

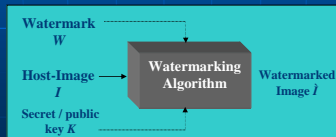
# Differential Evaluation Algorithm Based Fragile Image Watermarking

## Outline

- Introduction
- Review of digital watermarking
- Simple DCT based watermarking method
- DE-based watermarking method
- Experimental results
- Conclusion

## Introduction

- Digital watermarking is to embed secret information, or the watermark into digital media.



## Watermarking Application Areas

- Copyright Protection
- Content Archiving
- Meta-data Insertion
- Broadcast Monitoring
- Tamper Detection
- Content Authentication
- Fingerprinting

### Perceptivity of watermark

Visible

Invisible

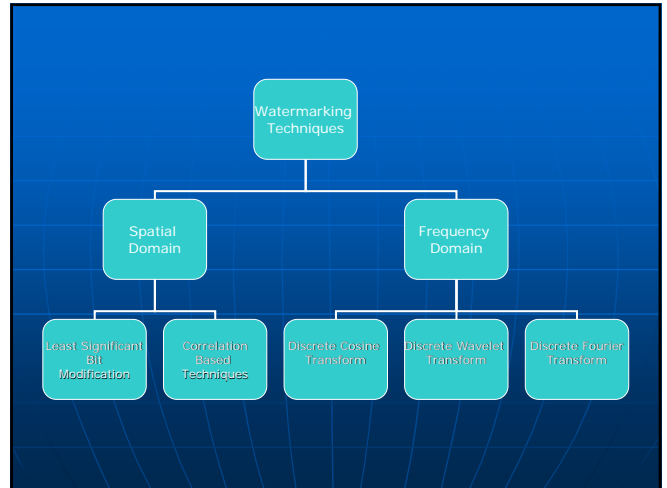
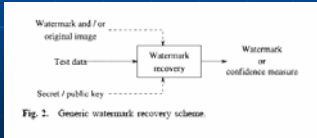
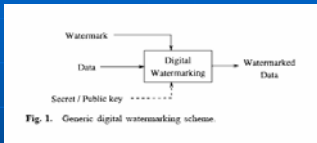
### Robustness of watermark

Robust

Semi-fragile

Fragile

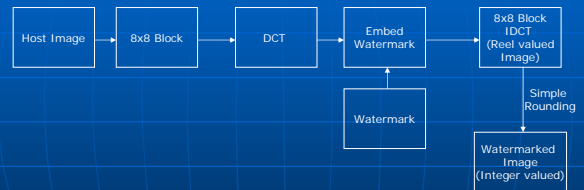
# Basic Watermarking Principle



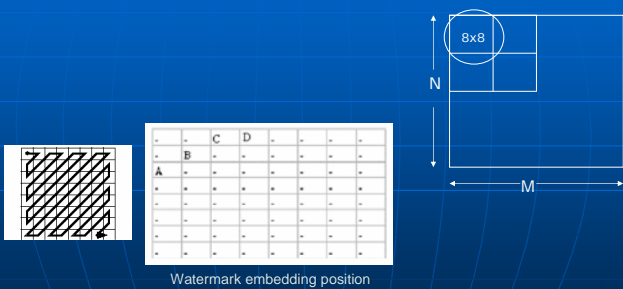
# Watermark Extracting Methods

Required Data	Non-blind	Semi-blind	Blind
Host Image ( $I$ )	○	⊗	⊗
Secret/public key ( $K$ )	(○)	○	○
Watermark ( $W$ )	○	○	⊗

# Simple DCT based Watermarking Flowchart



# Simple DCT based Watermarking Algorithm



# An example of Simple Watermark Embedding and Extracting

(a) Intensity values of the original 8x8 input image

110	111	114	112	111	111	114	111
111	111	111	111	111	111	111	111
114	111	111	111	111	111	111	111
111	111	114	111	111	111	111	111
111	111	111	111	111	111	111	111
111	111	111	111	111	111	111	111
111	111	111	111	111	111	111	111
111	111	111	111	111	111	111	111

(b) DCT transformed image

395.50	14.50	0.00	0.00	0.00	-0.34	-2.05	111.83
-5.17	2.68	1.32	-0.05	3.10	-2.62	2.08	-3.37
0.00	0.00	0.15	0.11	-0.33	0.15	-0.19	-0.30
4.44	-1.40	0.33	2.20	-0.74	-0.43	1.01	2.20
0.50	3.14	1.07	-0.45	1.50	0.20	1.40	1.41
-4.32	-2.29	-2.29	-2.45	-2.39	2.17	2.00	-0.38
-2.07	1.44	1.41	1.37	1.34	0.15	0.00	1.74
0.07	3.70	-0.01	-1.01	1.12	-2.36	-2.10	-1.13

(c) The binary watermark

1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0

(d) Watermark embedding in DCT domain

395.50	14.50	0.00	0.00	0.00	-0.34	-2.05	111.83
-5.17	2.68	1.32	-0.05	3.10	-2.62	2.08	-3.37
0.00	0.00	0.15	0.11	-0.33	0.15	-0.19	-0.30
4.44	-1.40	0.33	2.20	-0.74	-0.43	1.01	2.20
0.50	3.14	1.07	-0.45	1.50	0.20	1.40	1.41
-4.32	-2.29	-2.29	-2.45	-2.39	2.17	2.00	-0.38
-2.07	1.44	1.41	1.37	1.34	0.15	0.00	1.74
0.07	3.70	-0.01	-1.01	1.12	-2.36	-2.10	-1.13

(e) IDCT transformed watermarked image

110.40	115.37	114.90	110.21	111.12	115.03	113.94	111.90
115.27	111.94	111.18	110.11	110.03	115.95	116.09	116.85
114.67	112.65	111.43	111.96	114.91	113.96	115.61	117.82
110.88	110.88	110.84	114.85	112.83	114.81	118.80	120.79
114.74	115.03	111.87	112.87	114.81	114.84	119.81	117.81
111.88	110.82	110.84	111.81	114.84	111.81	112.85	119.87
110.84	114.74	114.85	110.87	110.11	110.81	112.84	112.87
119.80	110.84	110.81	110.12	110.21	119.80	114.07	120.43

(f) Rounded watermarked image

110	115	114	110	111	115	113	111
115	111	111	110	110	116	116	117
114	112	111	112	115	114	116	118
111	110	110	115	113	113	119	121
114	115	111	112	114	114	119	121
111	110	110	111	112	112	120	121
110	114	114	110	110	112	112	119
120	110	110	110	110	114	114	121

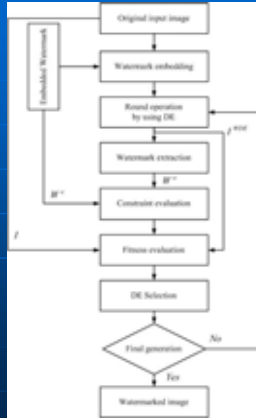
(g) DCT transformed watermarked image

395.50	14.50	0.00	0.00	0.00	-0.34	-2.05	111.83
-5.17	2.68	1.32	-0.05	3.10	-2.62	2.08	-3.37
0.00	0.00	0.15	0.11	-0.33	0.15	-0.19	-0.30
4.44	-1.40	0.33	2.20	-0.74	-0.43	1.01	2.20
0.50	3.14	1.07	-0.45	1.50	0.20	1.40	1.41
-4.32	-2.29	-2.29	-2.45	-2.39	2.17	2.00	-0.38
-2.07	1.44	1.41	1.37	1.34	0.15	0.00	1.74
0.07	3.70	-0.01	-1.01	1.12	-2.36	-2.10	-1.13

(h) Extracted Watermark

1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0

### Block diagram of DE-based watermarking method



### The solution of DE

S1=[0 0 0 0 1 0 1 1 1 1 0 1 0 0 1 1 1 1 0 0 0 1 1 1 1 1 0 1 1  
1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 0 1 1 1 1 0 0 0 1 0 1  
1 0 0 0 0 0]

0	0	0	0	1	0	1	1
1	0	1	0	0	1	1	1
0	0	0	1	1	1	1	1
0	1	1	1	1	0	1	1
1	1	1	1	1	1	1	1
1	1	1	0	1	0	0	1
1	1	1	0	0	0	1	0
1	1	0	0	0	0	0	0

Translation Map

- (1) If the signal is "1,"  $r^* = \text{Trunc}(r) + 1$ ,
- (2) If the signal is "0,"  $r^* = \text{Trunc}(r)$ .

### An example of translation operation using DE, Extracting Watermark

116.40	115.97	114.50	112.21	112.12	115.03	113.96	117.92
115.27	117.24	111.18	118.11	118.03	115.95	116.89	116.86
114.07	117.05	111.01	117.56	116.91	117.86	115.82	117.80
115.98	112.81	113.96	114.55	112.53	116.13	116.30	120.79
114.99	115.30	111.21	112.83	114.85	114.86	117.88	121.85
112.80	109.32	110.86	111.93	116.36	121.01	122.05	115.07
109.86	114.85	114.95	113.21	118.11	123.18	123.84	119.21
119.92	119.96	118.03	119.12	120.21	119.30	126.97	121.40

IDCT transformed watermarked image

118	115	114	112	113	115	116	118
116	117	112	118	118	120	117	117
114	117	111	118	117	118	116	118
110	111	114	115	111	116	119	111
115	116	112	113	117	115	118	122
113	110	111	111	117	121	122	120
110	115	115	119	118	123	124	118
120	120	118	119	120	119	126	123

Watermarked image rounded by DE

	B	M	
1			

Extracted watermark

132.75	16.46	4.81	2.99	0.00	-0.51	-2.34	-2.47
-8.92	2.97	0.85	-0.03	3.44	-2.49	2.26	-3.01
19.86	5.26	-0.03	1.68	-3.23	1.34	-0.41	0.96
-6.31	1.99	2.46	2.59	-0.63	-0.88	3.19	2.49
13.00	3.12	6.33	-4.83	1.75	-0.07	0.90	3.30
-4.49	-2.93	-2.64	-2.66	-2.36	2.30	1.59	-0.86
-1.25	6.73	3.59	1.52	1.59	-0.62	1.03	1.59
13.25	3.11	-0.39	-0.43	1.05	-2.55	-2.27	-1.43

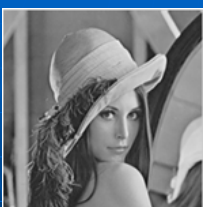
DCT transformed watermarked image

### Constraint and Fitness Functions used by DE

$$C = \sum_{i=1}^n |Watermark_i - Watermark_i| = 0$$

$$F(gen) = \sum_{i=1}^n |Watermarked\_image\_block - Original\_image\_block|$$

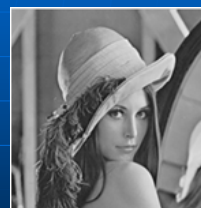
### Simulation Results



Host Image  
256x256



Embedded Watermark  
64x64



Watermarked Image  
256x256



By simple rounding



By DE

$$\text{PSNR} = 10 \times \log_{10} \left( \frac{255^2}{\sum_{i=1}^N \sum_{j=1}^N [h(i,j) - h^{GA}(i,j)]^2} \right)$$

$$\text{NC} = \frac{\sum_{i=1}^N \sum_{j=1}^N W(i,j) \times W^E(i,j)}{\sum_{i=1}^N \sum_{j=1}^N [W(i,j)]^2}$$

	By simple rounding	By novel DE
PSNR values of original and watermarked images	63,4	57,51
NC values of embedded and extracted watermark	0,513	1

Thanks for your attention  
- Questions? -