Lecture 15-1-Digital Watermarking

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Watermarking

We all like watermarks，so charming···

Purpose of Digital Watermarking

➢ Anti-counterfeiting（防伪）：

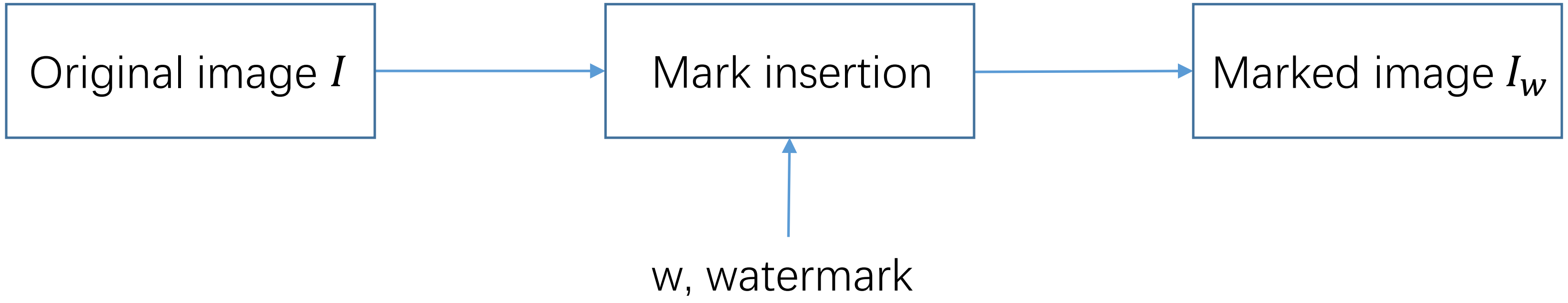
Embedding information into an image, so that:

- Image seems unchanged
- Watermark can be extracted even after processing.
- Removing watermark should destroy the image.

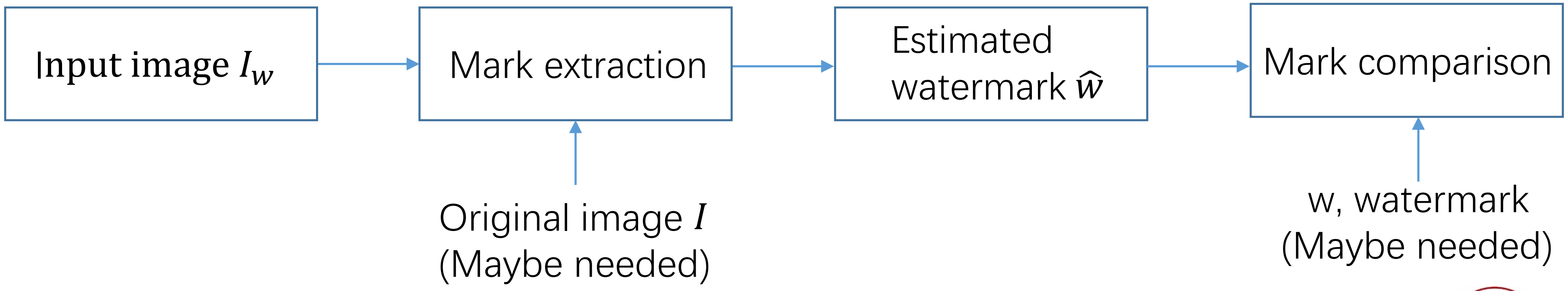
Anti-counterfeiting

Fundamentals of Image Compression

- **Insertion/ embedding:**



- **Detection:**


Input image I_w
Mark extraction
Estimated watermark $\hat{w}$
Mark comparison
Original image I (Maybe needed)
w, watermark (Maybe needed)

Spatial watermarking

- Idea: mark less significant bits.

w is a 2-bit image; I is a 8-bits image.

$$I_w = \left[\frac{I}{4}\right] * 4 + \frac{w}{64}$$

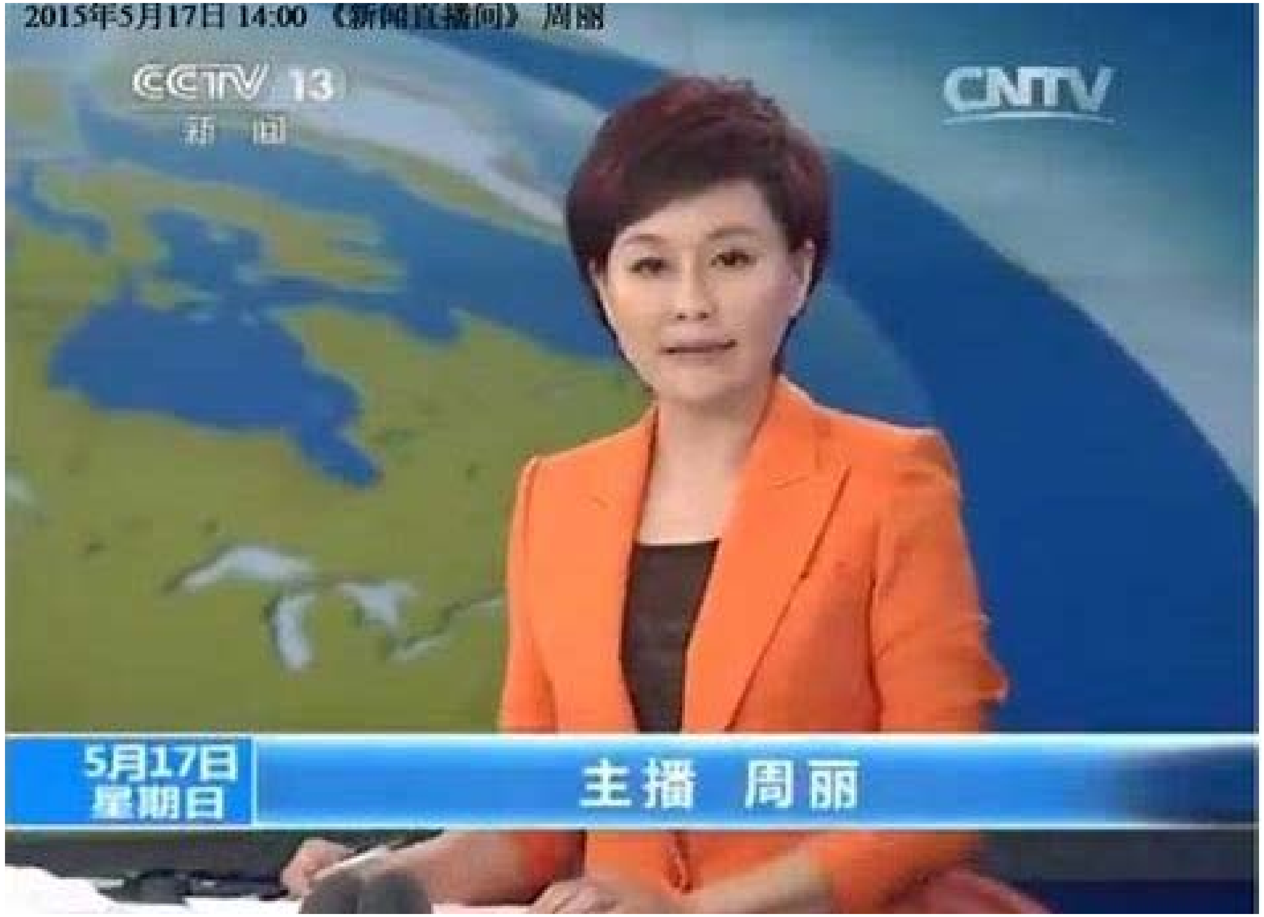
↑

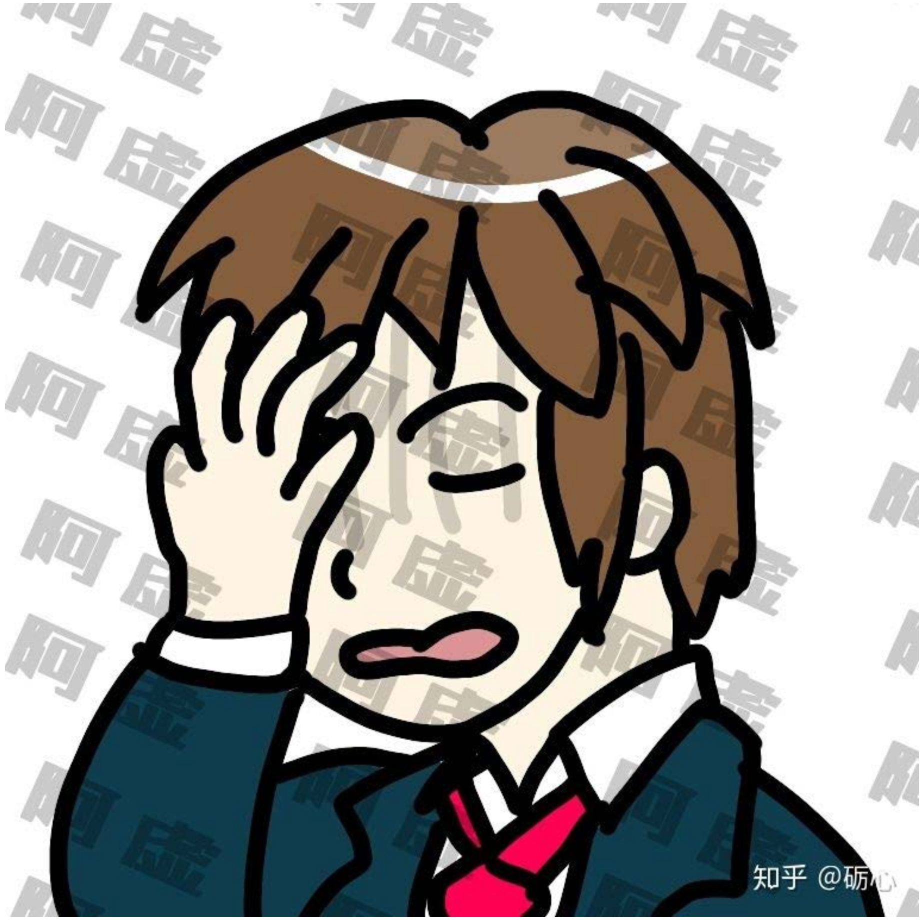
Take the floor
6-bits approx + 2 bits’s of w

- Easy to remove.

- Not robust at all to all kinds of noise.

Spatial watermarking





Anti-counterfeiting

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Robust watermarking in frequency domain 1

- **Idea: hide information in visually important frequency bands.**
- Embedding:
  - Compute DCT of the entire image.
  - Find K largest magnitude coefficients $\boldsymbol{c_1}, \boldsymbol{c_2}, \boldsymbol{c_3}, \cdots, \boldsymbol{c_K}$ (not included DC).
  - Watermark is a K-length random vector or a logo image: $\boldsymbol{w_1}, \boldsymbol{w_2}, \boldsymbol{w_3}, \cdots, \boldsymbol{w_K}$.
  - Embed the watermark: $\boldsymbol{c'_i} = \boldsymbol{c_i}\ (\mathbf{1} + \boldsymbol{\alpha w}_{\mathrm{i}})$ (α>0) .
  - Replace $\boldsymbol{c_i}$ with $\boldsymbol{c'_i}$, and take the inverse DCT.

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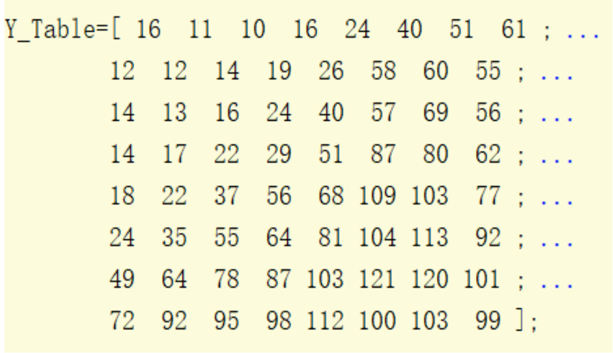
Robust watermarking in frequency domain 1

- **Decoding:**
  - **Compute DCT of the image.**
  - **Extract K coefficient in known locations (side information, may differ from original case).**
  - **Compute $\widehat{\boldsymbol{w'}}_{\boldsymbol{i}} = (\frac{\boldsymbol{c'}_{\boldsymbol{i}}}{\boldsymbol{c}_{\boldsymbol{i}}} - \mathbf{1})/\boldsymbol{\alpha}$**
  - **Find information in $\widehat{\boldsymbol{w'}}_{\boldsymbol{i}}$.**

Robust watermarking in frequency domain 2



```
Y_Table=[ 16  11  10  16  24  40  51  61 ; ...
          12  12  14  19  26  58  60  55 ; ...
          14  13  16  24  40  57  69  56 ; ...
          14  17  22  29  51  87  80  62 ; ...
          18  22  37  56  68 109 103  77 ; ...
          24  35  55  64  81 104 113  92 ; ...
          49  64  78  87 103 121 120 101 ; ...
          72  92  95  98 112 100 103  99 ];
```

- **Idea: hide binary information in comparable values.**
- **Simple frequency-flipping method: (block-based)**
- **Compute DCT of cropped blocks.**

- **Choose 2 DCT coefficients location that are expected to have comparable average values/range.**

  N(4,1) = N(2,3) = 14;

- **Per 8X8 block, compute DCT c(u,v);**

  c(4,1) > c(2,3) **then bit 0;** c(4,1) > c(2,3) **then bit 1;**

- **If coefficients don’t already match w, flip them.**

Take home message

➢ **Desirable properties for digital watermark**

- Visual imperceptible
- Statistically imperceptible
- Robust to inadvertent or intentional attacks.
  - Cropping resizing, compression, enhancement, rotation.
  - Print image/rescan, collusion.
- Alternative: fragile watermark breaks as soon as image is modified.
- High capacity.
- Speed of embedding and detection.