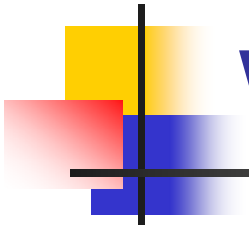
Digital Watermarking of Color Images

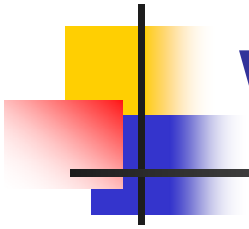
Heather Wood

Research funded by NSF



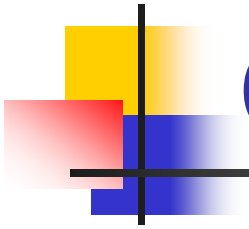
Why??

- Ease of access to digital media with growth of internet
- Combat copyright infringement
- Ease of attacking a digital image



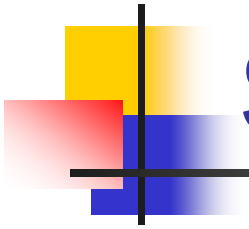
Watermarking Overview

- Many different techniques
- Visible vs. Invisible Embedding
- Blind vs. Non-blind Extraction
- Spatial Domain
- Transform Domain
- Image Normalization
- ACF Peaks



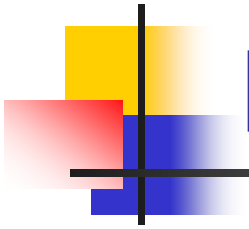
Grayscale Watermark

- Pseudorandom Permutation
- Randomly rearrange watermark pixels into order that is reversed in extraction phase to decrease vulnerability



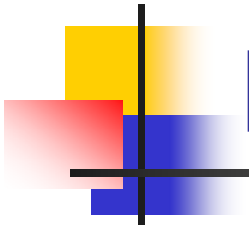
Spatial Domain Method

- Achromatic Component
- Embed one pixel of grayscale watermark into all pixels in one 8x8 pixel block of the achromatic component
- Saturation Adjustment
- Thresholds: α and β



DCT Domain Basics

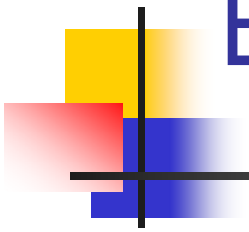
- Achromatic component
- Perform DCT operation on each 8x8 pixel block
- Embed one pixel of watermark into the first pixel of each block in DCT Domain
- Inverse DCT
- Saturation Adjustment



DCT Domain Low Frequency

- Same as other DCT Domain technique until embedding actual watermark pixels
- Embed one pixel of watermark in first 2x2 pixel block in each DCT block
- 3 pixels are in low-frequency range

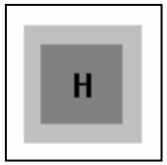
Extraction and Correlation



- Reverse saturation adjustment to estimate achromatic component of watermarked image
- subtract original values from corresponding watermarked pixels
- reverse pseudorandom permutation
- Calculate Correlation Coefficient

Originals

Original Color Image



Watermark

Spatial Domain Results

Original

Watermarked

Difference

DCT Domain Results

Original

Watermarked

Difference

DCT Domain 2 Results

Original

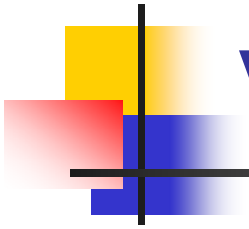
Watermarked

Difference

JPEG Compression Results

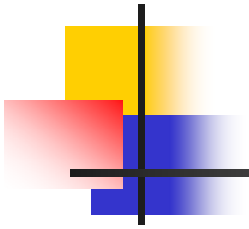
Watermark Correlation Coefficients

JPEG Compression Quality (%)											
Method	***10***	***20***	***30***	***40***	***50***	***60***	***70***	***80***	***90***	***100***	***BMP***
Spatial Domain	.054	.100	.123	.195	.238	.300	.334	.406	.560	.722	.991
DCT Domain	.054	.100	.123	.195	.238	.300	.334	.407	.559	.722	.991
DCT Domain 2	.039	.045	.067	.109	.115	.125	.146	.216	.356	.651	.994



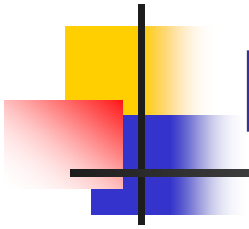
Various Attack Results

Watermark Method	***Gaussian Filter 3x3***	***Crop 25%***	***Rescale ½***	***Rescale x2***
Spatial Domain	0.925	0.019	0.000	0.008
DCT Domain	0.920	0.021	0.000	0.013
DCT Domain 2	0.902	0.022	0.023	0.002



Conclusions

- Loss of information when image saved
- When saved as bitmap file, all floating point numbers are rounded to whole numbers
- Small change loses some of watermark information



Future Research

- Geometric attacks
- JPEG compression
- DCT coefficients