Image Steganography

Hello!

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Introduction

What is steganography?

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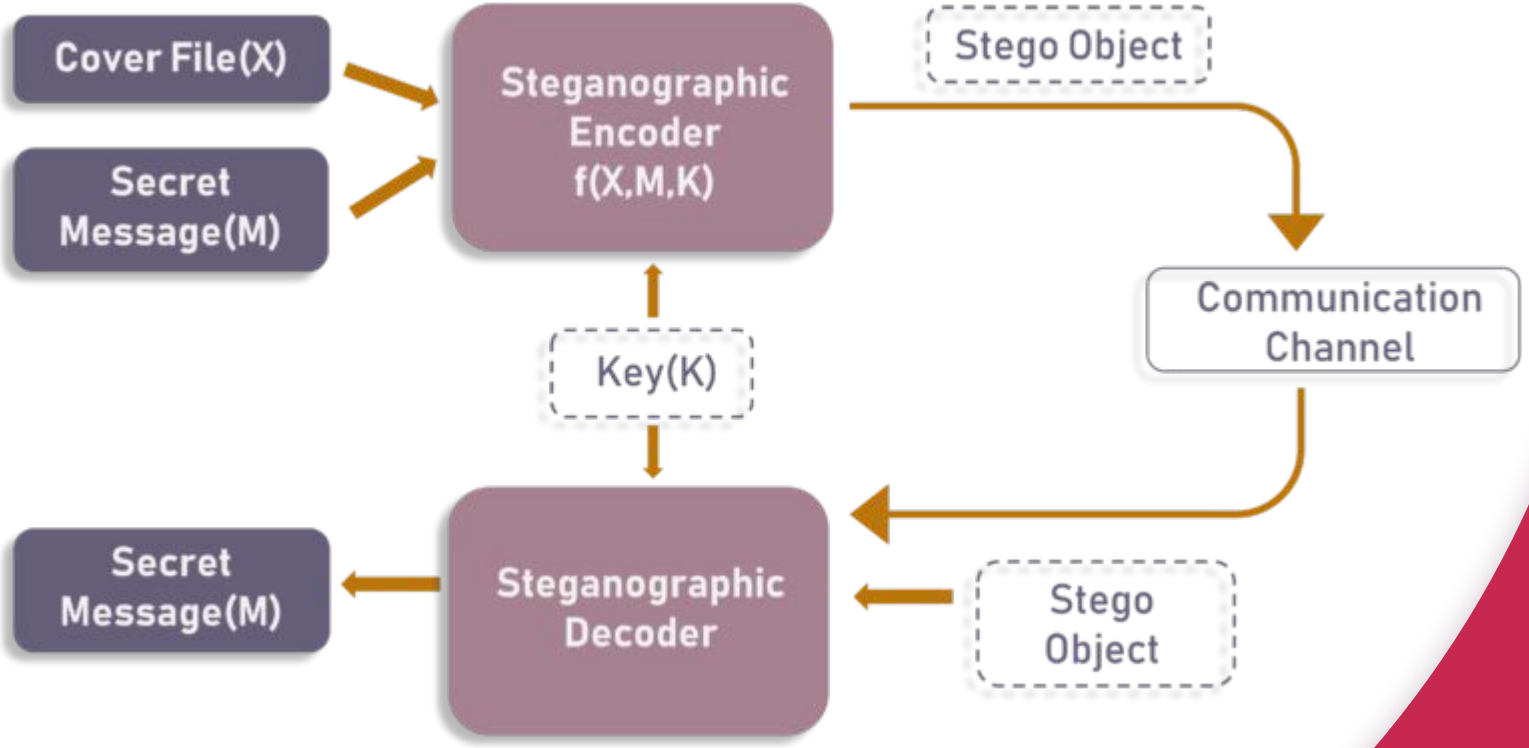
Steganography is the art and science of embedding secret messages in a cover message in such a way that no one, apart from the sender and intended recipient, suspects the existence of the message

Demonstration

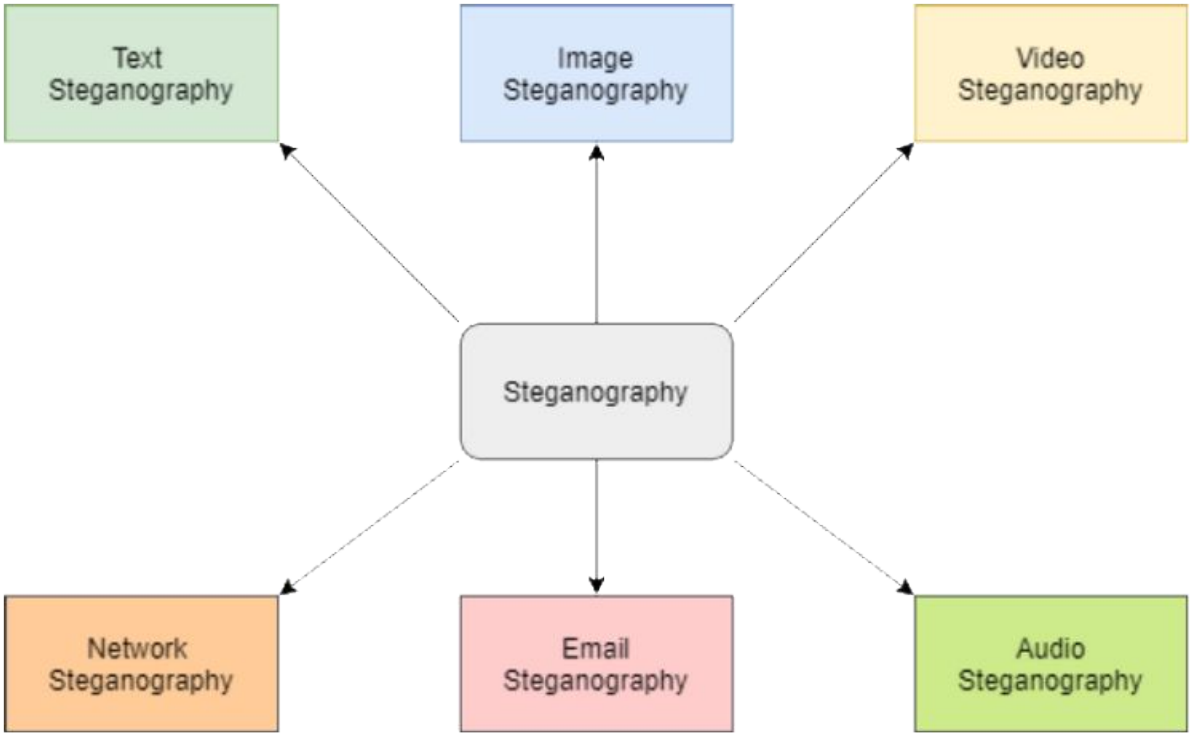
No Message

Attack at midnight

Steganographic model



Types of Steganography

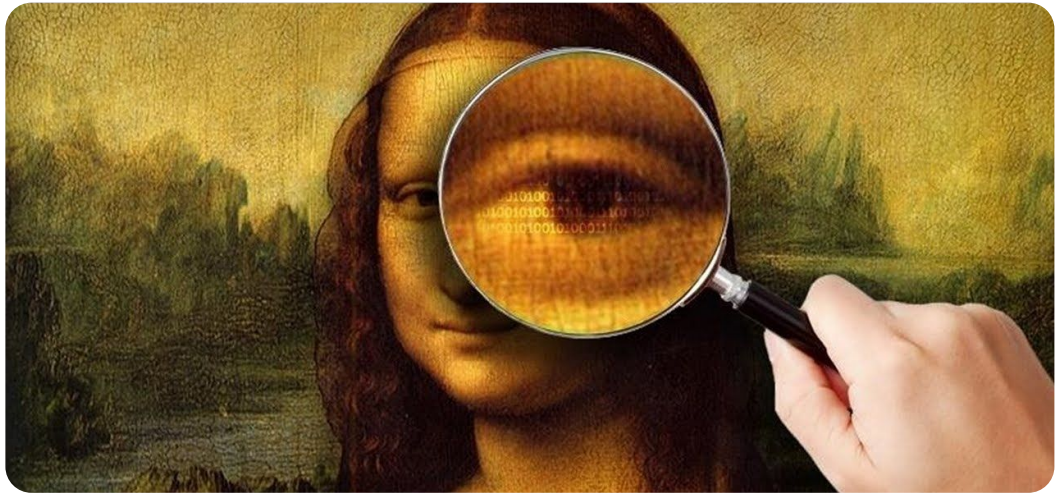


Steganography vs Cryptography

	STEGANOGRAPHY	CRYPTOGRAPHY
Definition	It is a technique to hide the existence of communication	It's a technique to convert data into an incomprehensible form
Purpose	Keep communication secure	Provide data protection
Data Visibility	Never	Always
Data Structure	Doesn't alter the overall structure of data	Alters the overall structure of data
Key	Optional, but offers more security if used	Necessary requirement
Failure	Once the presence of a secret message is discovered, anyone can use the secret data	If you possess the decryption key, then you can figure out original message from the ciphertext

Applications

- Confidential communication
- Secret data storing
- Protect copyrights



Methods

LSB, LSBM, PVD...

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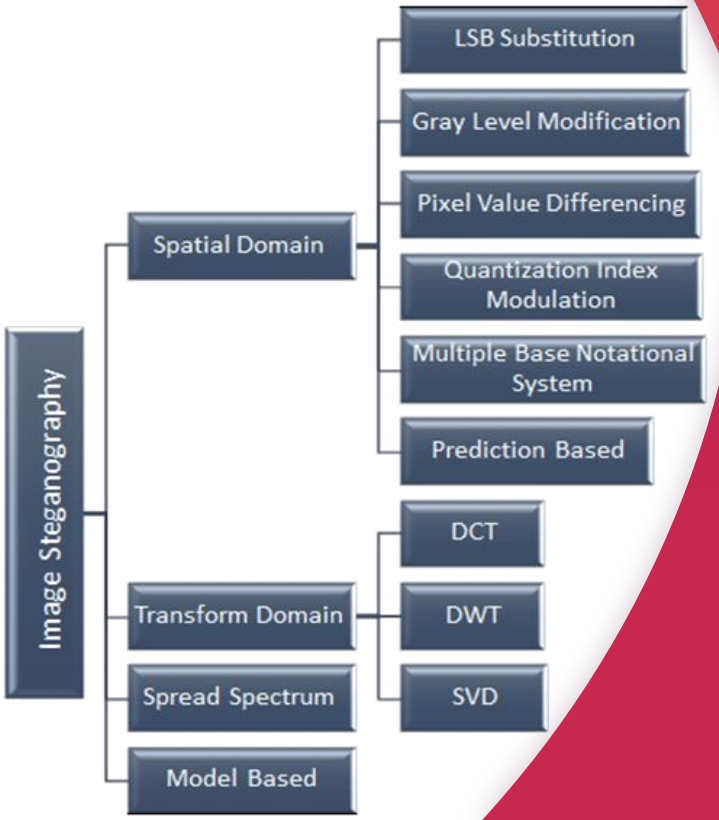
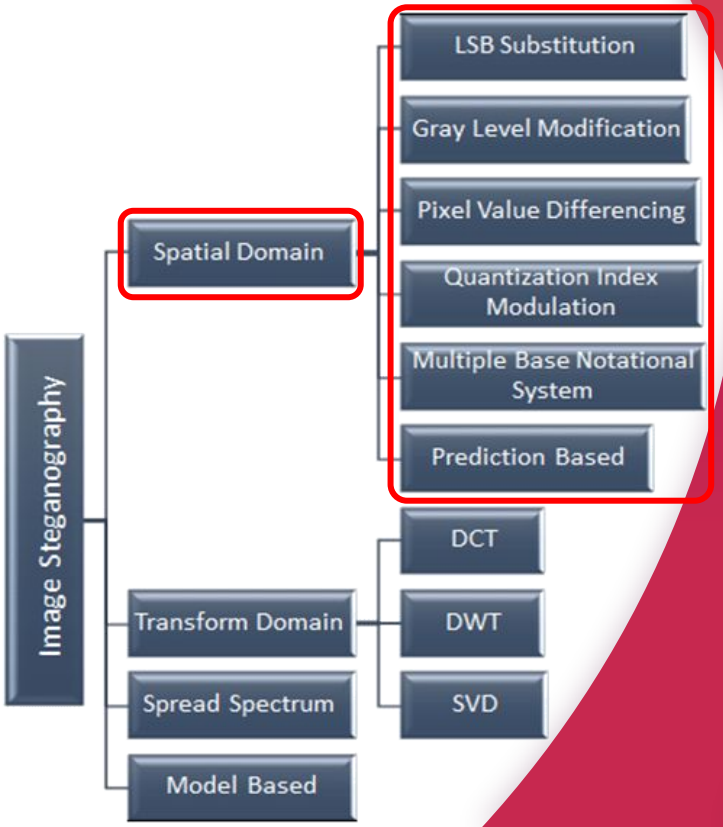
Overview of groups of methods

- Spatial domain
- Transform domain
- Spread spectrum method
- Optimization method...

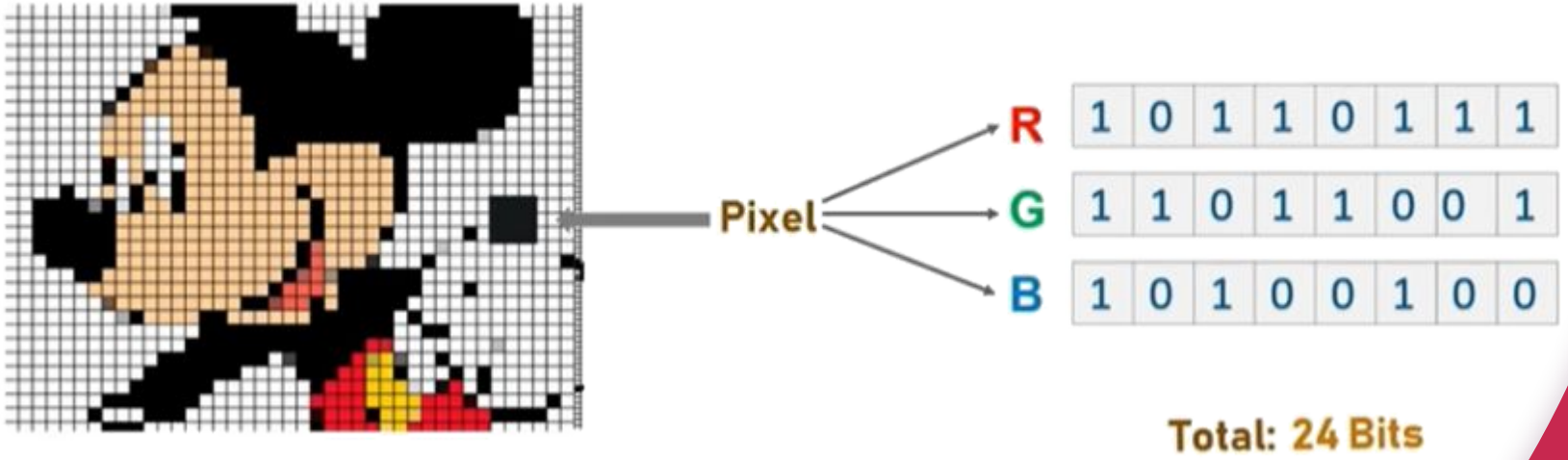


Spatial domain

- Modifying secret message and cover image in spatial domain which involves embedding at level of least significant bits (LSB).
- E.g: LSB, LSBM



Least Significant Bits (LSB)



Least Significant Bits (LSB)

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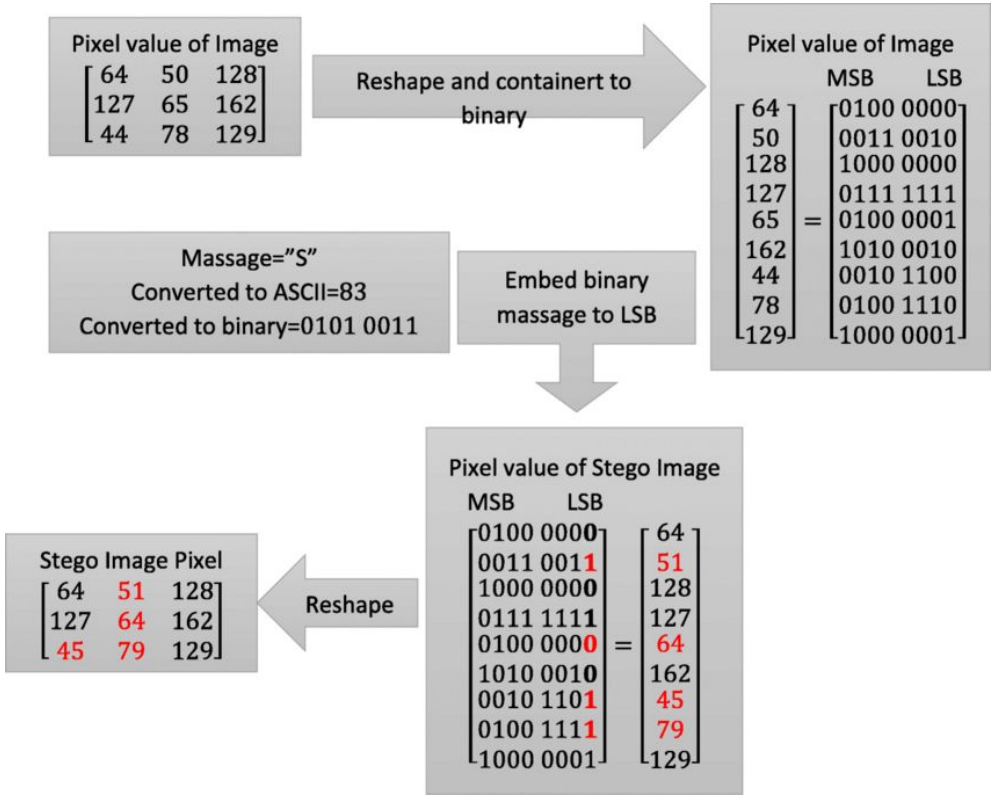


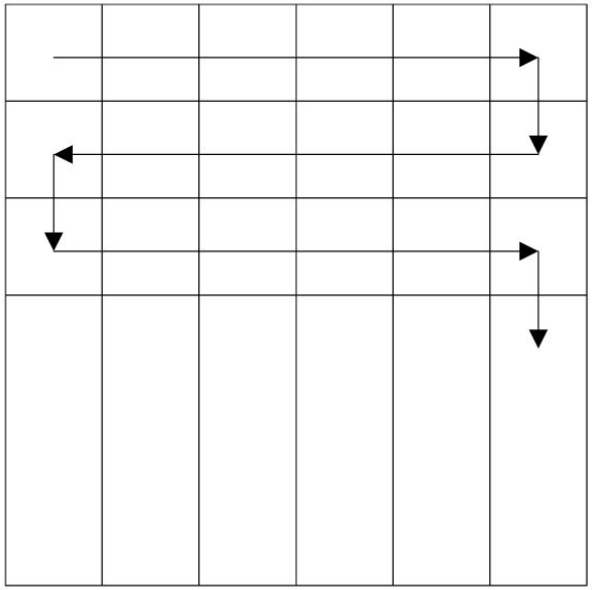
Least significant bits matching (LSBM)

- Check matching between secret bit and LSB of cover image.
- If they does not match, then +1 or -1 added to the corresponding pixel value.

Pixel-value Difference (PVD)

A steganographic method for images by pixel-value differencing, Da-Chun Wu, Wen-Hsiang Tsai

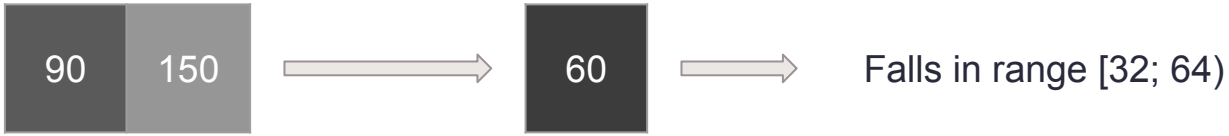
- Process 1x2 blocks.
- Use a list of *perceptibility ranges*.
- Sender and receiver agree upon a traversal order.



Pixel-value Difference (PVD)

A steganographic method for images by pixel-value differencing, Da-Chun Wu, Wen-Hsiang Tsai

- Low capacity, highly imperceptible → narrower ranges and vice versa.
- Ex. using width list (8, 8, 16, 32, 64, 128):



Thus we can adjust the difference to 40.

Pixel-value Difference (PVD)

A steganographic method for images by pixel-value differencing, Da-Chun Wu, Wen-Hsiang Tsai

- Embed process:
  - Calculate the difference *d = a2 - a1*.
  - Get lower and upper bound *l*, *u* of that range.
  - Embedding capacity is *log2(l - u + 1) = n* bits.
  - Convert next *n* bits in stream to decimal number *b*.
  - Let the new diff. be *d' = l + b < u*.
  - Range check.
  - Replace (a1, a2) with (a1', a2') using:

$$f((a_1, a_2), m) = \begin{cases} (a_1 - \lceil m/2 \rceil, a_2 + \lfloor m/2 \rfloor) & \text{if } d \text{ is odd} \\ (a_1 - \lfloor m/2 \rfloor, a_2 + \lceil m/2 \rceil) & \text{if } d \text{ is even} \end{cases}$$

where *m = d' - d*.

Pixel-value Difference (PVD)

A steganographic method for images by pixel-value differencing, Da-Chun Wu, Wen-Hsiang Tsai

- Extract process:
  - Calculate the difference *d = a2 - a1*.
  - Get lower and upper bound *l*, *u* of that range.
  - Embedding capacity is *log2(l - u + 1) = n* bits.
  - Range check.
  - Convert *d - l* to binary, pads to *n* bits and append to output.

An adaptive PVD method

Adaptive PVD Steganography Using Horizontal, Vertical, and Diagonal Edges in Six-Pixel Blocks, Sekhar et al.

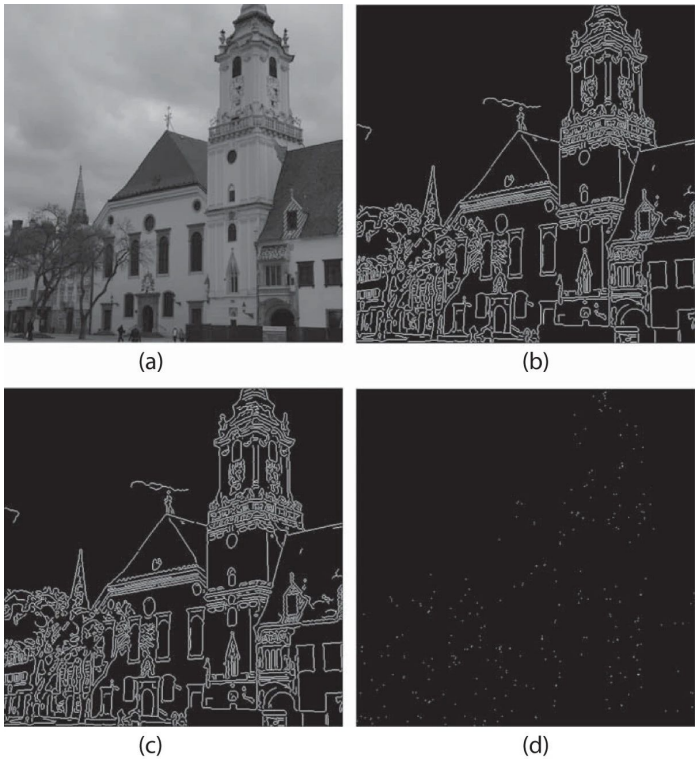
- Operate on 2x3 or 3x2 blocks → more embedding capacity.
- Adaptive in the sense that no fixed table in required, reducing step effect in pixel-difference histogram.

An edge-based method

Edge-based image steganography, Islam et al.

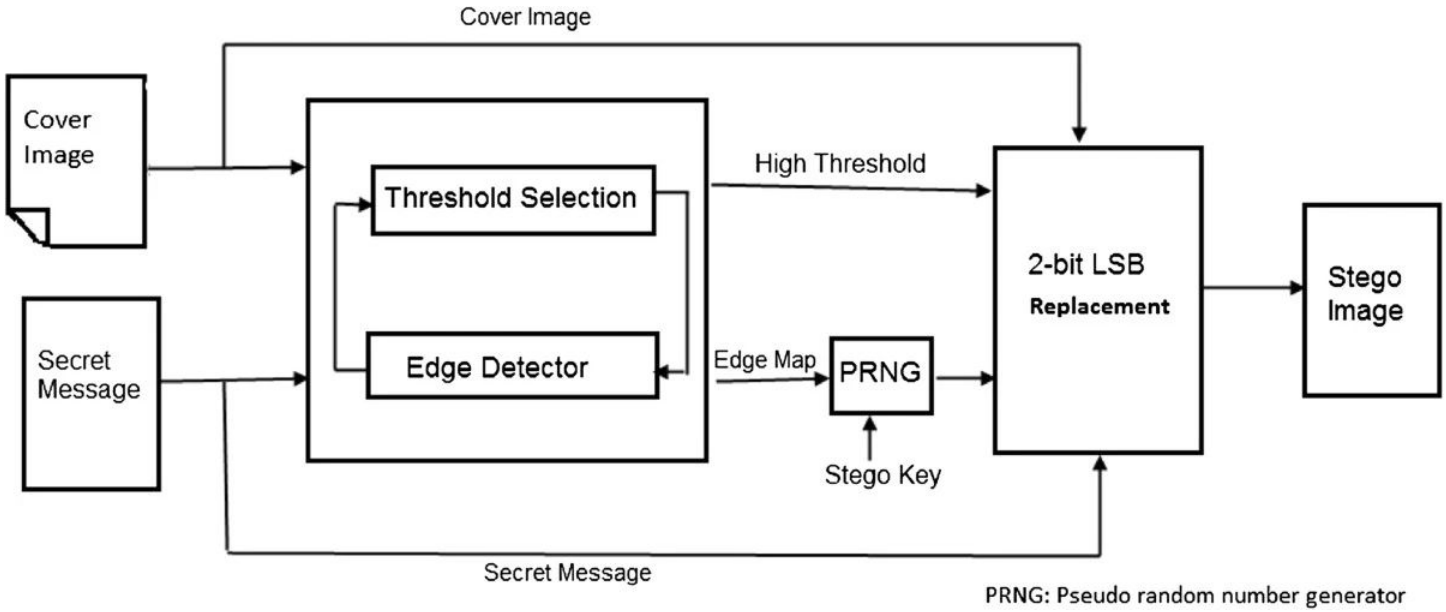
If we apply LSB on a normal edge mask, there is a problem.

(d) if the difference using the same edge detector on cover and stego image.



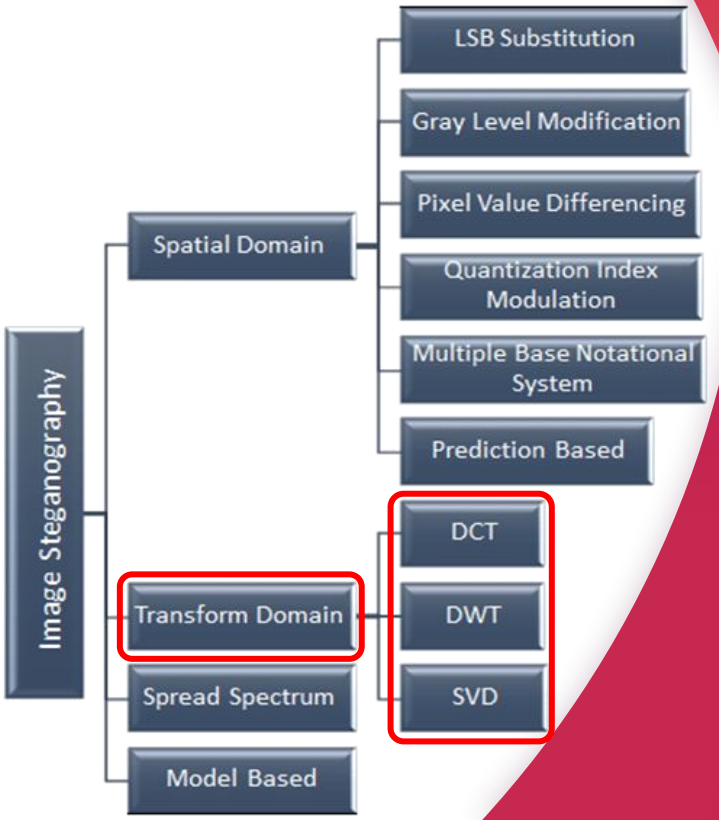
An edge-based method

Edge-based image steganography, Islam et al.



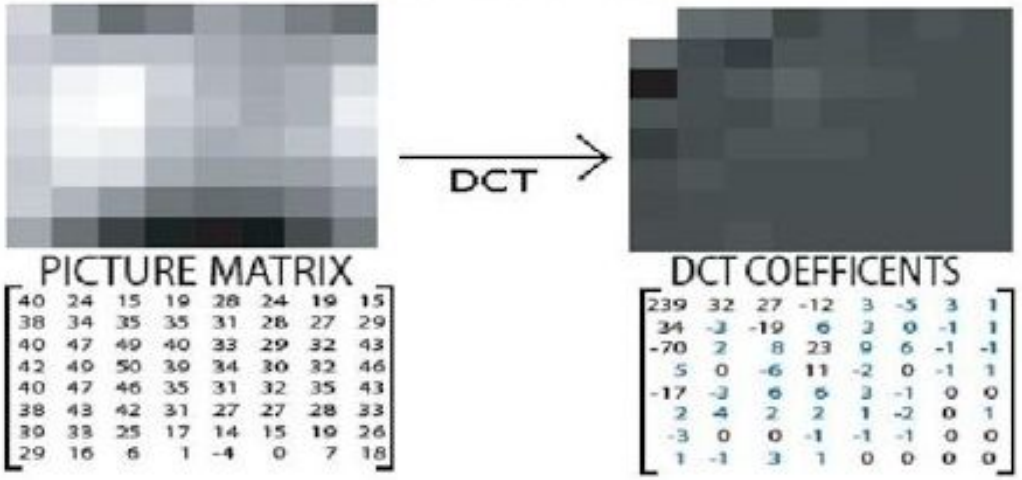
Transform domain

- Transform image from time domain to frequency domain
- Secret data is hidden in transform coefficients.
- E.g: Discrete cosine transform (DCT), discrete wavelet transform (DWT)



DCT-based image steganography

- Closely relates to JPEG compression.
- DCT applied on each 8x8 blocks



DCT-based image steganography

- Hide data in LSB after quantization.
- Receiver decode DCT coefficients and get the output from LSBs.
- Is part of the compression, but not resistant to unwanted compression.
- https://github.com/lukechampine/jsteg

Our DCT-based method

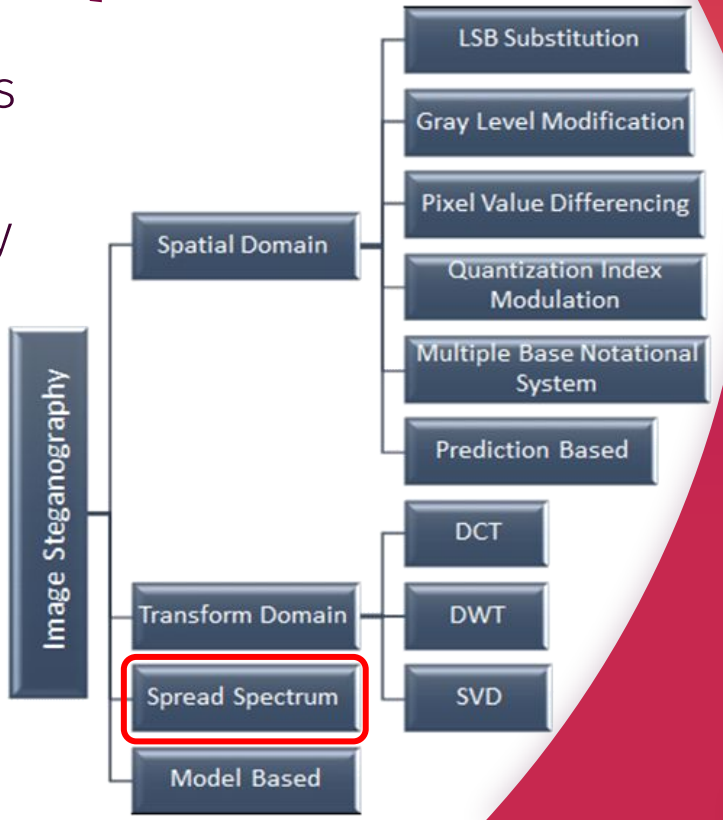
- Hide data in the *n*-th significant bit of DCT coefficients.
- The coefficient must be larger than a threshold.
- More resistant to accidental compression (e.g. through social networks).
- Tradeoff between resistance and image distortion.

Our DCT-based method

- Problem: overflow rounding error after IDCT in near-0 and near-255 regions.
- Possible solution: employ a range check similar to PVD?

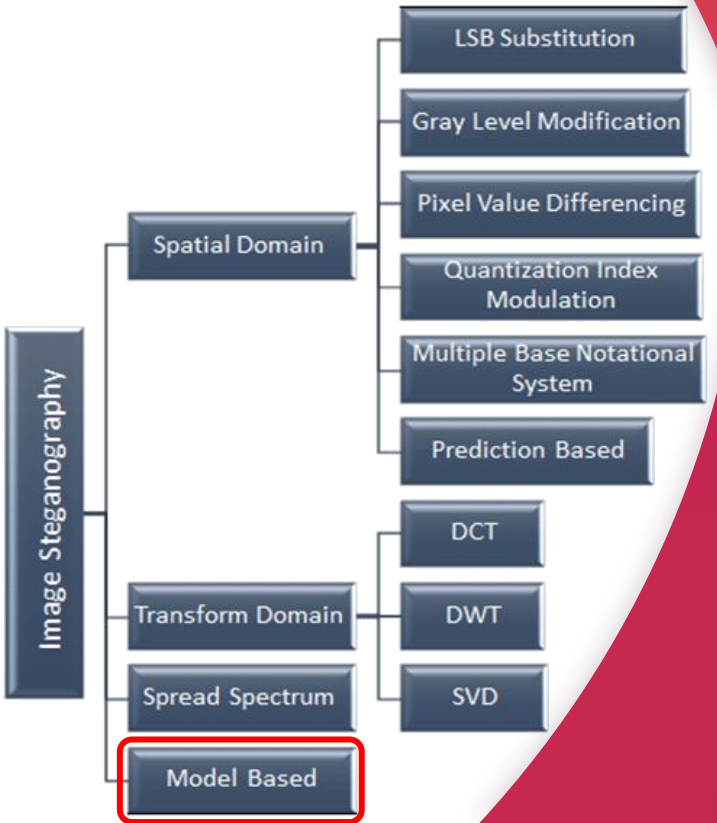
Spread spectrum technique

- Spread narrowband signal across wideband signal.
- The energy of narrowband at any given frequency becomes low and hard to detect
- Data is embedded or hidden as noise to cover image (may be gaussian noise).
- Data is modulated with pseudorandom sequence and added to image.



Optimization method (Model-based)

- Genetic algorithms (GA) and particle swarm optimization (PSO) are used in steganography.
- Optimized to find best starting point in spatial domain and directions, coefficients in transform domain.
- Hide secret message in those selected pixels.



Demo

Embed & Extract message

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Reference

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Reference

- Blog:
  - https://towardsdatascience.com/hiding-data-in-an-image-image-steganography-using-python-e491b68b1372
  - https://jis-eurasipjournals.springeropen.com/articles/10.1186/1687-417X-2014-8
  - https://www.researchgate.net/publication/318853215_Adaptive_PVD_Steganography_Using_Horizontal_Vertical_and_Diagonal_Edges_in_Six-Pixel_Blocks
  - https://www.sciencedirect.com/science/article/abs/pii/S0167865502004026
  - https://www.nayuki.io/page/fast-discrete-cosine-transform-algorithms
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Thanks!

Any questions?