



An Improved Raw Quick Pairs Blind Steganalysis Method

By

Benjamin Rodriguez

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Approach to Blind Steganalysis

University of Texas at San Antonio

in cooperation with

AFIWC/IOD

Benjamin M. Rodriguez, Sos S. Agaian, Ph.D., James C. Collins



STEGANOGRAPHY



Steganography (data hiding) is the art of hiding messages in an undetectable method onto a communication signal.

The art of steganography is a rapidly growing field with potential applications for copyright protection (watermarking), hiding executables for access control of digital multimedia data, embedded captioning, secret communications, etc.



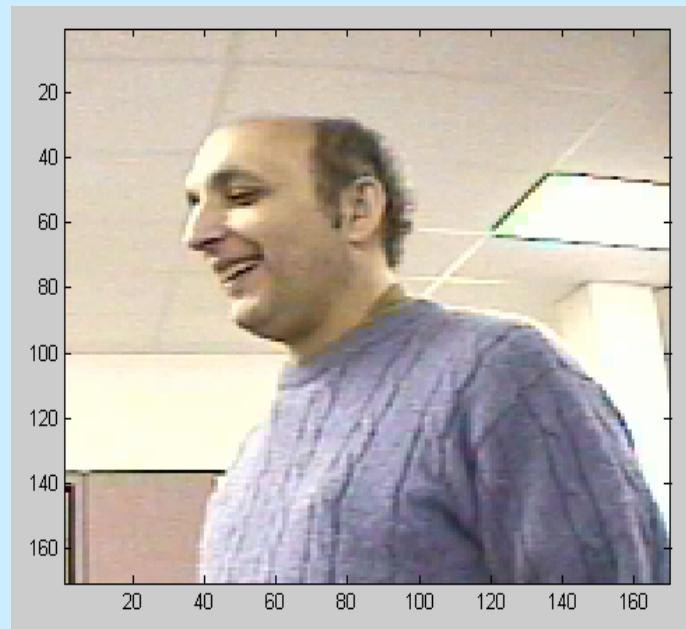
Is this a Stego-Image?



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Simple LSB Embedding



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Embedding Images



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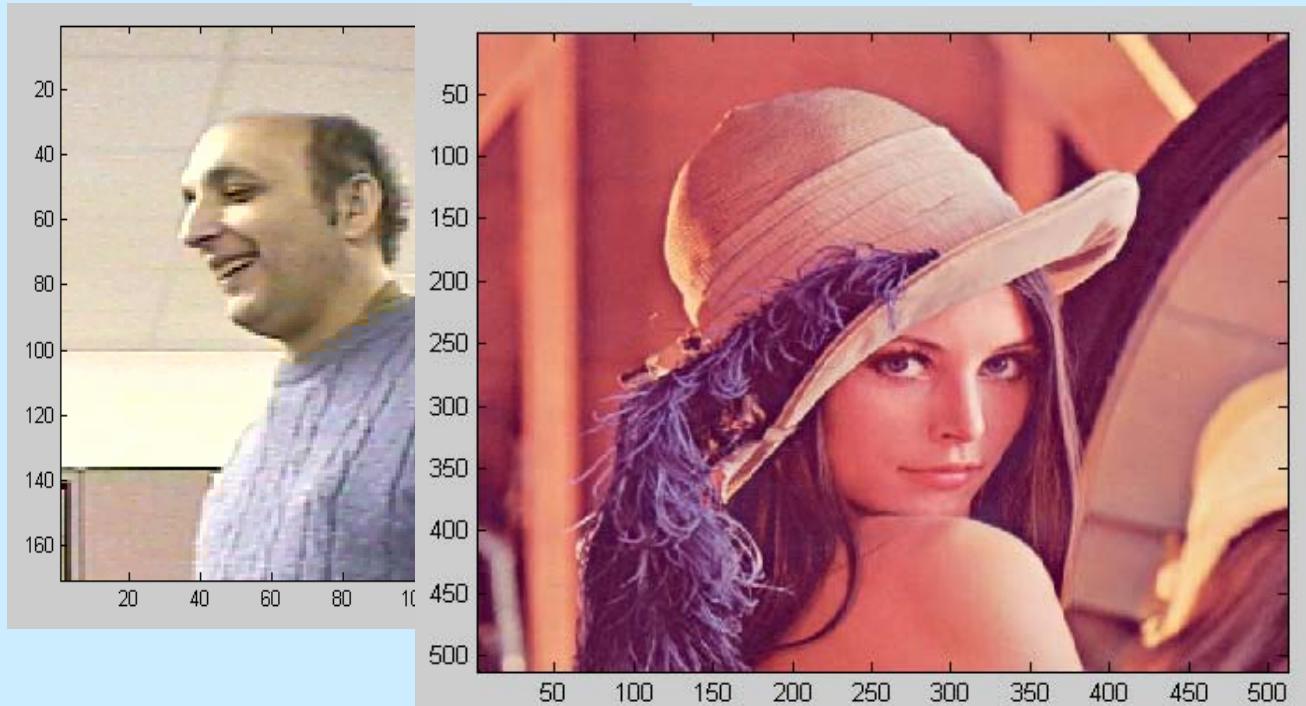
Embedding Images



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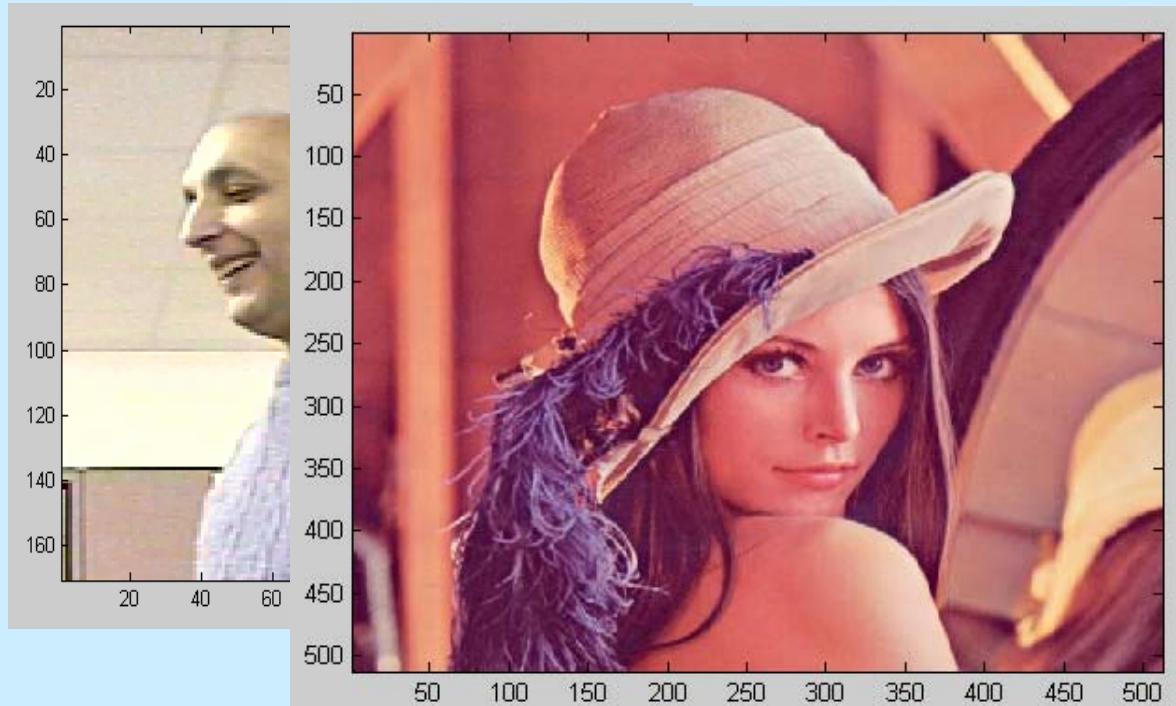
Embedding Images



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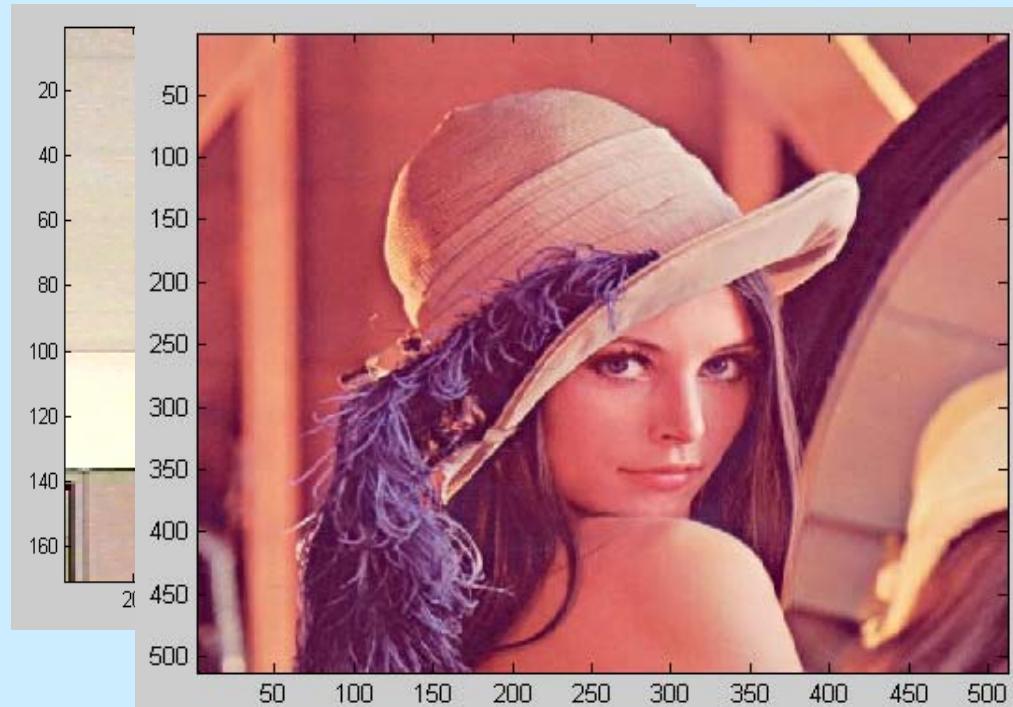
Embedding Images



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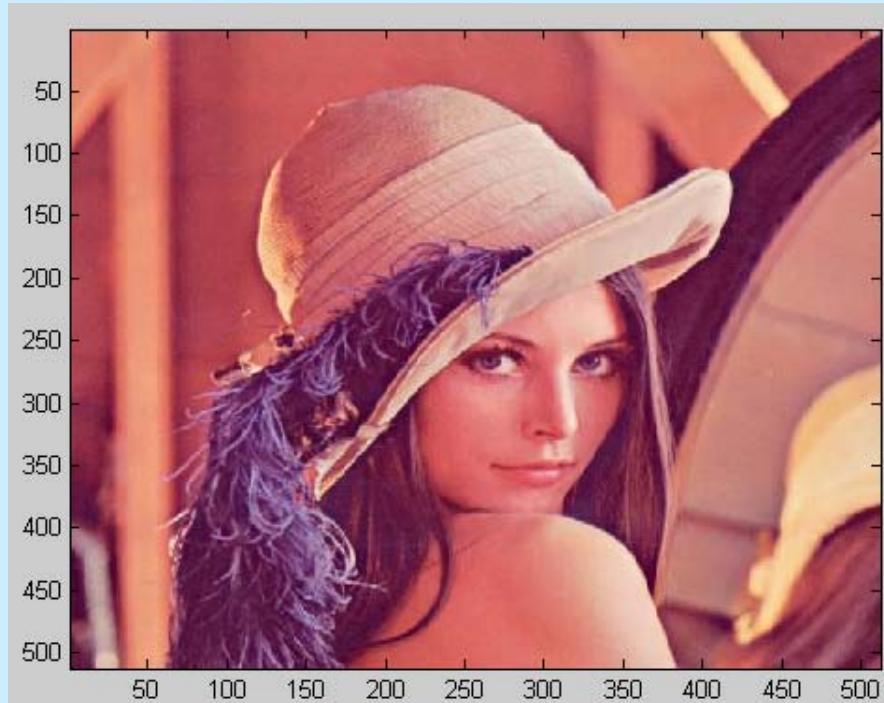
Embedding Images



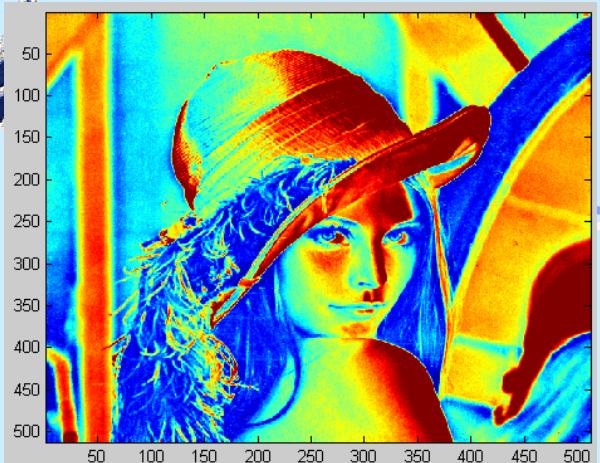
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Embedding Images



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The 8-bit layer of the original image is divided into 8 individual layers to prepare the image for data embedding in the LSB (least significant bit).

bit- 2^7

bit- 2^6

bit- 2^5

bit- 2^4



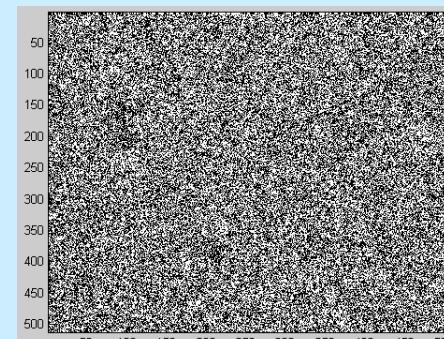
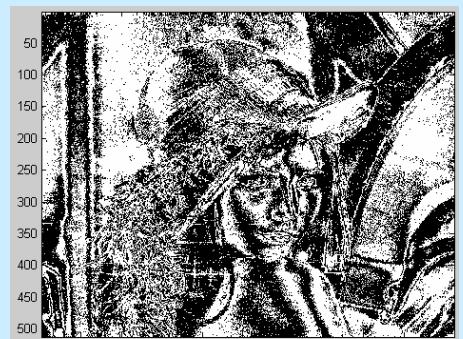
MSB

bit- 2^3

bit- 2^2

bit- 2^1

bit- 2^0

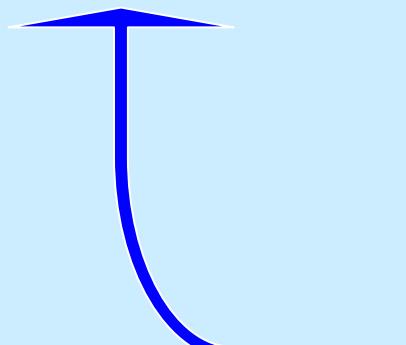
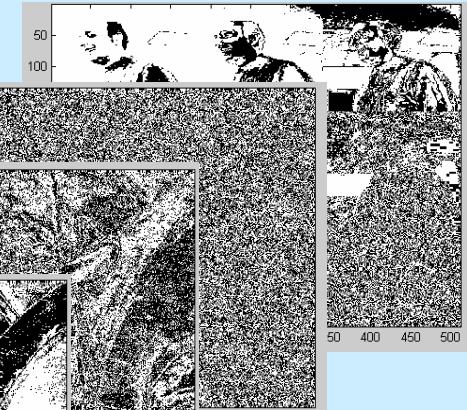
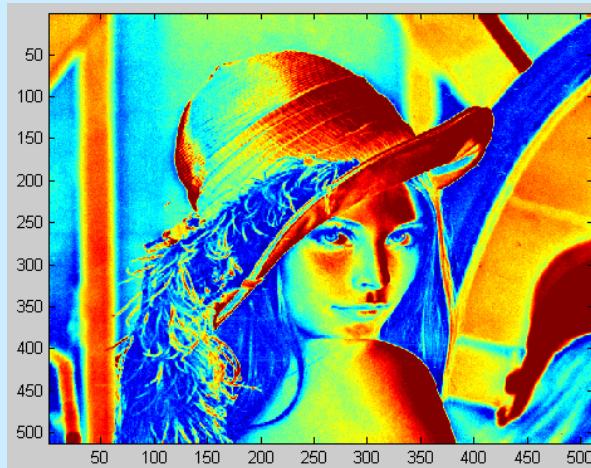


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LSB



Rebuilding Lena Image

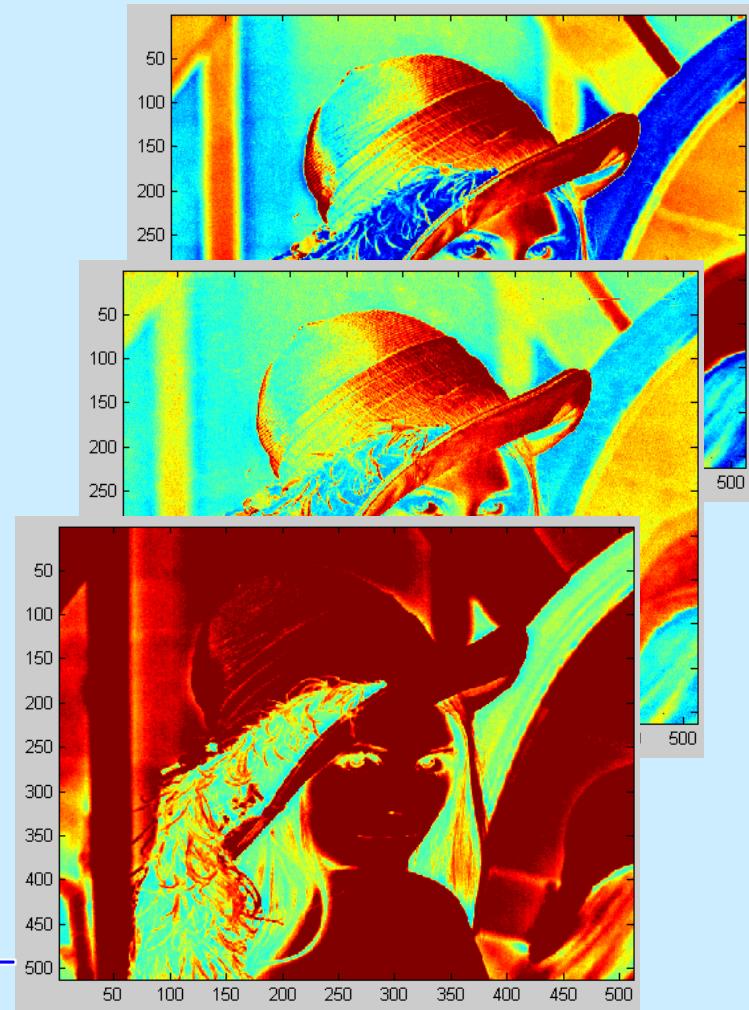


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Rebuilding Lena Image

24-bit Image (512x512x3)



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Embedding Types

1. Embedding of text onto a cover image.
2. Embedding an image onto a cover image.
3. Embedding with compression.
4. Embedding information randomly w/wo a key.



Internet Embedding Types

- S-Tools 4

<http://members.tripod.com/steganography/stego/software.html>

- SecurEngine2

<http://secureengine.isecurelabs.com/>

- wbStego 3.51

<http://wbstego.wbailer.com/>



Steganalysis

The blind steganalysis attempts to detect steganographic data without knowledge about the steganographic system.



Factors in secret message detection

- **Message length**
 - *The less information we embed into the cover-image, the smaller the probability of introducing detectable artifacts by the embedding process*
- **Cover-images properties**
- **Image format**
 - *Example the main common images stored in the JPEG format are a very poor choice for steganographic methods*



Basic Existing Detection Methods

Spatial Domain

Statistical analysis of LSB embedding

Frequency Domain

Analysis of image transformations



Existing Spatial Methods

- Jessica Fridrich, Miroslav Goljan , Rui Du
“Detecting LSB Steganography in Color and Grayscale Images”
- N.F. Johnson, S. Jajodia
"Steganalysis: The Investigation of Hidden Information"
- A. Westfeld and A. Pfitzmann
“Attacks on Steganographic Systems”
- S. Dumitrescu, X. Wu, and Z. Wang
“Detection of LSB Steganography via Sample Pair Analysis”
- R. Chandramouli, Nasir Memon
“Analysis of LSB based Image Steganography Techniques”



Limitations

- Detection on low percentages, 1%, are extremely difficult.
- Other methods have difficulty detecting stego data embedded by wbStego and SecurEngine.
- Localization is not possible.
- No information is available on stego removal.
- The previous mention methods focused on special sized images during testing (Fridrich, Johnson, Westfeld).



Raw Quick Pairs₁

Raw Quick Pairs has a primary focus to inspect one or more high color-depth digital images for statistical artifacts that are caused by embedded data using the Least Significant Bit (LSB) method.

- *It is used to analyze the security of the most common steganographic techniques that embed data randomly onto various-bit digital colored images.*
- *It is optimized with the use of steganalytic techniques that adjust the parameters to minimize the probability of erroneous detection for data embedding capacities of 0.01 – 0.03 bits per pixel.*
- *It is presented in a new steganalytic technique based on analyzing the various structures of the sets of unique colors in the RGB color cube for detection purposes.*

[1] Jiri Fridrich, Rui Du, Meng Long, Steganalysis Of LSB Encoding In Color Images, IEEE 2000



Problems in Detection

- Which steganalysis method is best, with respect to speed and effectiveness, at determining the specific location (cover area of an image) of the hidden data on the arbitrary size color or grayscale images?
- Can existing methods be improved that would detect very short hidden messages?
- Is it possible to recover or remove the hidden data without significantly impacting the image quality?
- Is it possible to detect and remove the hidden data when the images are noisy.
- How can one determine the percentage of altered bits.



Proposed New Method

We will present a method in the Spatial Domain.

Improved Raw Quick Pairs (Spatial)

Is based on statistical analysis of discrete properties in sampled pairs of pixels (one plane) compared on various structures derived from an image.



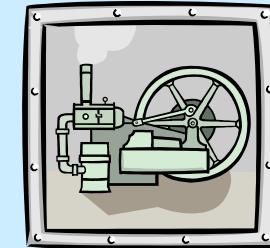
Pixel Comparison Definition

- In general adjacent pixels are compared in pairs for various statistical methods
- Pixels are compared in adjacent pairs as in:
“Detecting LSB Steganography in Color and Grayscale Images”
- Proposed method uses statistical comparison of pixels



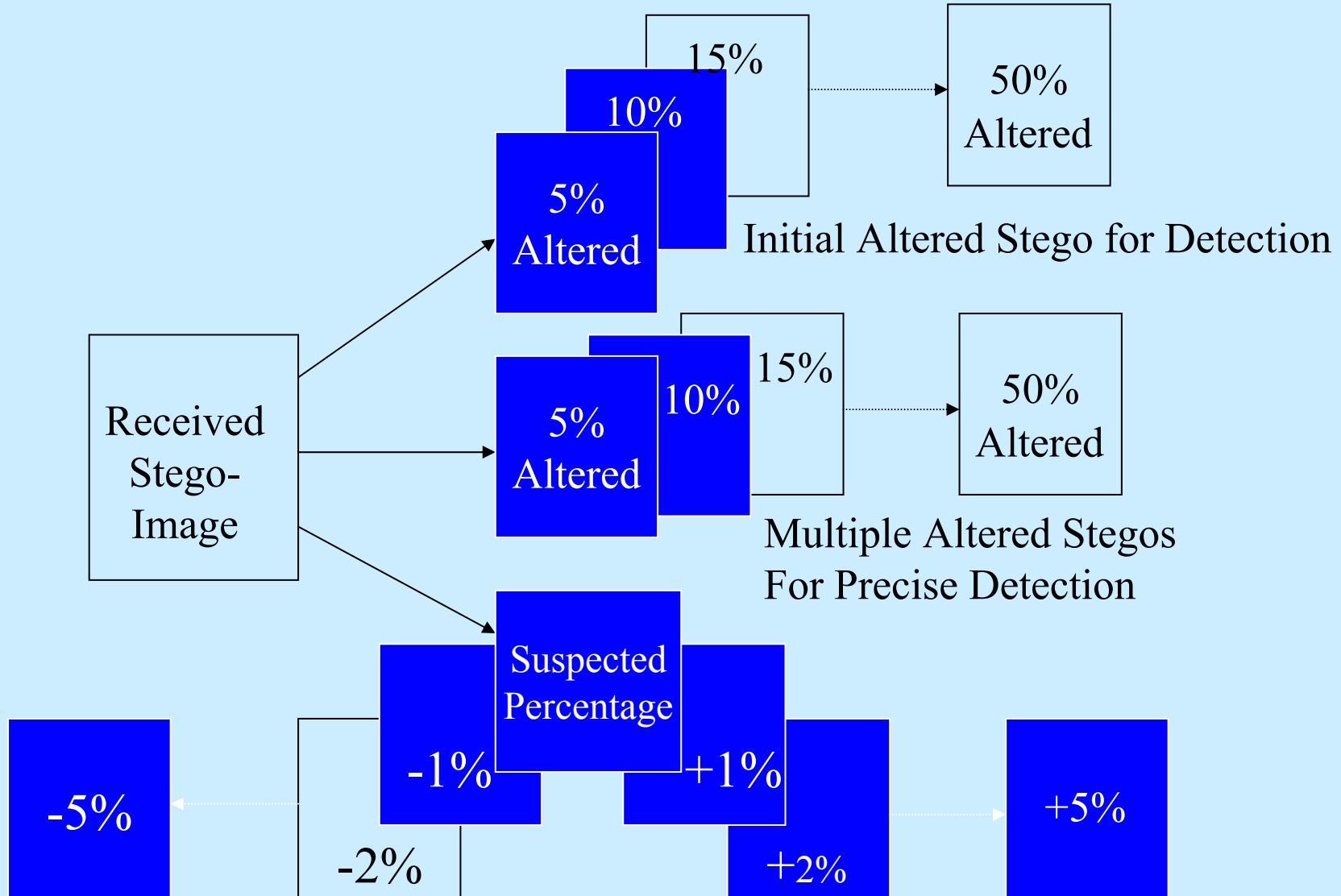
Global Detection Algorithm

- Input image
- Choose the pixels to be compared
- Determine statistical measure of compared pixels
- Generate a new image from the received image by altering pixels on the LSB
- Calculate the statistical measure of compared pixels for the new image
- Use the two sets of statistics to determine if stego exists
- If stego does not exist or suspicion is unknown choose another set of pixel to be compared and repeat the above steps





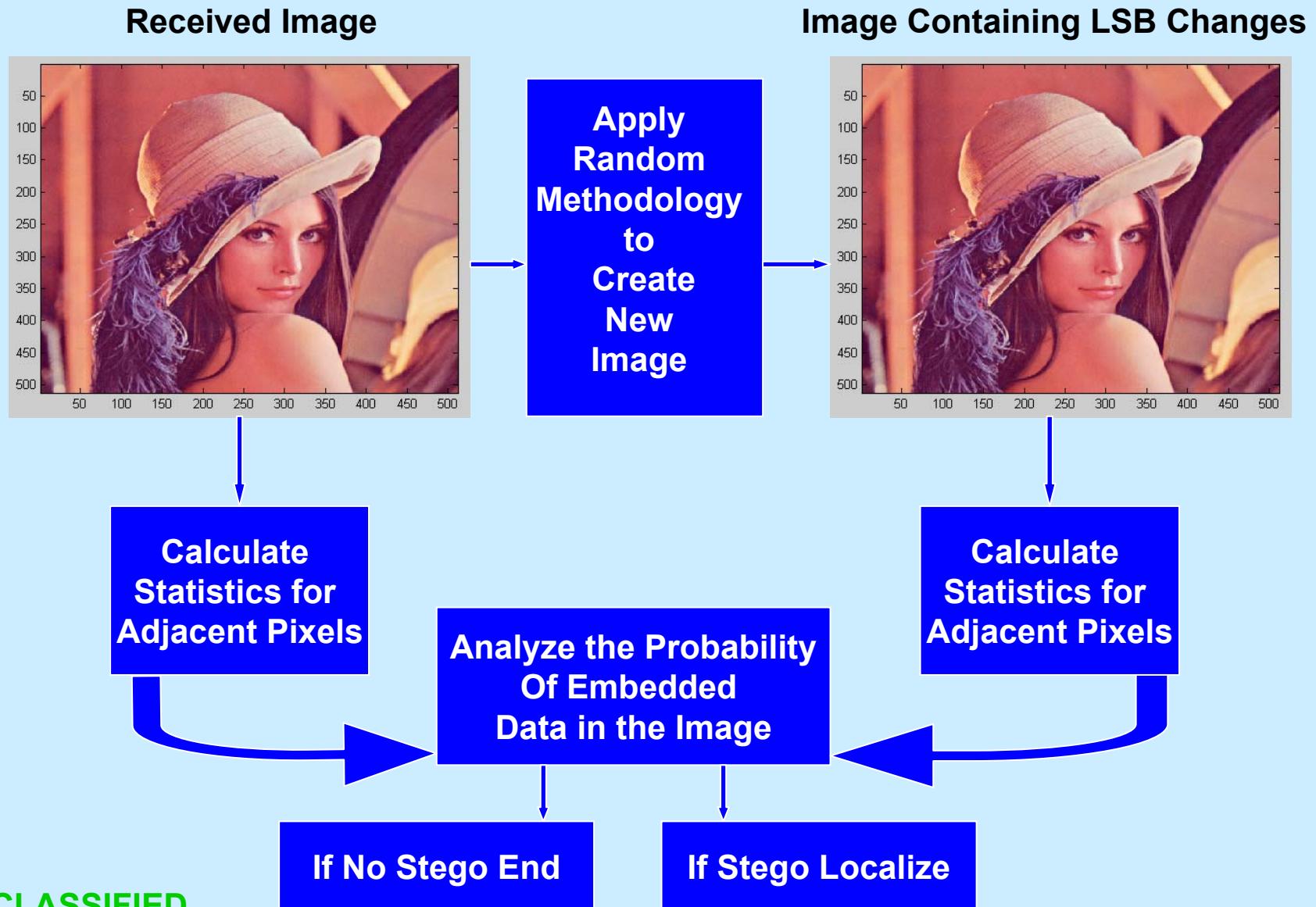
Initial Detection Method



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Localized Algorithm Scheme



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Localization Algorithm



- If small percentage is suspected
 - Divide the image into random $k \times m$ sections
 - Apply the detection algorithm to each section
 - If necessary determine the percentage altered pixel per section
- Remark: Best size section for Improved Raw Quick Pairs are no smaller than 16x32 pixels.



Images Analyzed

Image	Name	Size
	Lenna (Internet Image)	512 X 512
	Fisherman Pier (Clean Image)	1350 X 950
	Fall Leaves (Scanned Image)	1713 X 1200
	Golden Gate (Clean Image)	1488 X 2240
	Garden of the Gods (Air Brushed w/Adobe)	300 X 454

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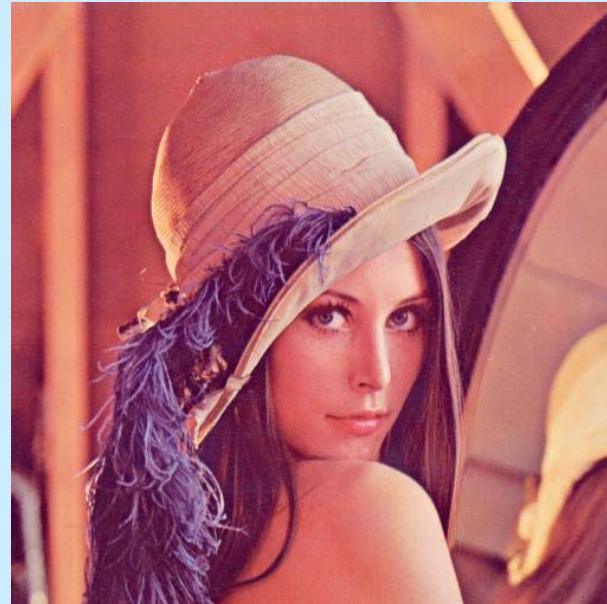
Images Analyzed

Image	Name	Size
	Mona Lisa (JPEG Image Converted)	1155 X 743
	Psyche Garden (JPEG Image Converted)	287 X 183
	Flag (Altered Format to BMP)	512 X 512
	Trolley (Clean Image)	900 X 1400
	Chess Match (Clean Image)	1360 X 1020

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High Color Lena Image



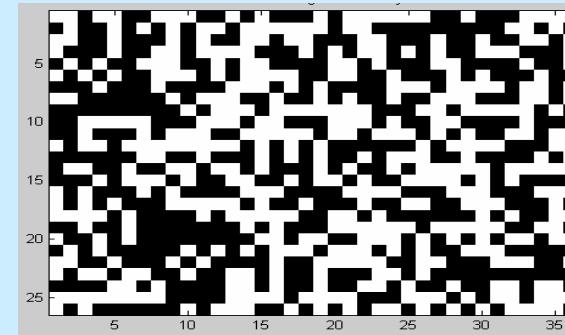
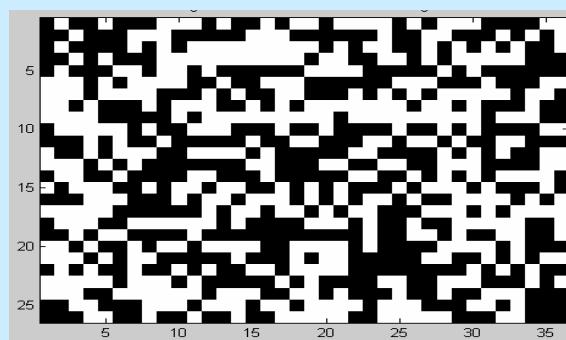
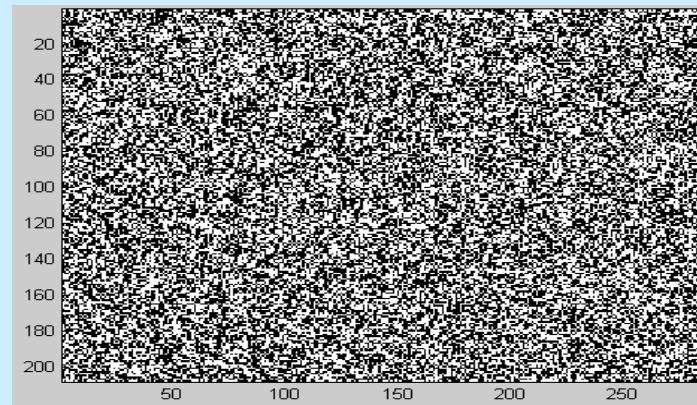
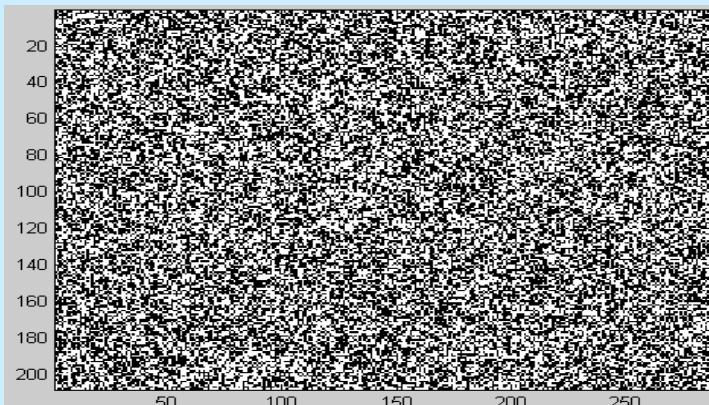
LSB Embedded Information

Detectable At 3%



Analysis

The Original Lena Image was altered by 49.1%, LSB



Zoomed In View Of Both
Received (L) and Altered (R)
Images Indicating Changes



Global Detection Method (QLA)



Images Embedding Tools	8% - 15% RQP / New Method	25% RQP / New Method	>= 50% RQP / New Method
Lenna SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y
Fisherman Pier SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	N / Y Y / Y N / Y	Y / Y Y / Y Y / Y
Fall Leaves SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y
Golden Gate SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y
Garden of the Gods SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	N / Y Y / Y N / Y	Y / Y Y / Y Y / Y

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Global Detection Method (QLA)



Images Embedding Tools	8% - 15% RQP / New Method	25% RQP / New Method	>= 50% RQP / New Method
Mona Lisa SecureEngine2 S_Tools 4 wbStego	N / N N / Y N / N	N / Y Y / Y N / Y	Y / Y Y / Y Y / Y
Psyche Garden SecureEngine2 S_Tools 4 wbStego	N / N N / Y N / N	N / Y Y / Y N / Y	Y / Y Y / Y Y / Y
Flag SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y
Trolley SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y
Chess Match SecureEngine2 S_Tools 4 wbStego	N / Y N / Y N / Y	Y / Y Y / Y Y / Y	Y / Y Y / Y Y / Y

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Localization Detection Method (QLA)

Images Embedding Tools	Minumum Percentage of Data Detection	Best Pixel Area Size
Lenna Secure Engine wbStego	3%	2048
Fisherman Pier Secure Engine wbStego	1%	2048
Fall Leaves Secure Engine wbStego	2%	2048
Golden Gate Secure Engine wbStego	1%	2048
Garden of the Gods Secure Engine wbStego	5%	2048

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Localization Detection Method (QLA)

Images Embedding Tools	Minumum Percentage of Data Detection	Best Pixel Area Size
Mona Lisa Secure Engine wbStego	3%	2048
Psyche Garden Secure Engine wbStego	8%	512
Flag Secure Engine wbStego	2%	2048
Trolley Secure Engine wbStego	1%	512
Chess Match Secure Engine wbStego	1%	512

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Detection Percentage of Improved Raw Quick Pairs on S-Tools



- Improved Raw Quick Pairs can detect percentages of embedded information at about 8% or higher.
- RQP can only detect at about 20% or Higher.

Image type and size vary detection by a few percentage points.



Detection Percentage of

Improved Raw Quick Pairs on SecurEngine & wbStego



- Low percentages can be detected, 1%.
- Localization can be used to determine estimate areas containing stego.
- Concentrated area embedding methodologies are easier to detect.



Conclusion

- Advantages of Improved Raw Quick Pairs Method
- *Allows for precise location of concentrated regions of stego information.*
- *Gives a closer percentage of the embedded information.*
- *Can be used for quick scanning of images.*



Current Work

- Improved sensitivity of for detection of small amounts of data.
- Application Testing on JPEG2000, MPEG, and Fractal Compressed Images
- Development of Super Fast Algorithms
- Hardware Implementation of Detection Algorithms