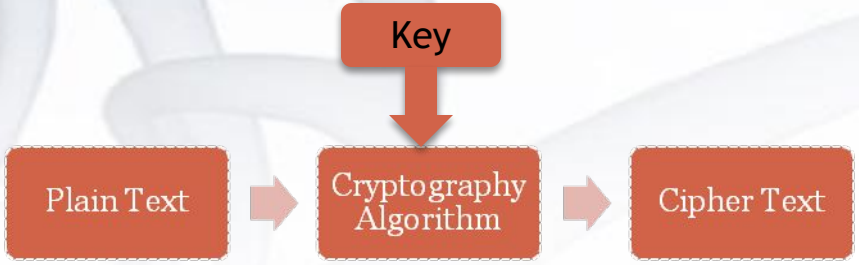
Multimedia Security Threats :

- Threats to stored multimedia
- Threats during communication
- Access level threats

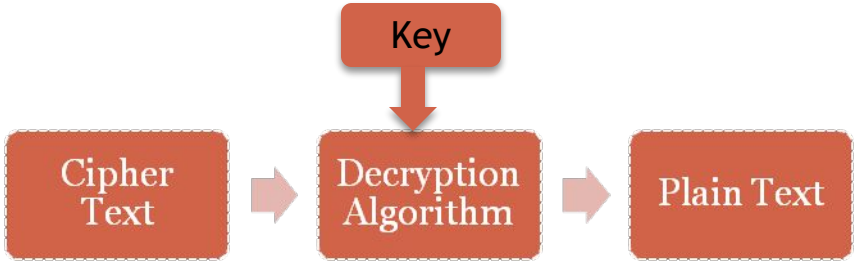
- Message alteration
- Leak and stealing of secured data

Cryptography

Encryption



Decryption

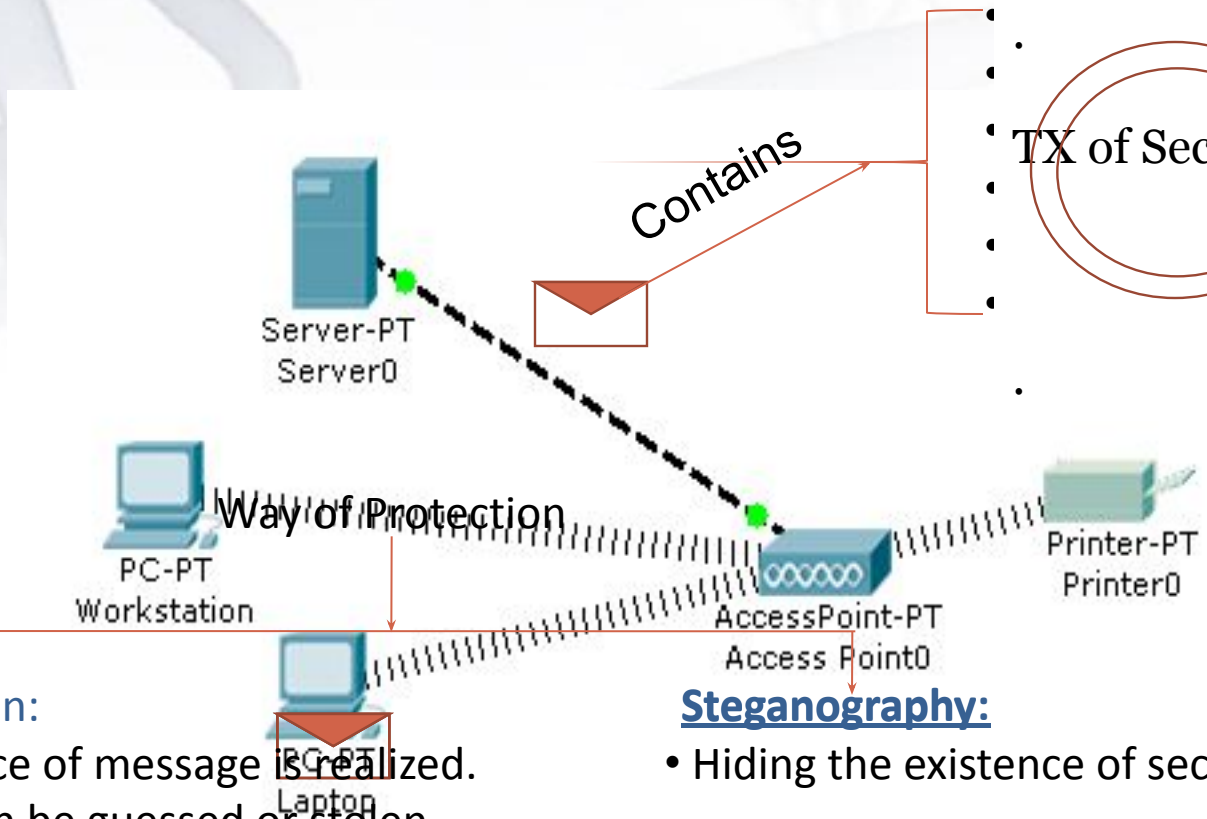


Cons of Cryptography

- Security key not unbreakable
- Security compromised if key is stolen
- Encrypted message can be identified and filtration is possible
- Message can be altered

Steganography solves these issues of Cryptography

Steganography



Steganography: Hiding Information

Step 1

Step 2

Step 3

Step 4

During Transmission nothing to suspect

Nothing to retrieve

Retrieving Back the Hided information

Pictorial view of Embedding Process

Cover Image

Embedding Algorithm

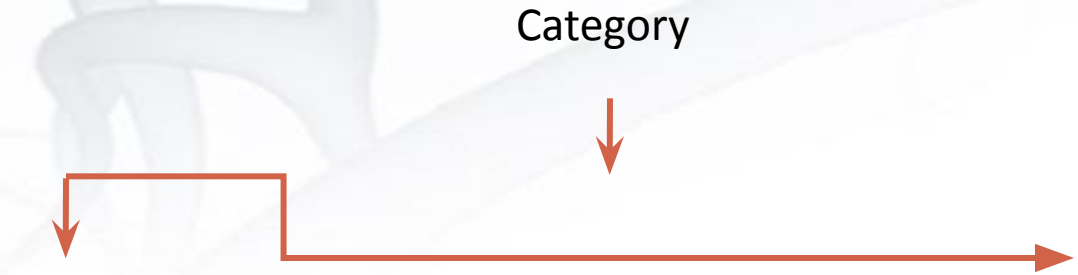
Stego Image

Message to be embedded

Any difference?

At least visually same.

Category: Based on Reversibility



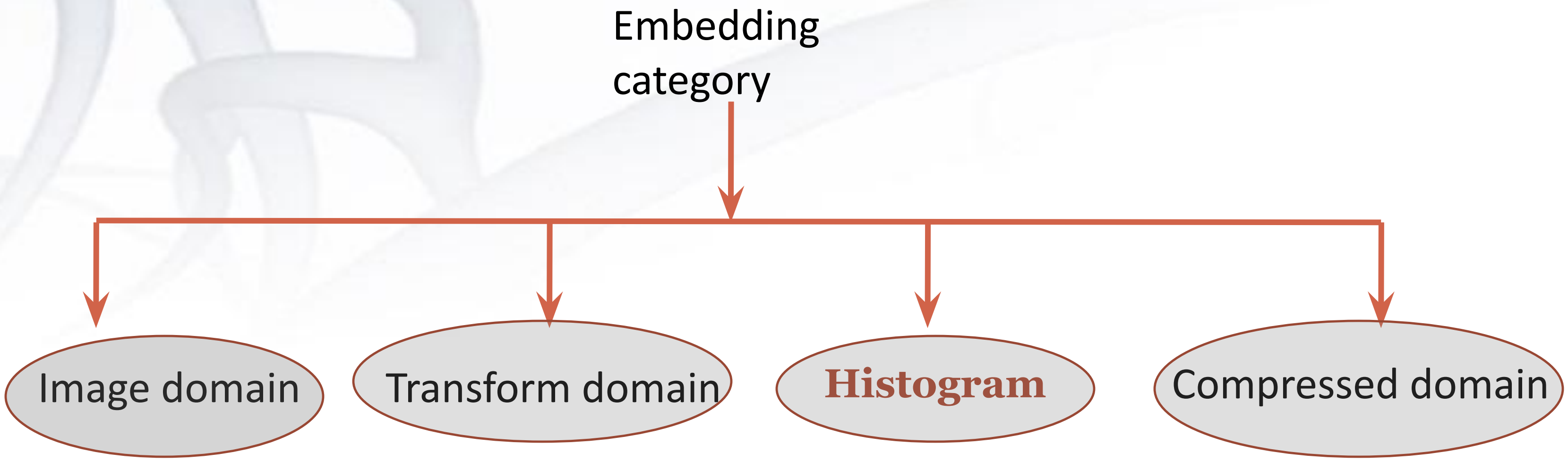
Lossy

if original image can not be retrieved

Loss less

if original image can be retrieved

Category: Based on Domain



Principle: embedding at pixel values
Common methods: LSB replacement, LSB matching, Add/Sub
Examples: Barl... (2003), Alattar (2004) ... Elsevier)

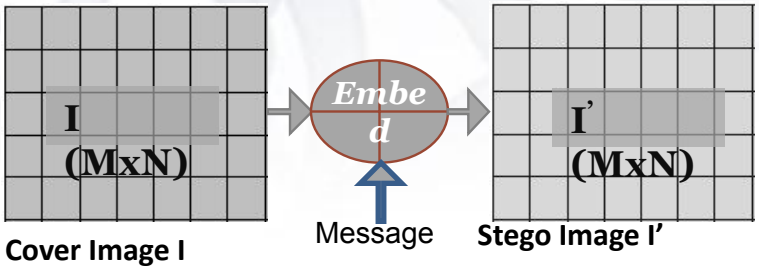
Principle: embedding ...
Common methods: wavelet, DCT, FFT ...
Examples: ... elsevier

Principle: embedding ...
Common method: ...
Example: Lin et al(... et al (2009), Tasi et al(2009), Wien et al (2010), Ni et al (2006)

Principle: first compression then embedding
Common method: Standard Compression algorithm+ embedding
Example: Chang et al(2007), Lu et al(2009)

Performance Parameters

1. Embedding Payload
   -How many message bits can be embedded.



Message: 0 1 0 1 0 0 1 … 1 0 0 1 …

Payload

2. Embedding capacity:
   - embedded bits per pixel (bpp)

$$capacity = \frac{number\ of\ bits\ embedded}{number\ of\ pixels\ in\ embedding\ space}\ bpp$$

3. PSNR: Peak Signal to Noise Ratio
   - To measure the visual quality

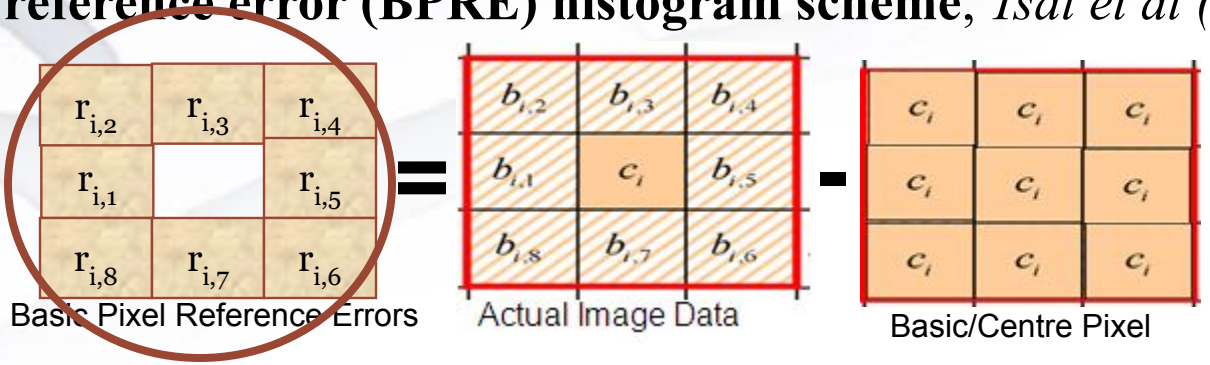
$$PSNR = 10 \times \log_{10} \frac{255^2}{MSE}\ (dB)$$

$$MSE = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} (I(i,j) - I'(i,j))^2$$

Where MSE: Mean Square Error

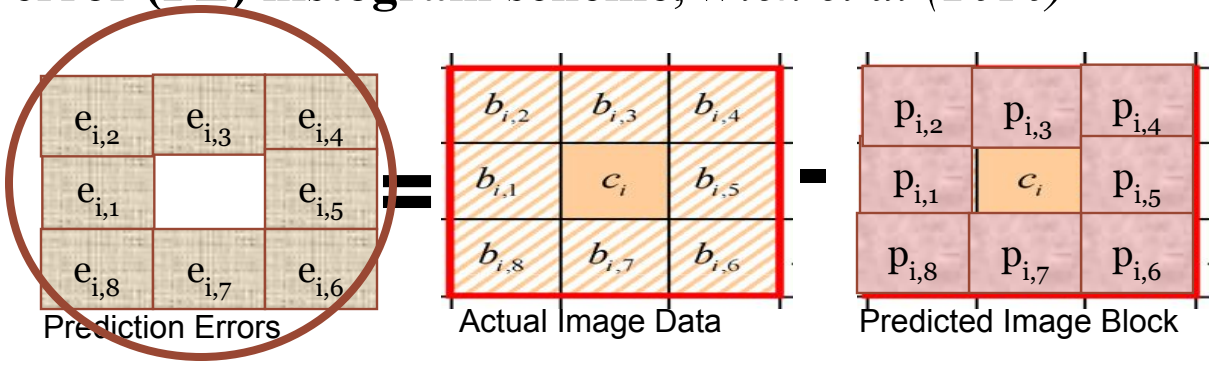
Error Histogram Steganography Schemes

1. **Basic pixel reference error (BPRE) histogram scheme**, *Tsai et al (2009)*



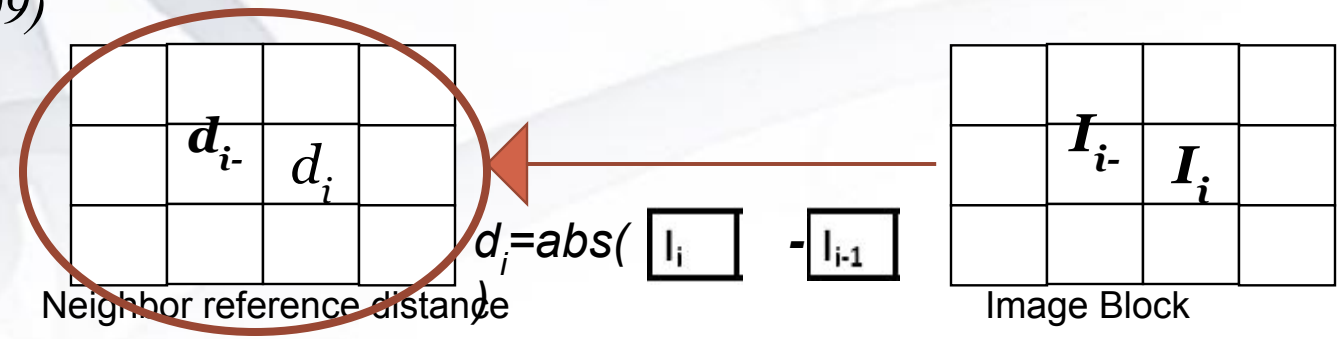
2. **Prediction error (PE) histogram scheme**, *Wien et al (2010)*

Embedding Space



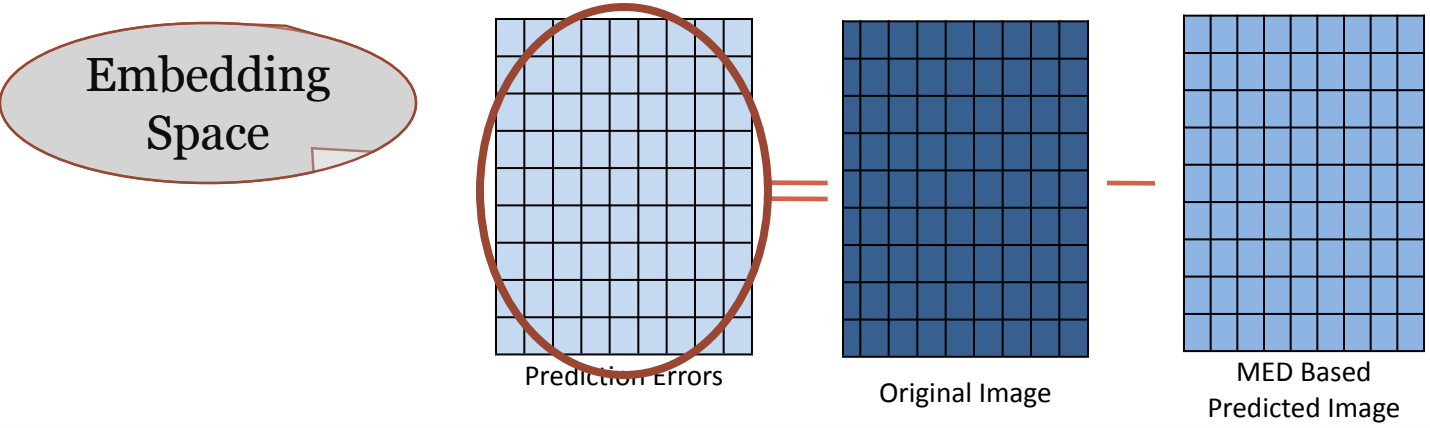
Error Histogram Steganography Schemes

3. **Neighbor pixel reference distance (NPRD) histogram scheme**, *Tai et al (2009)*



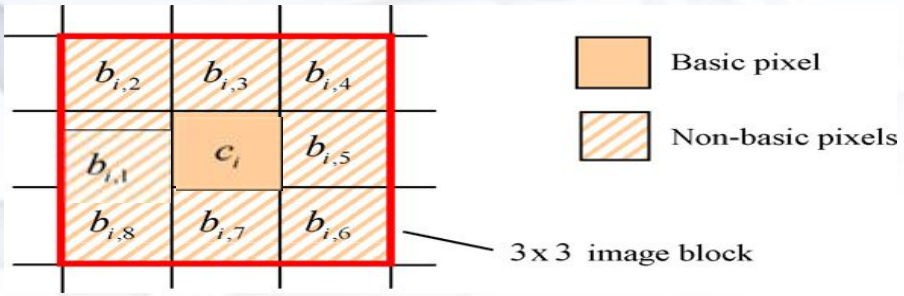
d_i is the neighbor reference error

4. **Median Edge Detection Based Prediction Error (MEDPE) histogram scheme**, *Wien Hong (2012)*



Basic pixel reference errors (BPRE) Scheme

1. Find **basic** and **non-basic** pixels

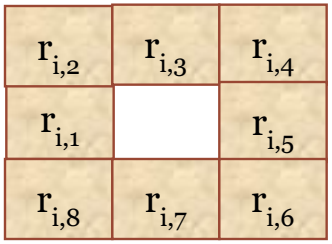


2. Find basic pixel reference error

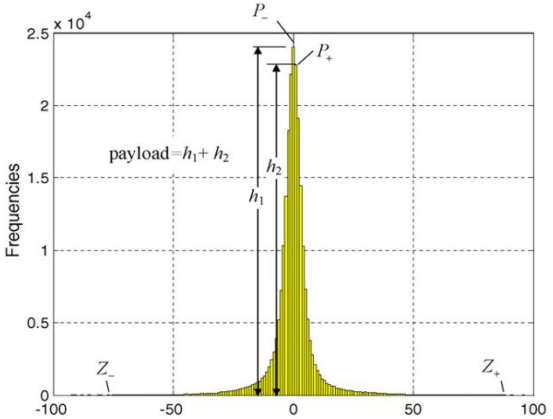
$$r_{i,j} = c_i - b_{i,j}, \quad 1 \le j \le 8$$

$r_{i,j}$ = -

3. Draw error histogram



BPRE



BPRE Histogram: h(i)

P_+: Position error with highest frequency
P_- : Negative error with highest frequency
Z_+: Highest positive error
Z_-: Highest negative error

h_1=Frequencies of P_- at histogram

h_2=Frequencies of P_+ at histogram

Z_+ P_- P_+ Z_-

BPRE Scheme Cont…

4. Entry to location map

Saturated pixels (0, 255) can't be used for embedding. So make a entry to location may.

250	0	255
230	220	210
0	251	255

Image block

Position of 0, 255 valued pixels

0,1	0,2	2,0
2,2	…	…
…	…	…

Location Map

5. Embedding process

if b≠0/255 then

$\tilde{r}_{i,j}=r_{i,j}+m \quad if\ r_{i,j}=P_+$

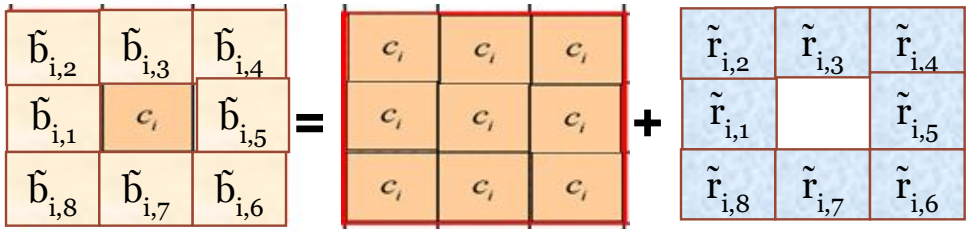
$r_{i,j}=r_{i,j}-m \quad if\ r_{i,j}=P_-$

Where m is message bit

Shift all other $r_{i,j}$ by 1 if $r_{i,j}>P_+$ and by -1 if $r_{i,j}<P_-$

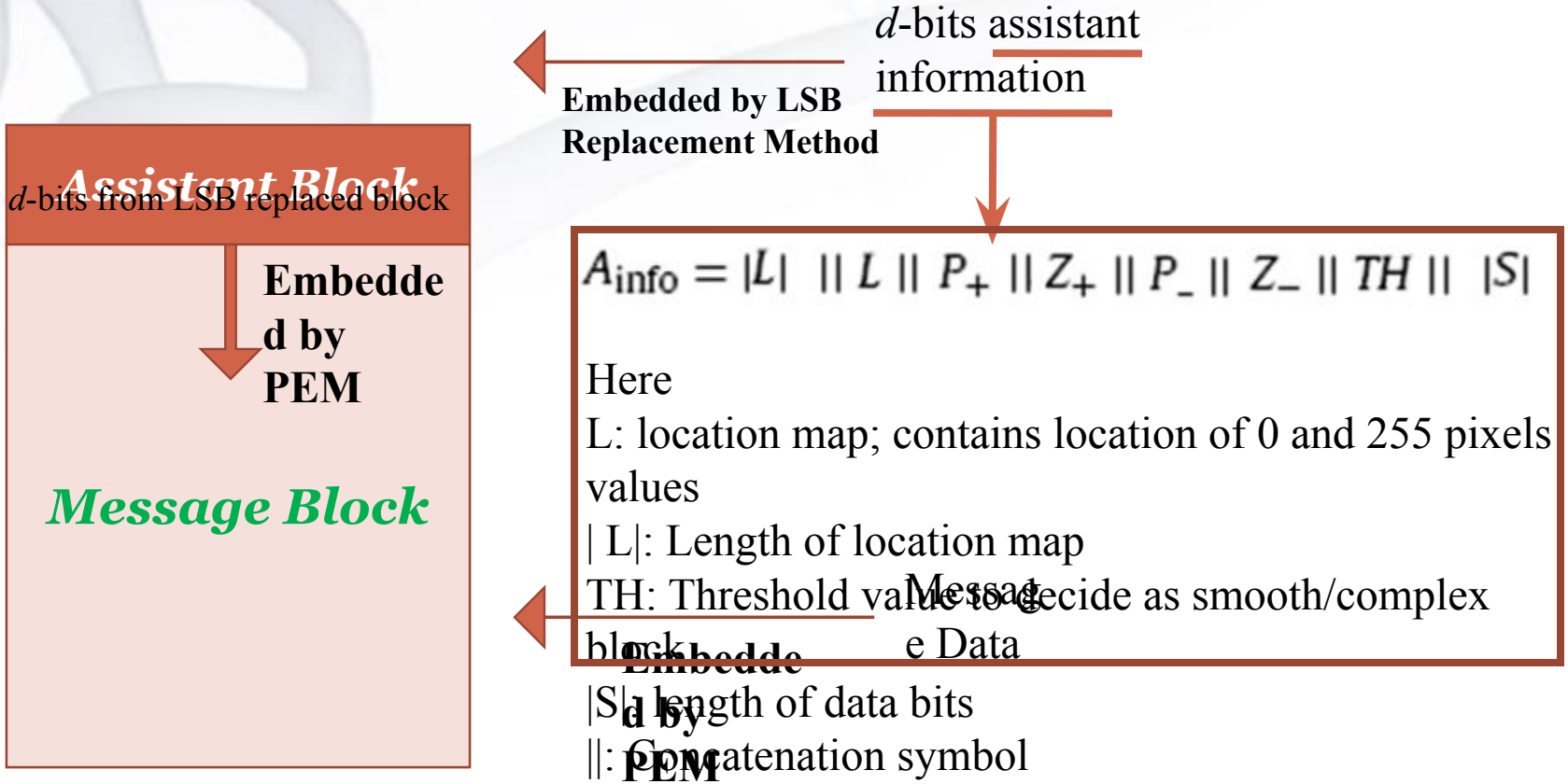
6. Calculating stego block

$$\tilde{b}_{i,j} \xleftarrow[forall j]{} c_i + \tilde{r}_{i,j}$$



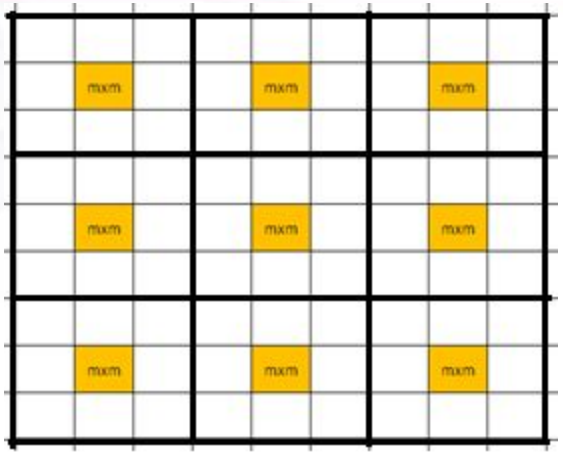
Prediction error (PE) histogram scheme

Divide cover image into assistant and message block

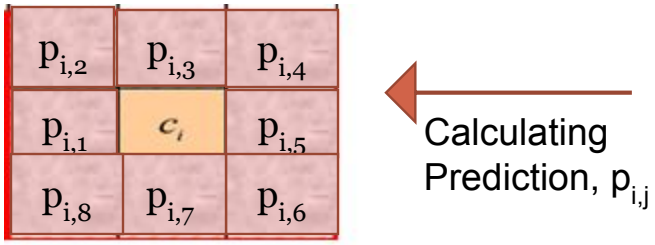


PE histogram scheme data embedding

1. Message block is divided into N mxm blocks.



2. Find four satellite basic pixels c_i^L, c_i^R, c_i^T c_i^B and calculate prediction values.



$$p_{i,1} = \text{round}(\tfrac{1}{3}(2c_i + c_i^L)),$$

$$p_{i,2} = \text{round}(\tfrac{1}{3}(c_i + c_i^L + c_i^T)),$$

$$p_{i,3} = \text{round}(\tfrac{1}{3}(2c_i + c_i^T)),$$

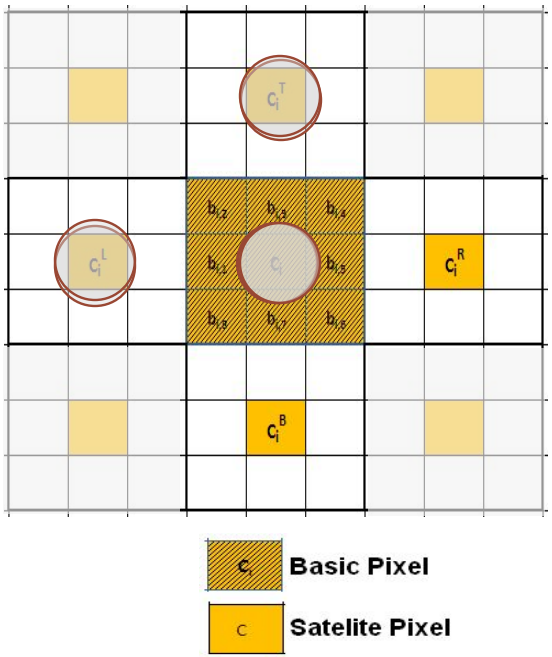
$$p_{i,4} = \text{round}(\tfrac{1}{3}(c_i + c_i^T + c_i^R)),$$

$$p_{i,5} = \text{round}(\tfrac{1}{3}(2c_i + c_i^R)),$$

$$p_{i,6} = \text{round}(\tfrac{1}{3}(c_i + c_i^R + c_i^B)),$$

$$p_{i,7} = \text{round}(\tfrac{1}{3}(2c_i + c_i^B)),$$

$$p_{i,8} = \text{round}(\tfrac{1}{3}(c_i + c_i^B + c_i^L)),$$



PE histogram scheme data embedding

3. Decide block as complex/smooth

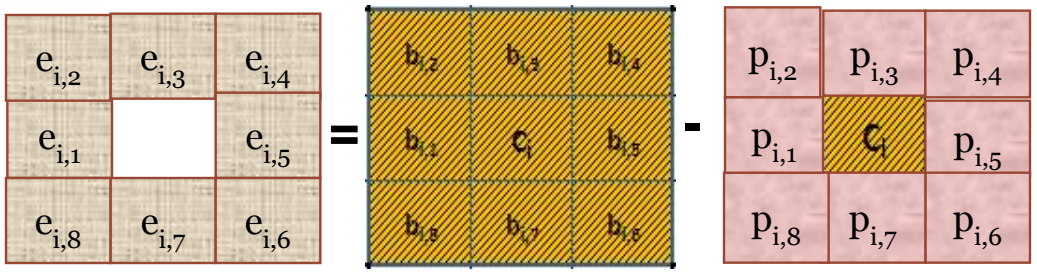
$$\mathrm{var}(c_i) = \frac{1}{5}\left((c_i - c_m)^2 + (c_i^L - c_m)^2 + (c_i^R - c_m)^2 + (c_i^T - c_m)^2 + (c_i^B - c_m)^2\right),$$

Block is complex if $\mathrm{var}(c_i) > TH$

Smooth Otherwise

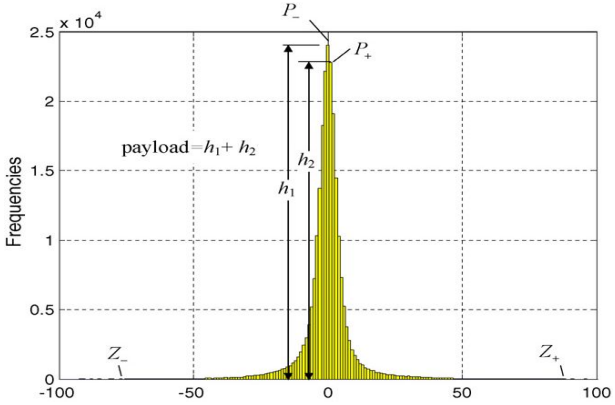
4. Calculate errors

$$e_{i,j} \xleftarrow[\forall j]{} b_{i,j} - p_{i,j}$$



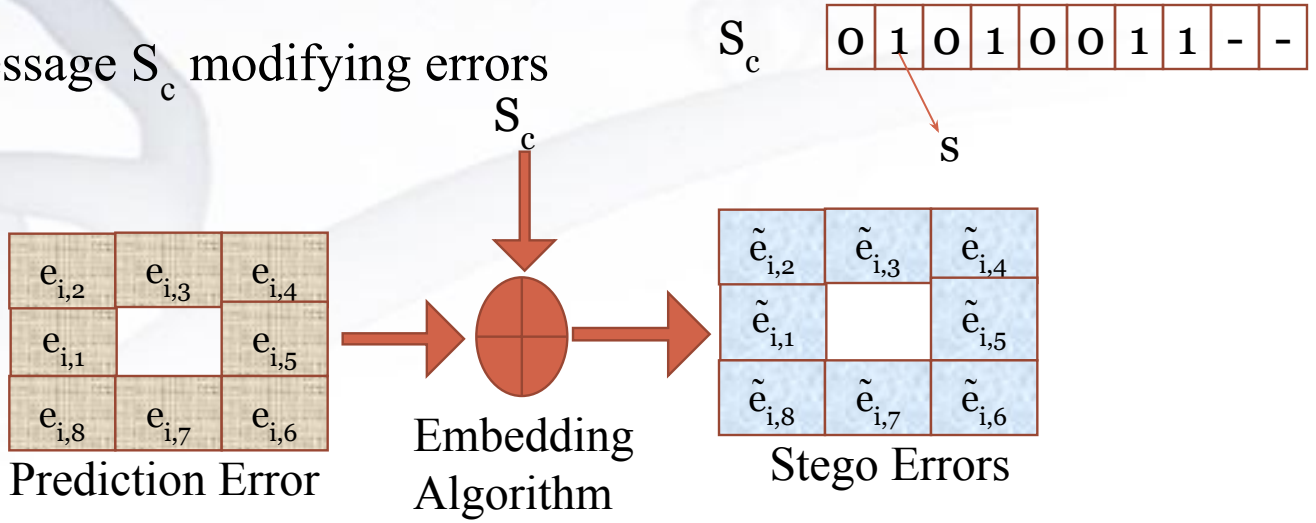
5.1. Draw error's histogram

5.2. Find (P_+, Z_+) and (P_-, Z_-)



PE histogram scheme data embedding

6. Embed message S_c modifying errors



a) Embedding at positive peak

$\tilde{e}_{i,j}=e_{i,j}+s$ if $e_{i,j}=P_+$

b) Embedding at negative peak

$\tilde{e}_{i,j}=e_{i,j}-s$ if $e_{i,j}=P_-$

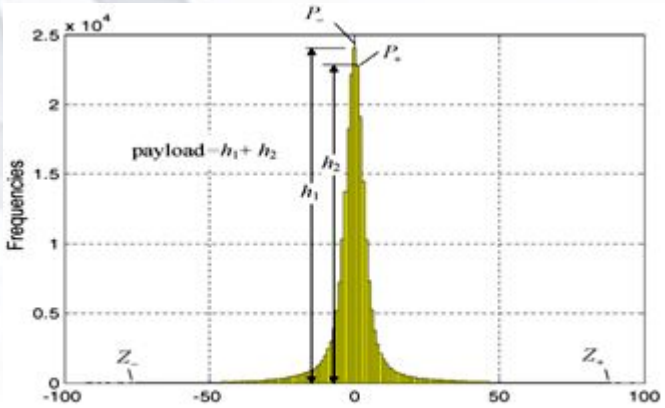
c) Not embedding but shifting

If $e_{i,j}\neq P_+$ or P_- Then
Shift $e_{i,j}$ by 1 if $e_{i,j}>P_+$ and
by -1 if $e_{i,j}<P_-$

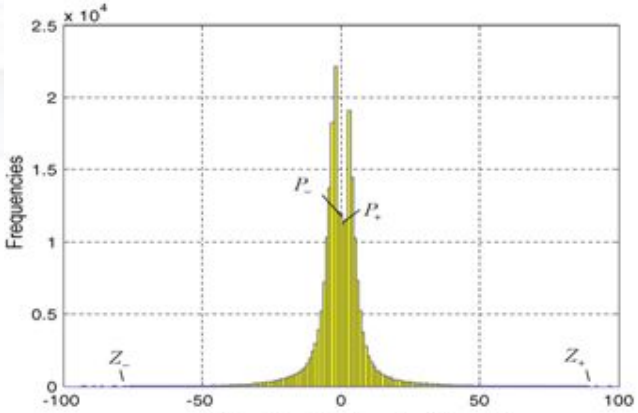
Where s is message bit

PE histogram scheme data embedding

Changes in histogram



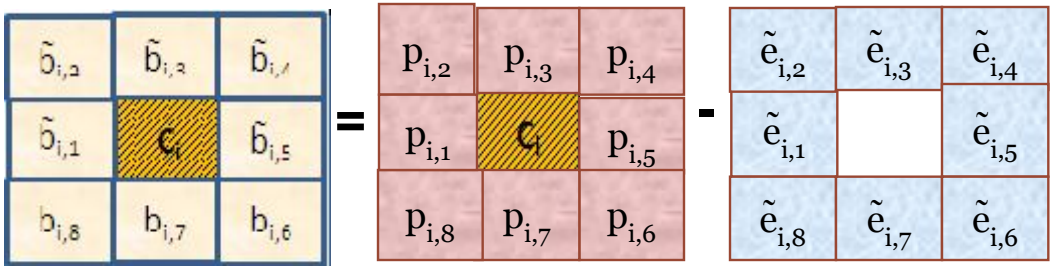
Prediction Error Histogram



Stego Error Histogram

7. Calculate Stego Image Block

$$\tilde{b}_{i,j} \xleftarrow[\forall j]{} p_{i,j} + \tilde{e}_{i,j}$$



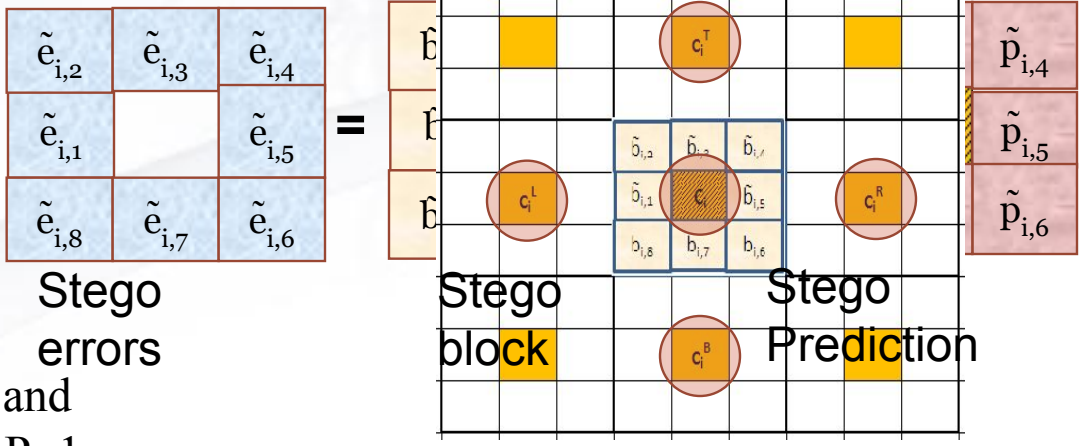
Stego matrix | Prediction matrix | Error matrix

Message embedding is done!!

PE histogram scheme data extraction

1. Measure predicted values
   No change in c_i and
   $c_i^L, c_i^R, c_i^T, c_i^B$ so p_{ij}. So

$$e_{i,j} \xleftarrow[\forall j]{} b_{i,j} - p_{i,j}$$



2. Extract message bit s

   s=0 if $\tilde{e}_{i,j}=P_+$ or $\tilde{e}_{i,j}=P_-$ and

   s=1 if $\tilde{e}_{i,j}=P_+ +1$ or $\tilde{e}_{i,j}=P_- -1$

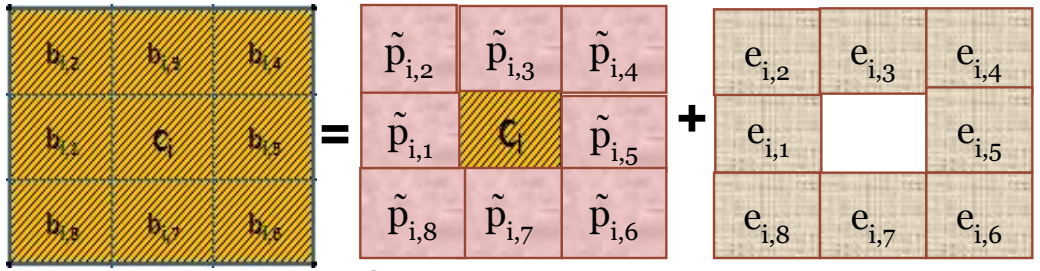
3. Calculate prediction errors

   $e_{i,j}=\tilde{e}_{i,j}-1$ if $\tilde{e}_{i,j}>P_+$

   $e_{i,j}=\tilde{e}_{i,j}+1$ if $\tilde{e}_{i,j}<P_-$

   $e_{i,j}=\tilde{e}_{i,j}$ otherwise

4. Reconstruction of original image



Extraction is done!!