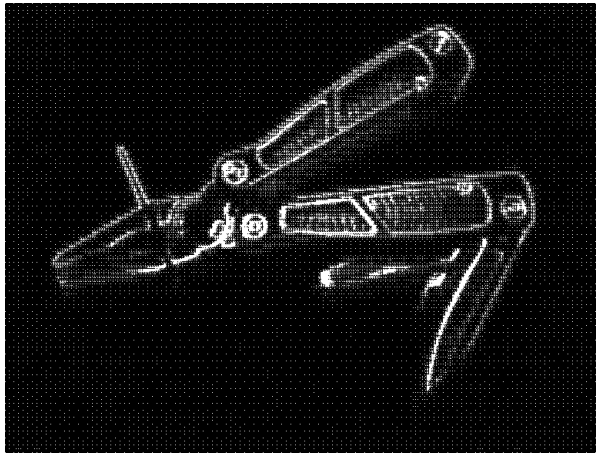
Diffusion-Based Image Compression in Steganography

Paper by Markus Mainberger, Christian Schmaltz, Matthias Berg, Joachim Weickert, Michael Backes



Frank Nedwed – 11.12.2012

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What is Steganography?

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"the practice of concealing messages or information within other non-secret text or data."

Here: hiding an image in another one

(and getting it out again)

What is Diffusion?

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"the spreading of something more widely"

Here: Simulating natural diffusion by partial differential equations

What is Diffusion?

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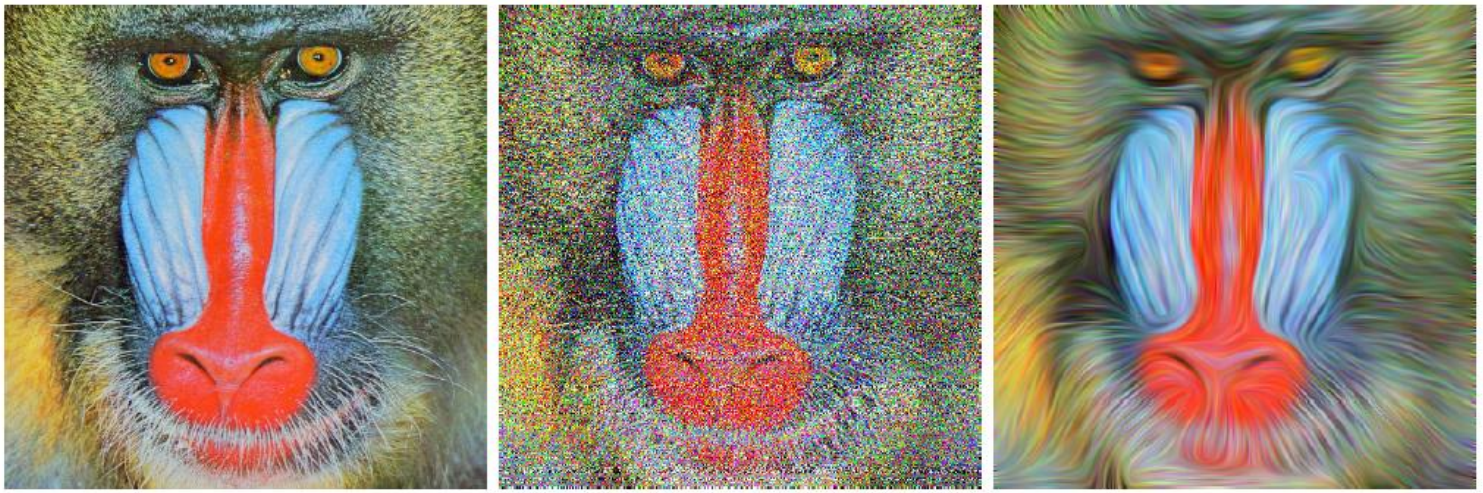
“the spreading of something more widely”

Here: Simulating natural diffusion by partial differential equations



What do we want to achieve?

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Hiding an image (or part of an image) in itself or another picture

- Without detectable traces
- In (almost) real-time
- Without significant loss of quality

- Retrieving the data with a password

The algorithm (idea)

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1. Choosing pixels as Dirichlet boundary
2. Storing them efficiently
3. Encrypting
4. Embedding them in the cover
5. Recovering the secret
6. Restoring the image with diffusion

1) Choosing the right pixels

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- Start with a rectangle defined by the boundaries of the image/censored part
- Divide it recursively into smaller rectangles
- Save characteristic points of the resulting rectangles

1) Choosing the right pixels

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- The resulting rectangles are compared with respect to their Laplace magnitude

$$\left|\Delta f_{\sigma}\right|_{i}$$

such that areas with higher contrast will be sampled more accurately

- the four corner pixels and the middle are saved

1) Choosing the right pixels

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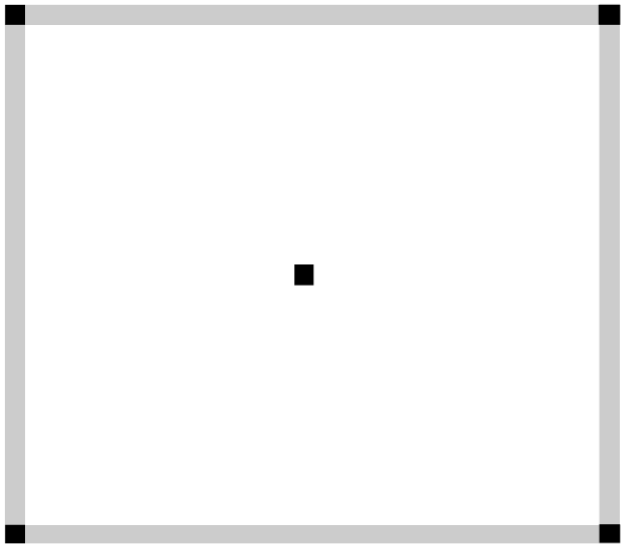
- The splitting process:



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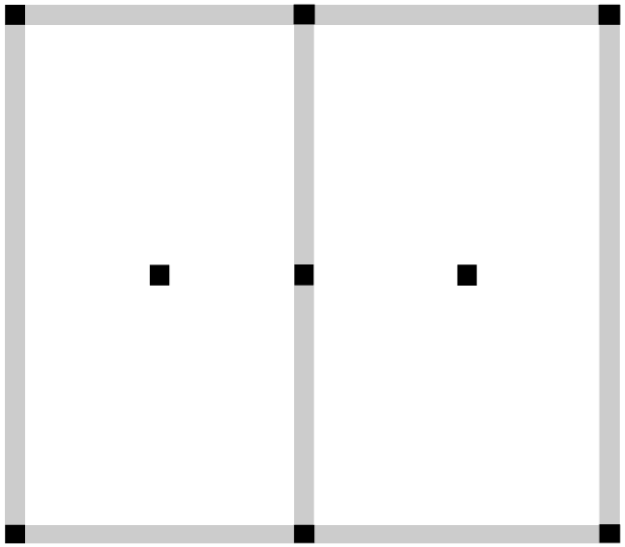

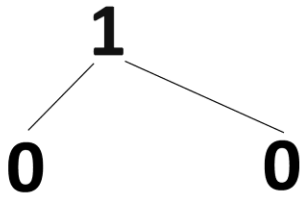

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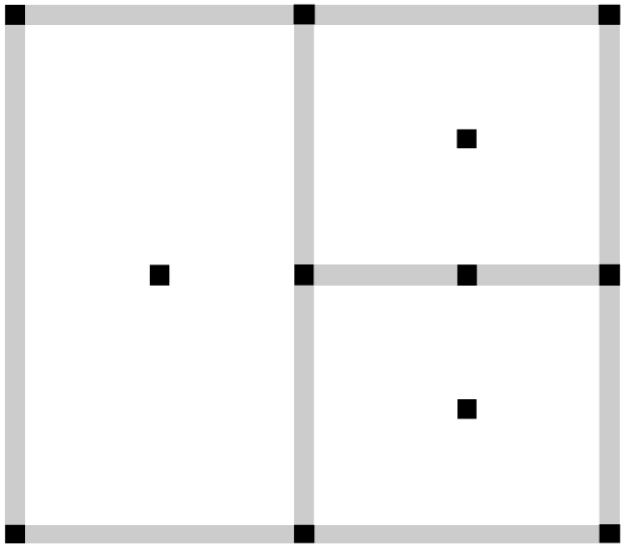

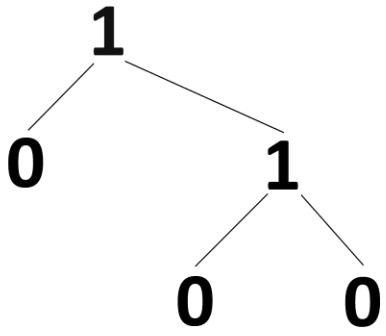

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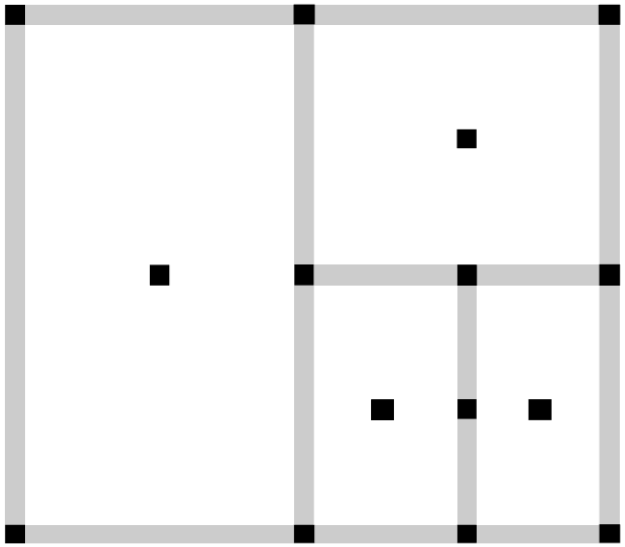

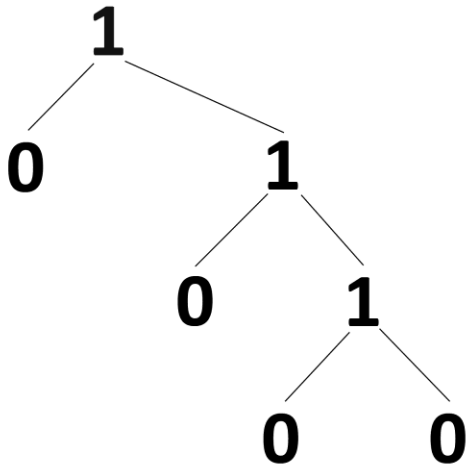

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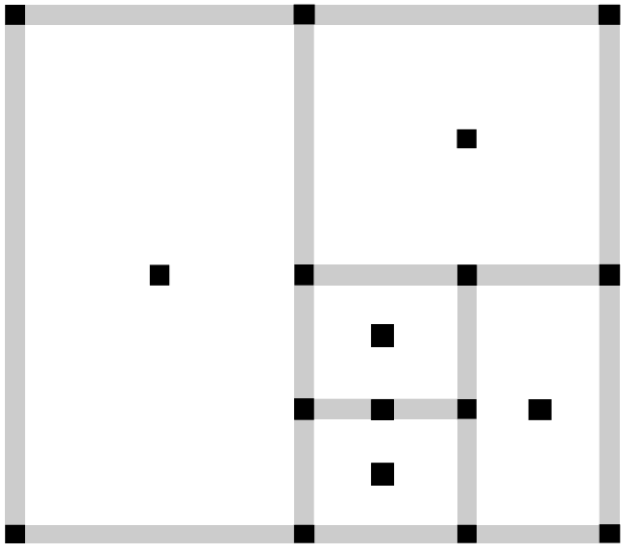

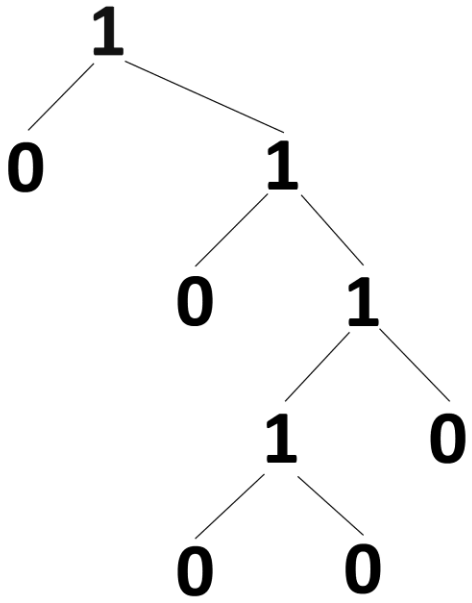

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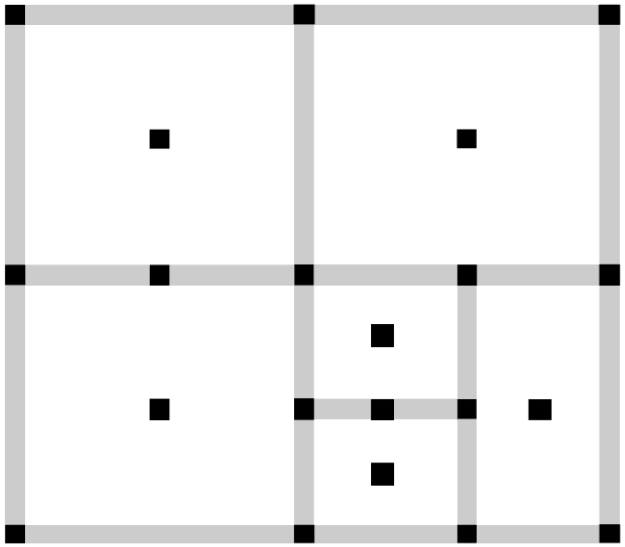

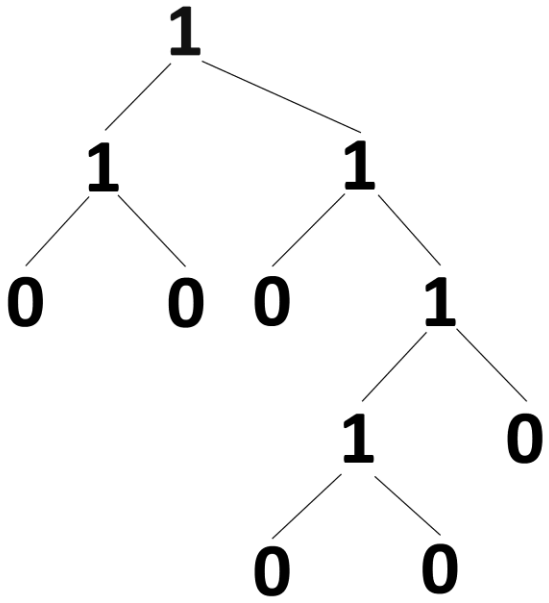

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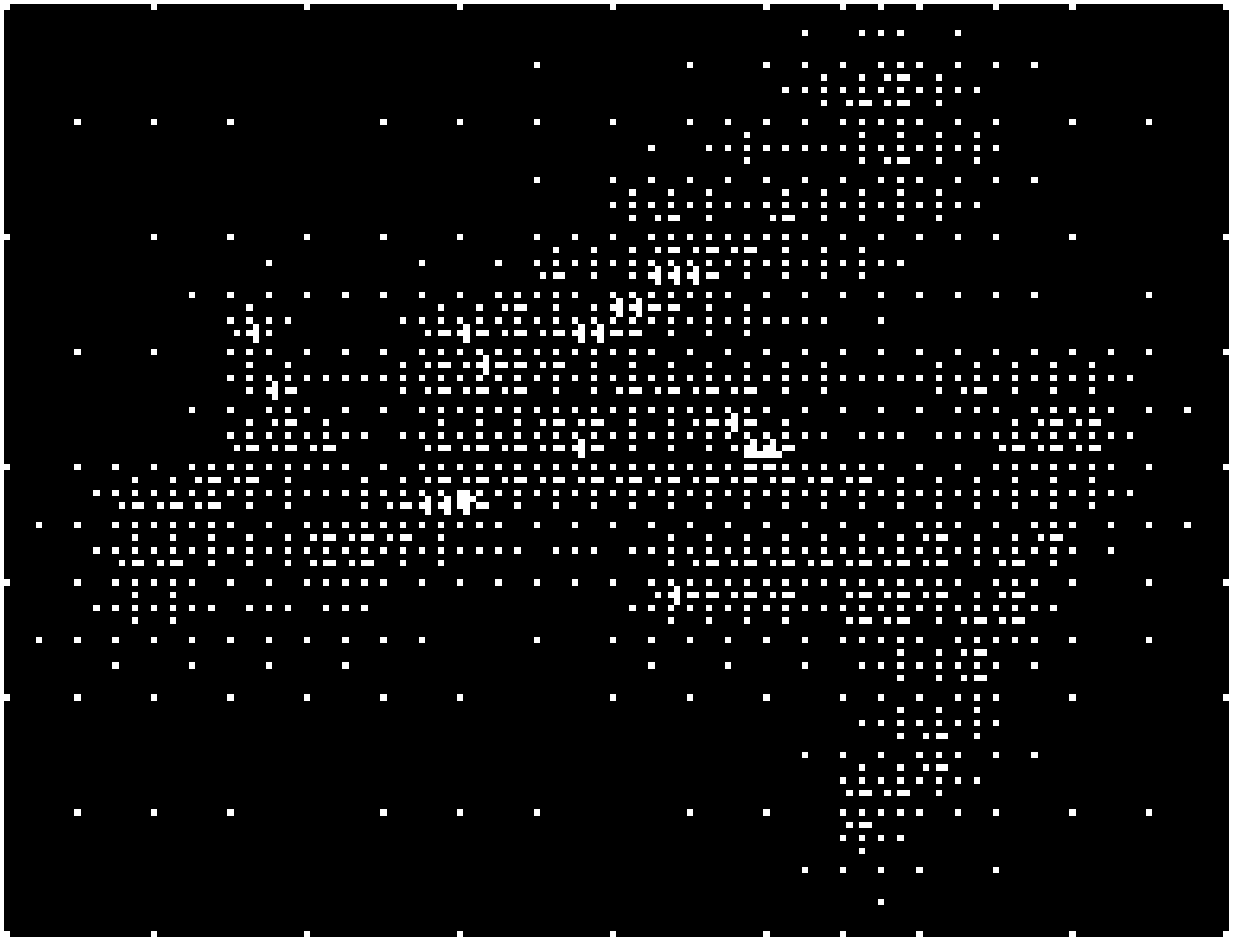

2) Representation

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- The information of the splitting process is stored as a binary tree
- The channels of the corresponding pixels are quantised to 32 values
- combined to a bitstream starting with its length

3) Encryption

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For specialists:

The bitstream is encrypted by

Advanced Encryption Standard (AES) in Cipher-block Chaining mode (CBC)

4) Hiding the information

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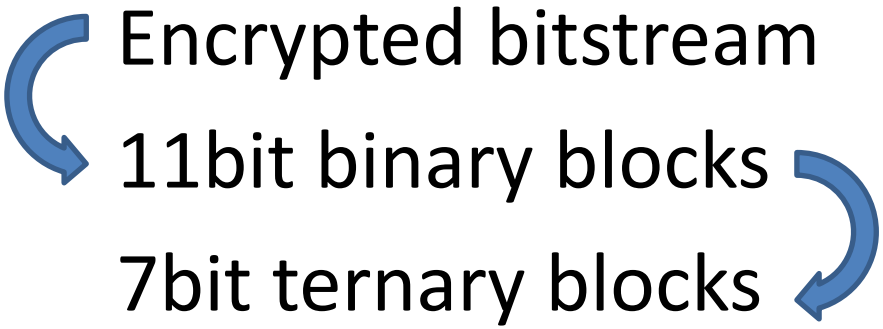

Using our password, we get a pseudo-random permutation

On those positions we hide the ternary bits using mod-3 matching

4) Hiding the information

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Mod-3 matching:

Value v, ternary bit t:

	= 1	v := v - 1
v – t mod 3	= 2	v := v + 1
	= 0	v := v

Special cases for v = {0, 1, 254, 255}

Special case: Censoring

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- Needs additional information about censored area
- Boundary information improves reconstruction
- Characteristic pixels on boundaries are not saved

Recovering the image

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The recovered secret serves as Dirichlet boundary data for the PDE:

$$\partial_t u = div\left(D\left(\nabla u_\sigma\right)\nabla u\right)$$

D has the two eigenvalues

$$\mu_1 = 1 \qquad \mu_2 = \frac{1}{\sqrt{1+\left|\nabla u_\sigma\right|^2 / \lambda^2}}$$

$\lambda > 0$ is a contrast parameter

Examples/Evaluation

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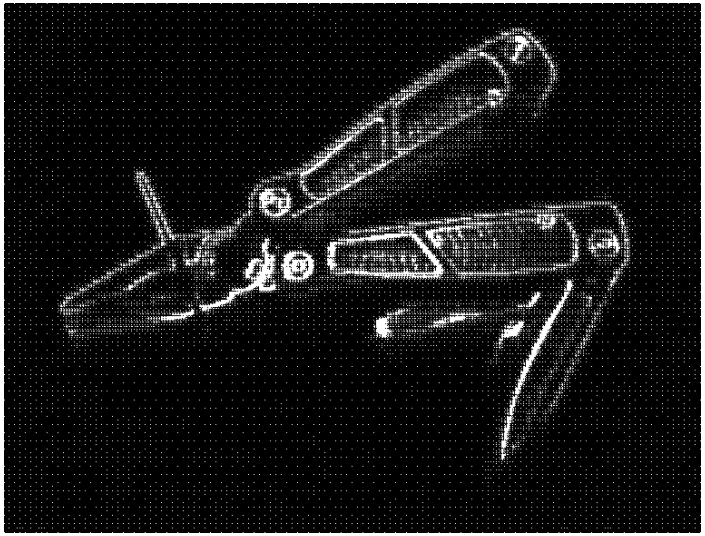

400x400 grayscale
Cover 20kb

768x584 RGB Secret
140kb

Diffusion process

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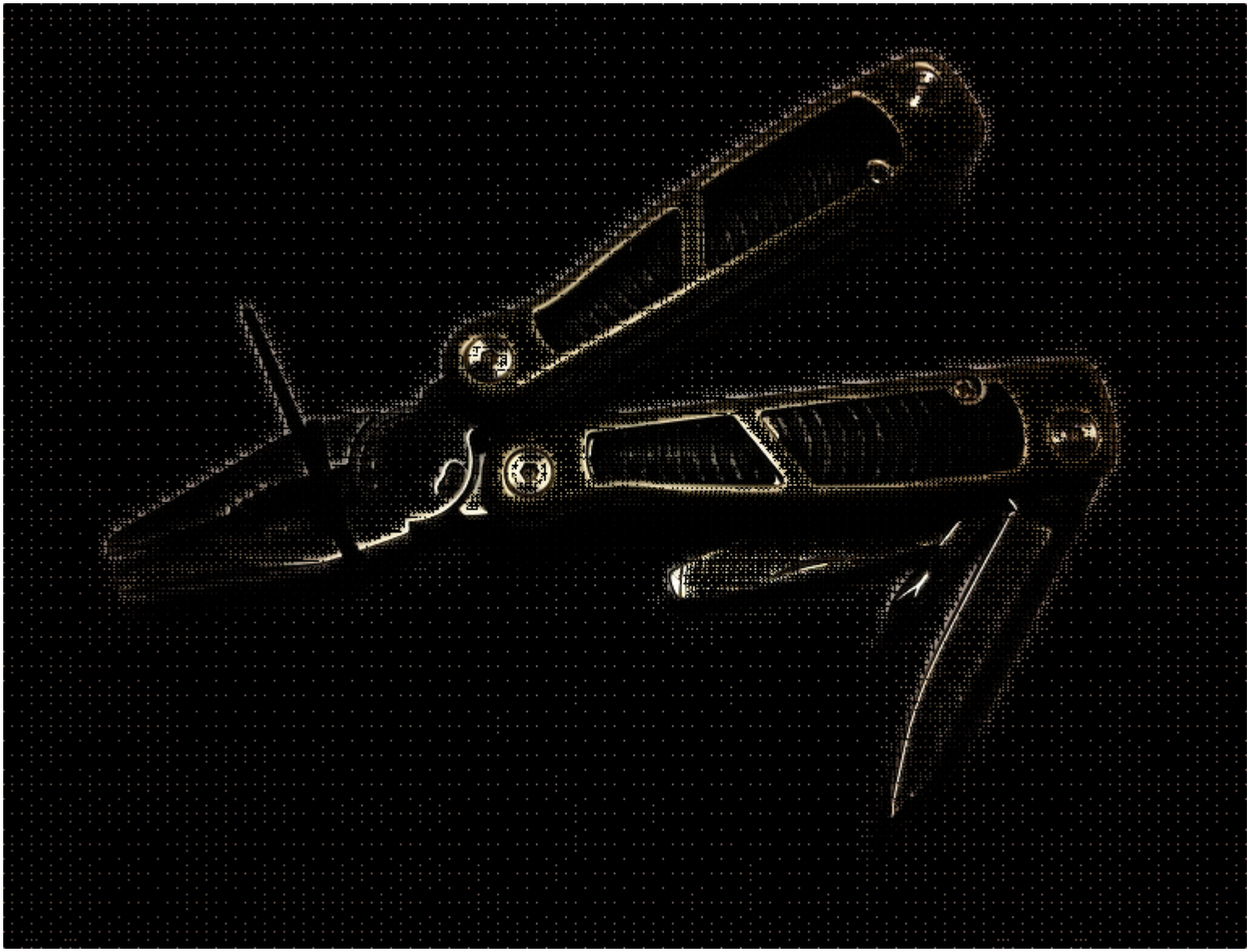

Examples

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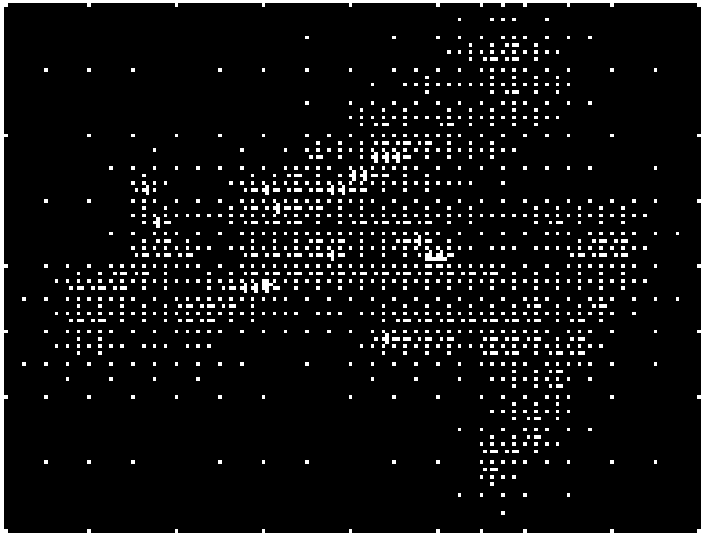

160x160 RGB Cover
10kb

192x146 RGB Secret
10kb

Low quality

Examples

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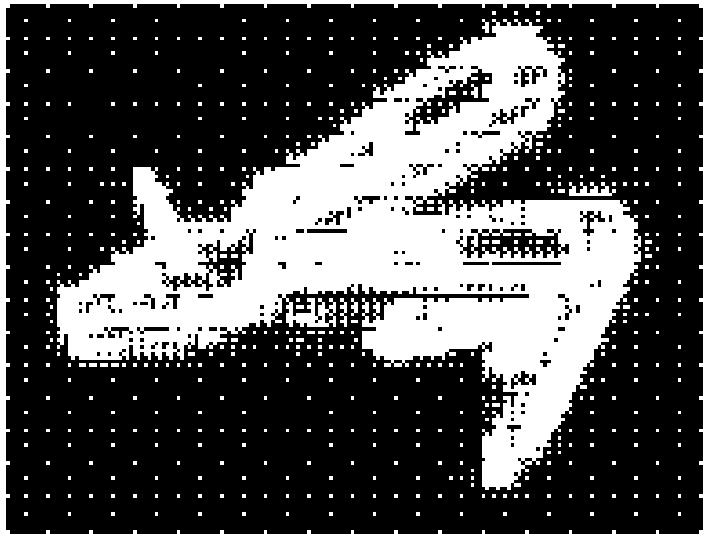

160x160 RGB Cover
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192x146 RGB Secret
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High quality

Censoring

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Censoring: (Original)

Censoring

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Censoring: (censored cover)

Censoring

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Censoring: (Reconstruction)

Censoring

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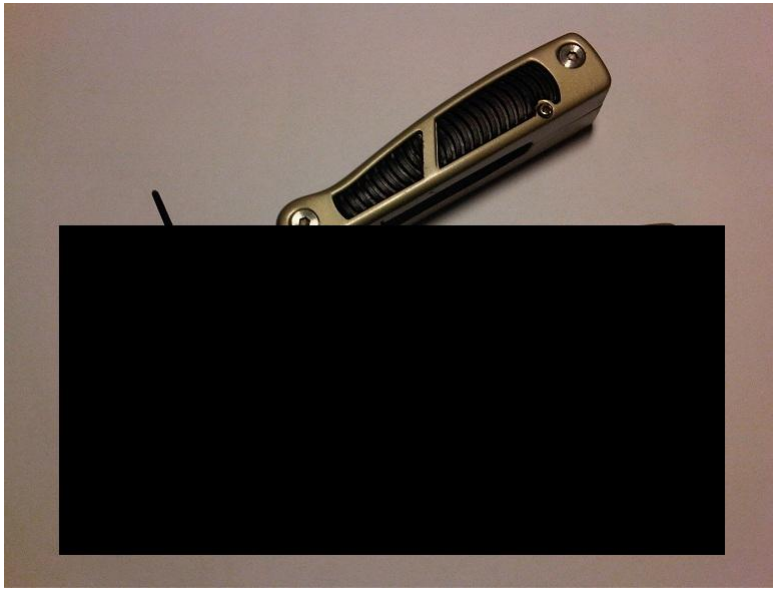
768x584 RGB Secret



Comparison

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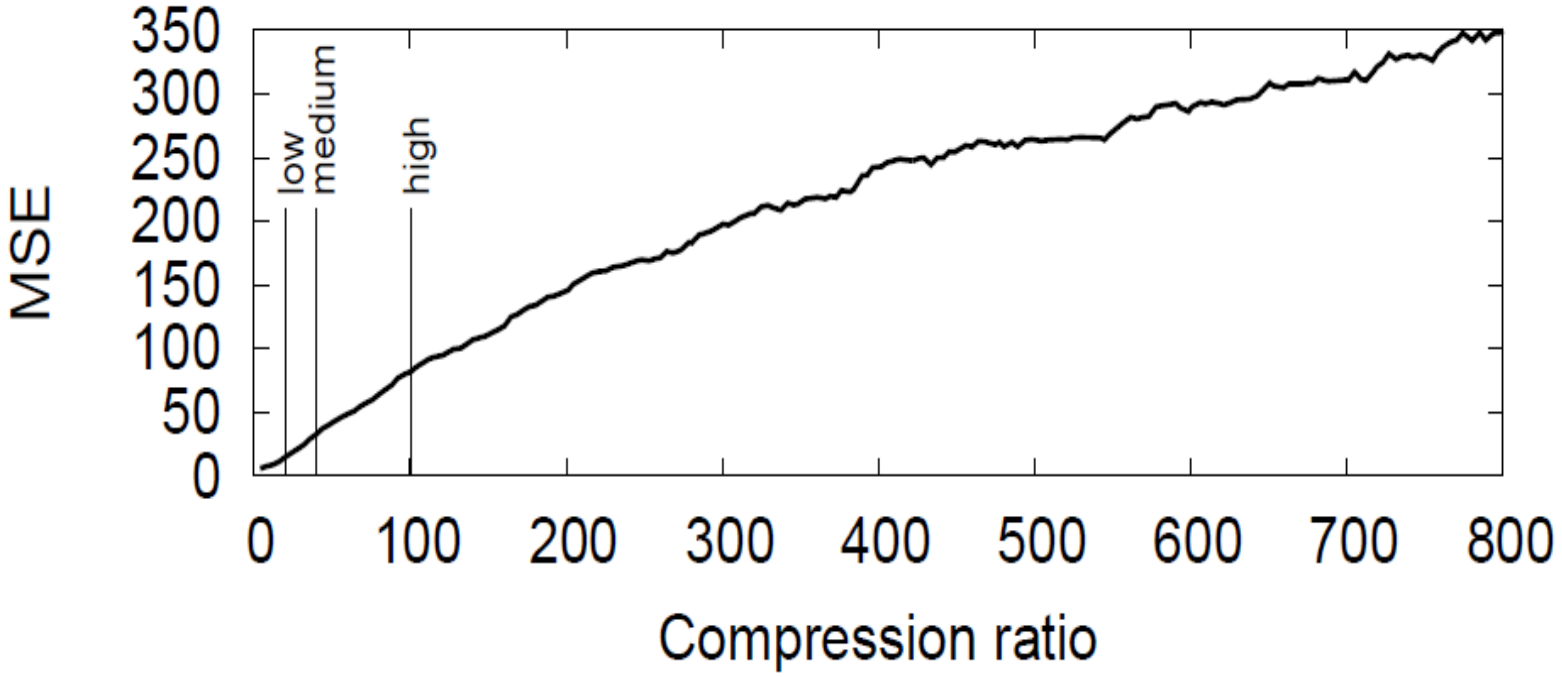

Fig.: Compression ratio vs. MSE

$$\text{MSE} := \frac{1}{M \cdot N} \sum_{m=1}^{M} \sum_{n=1}^{N} \left(f_{m,n} - u_{m,n} \right)^2$$

Evaluation

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- Combines many state of the art techniques
- Protected against detection/recovering
- (almost) real-time
- High quality of the results

- Vulnerable to changes of the cover

Outlook

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- Faster algorithms/implementations could further speed up this method
- Better choice of important pixels could improve the quality
- Extension of this method to image sequences, etc.

Quiz

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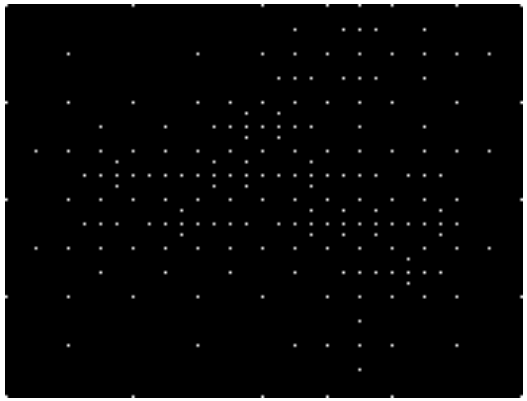
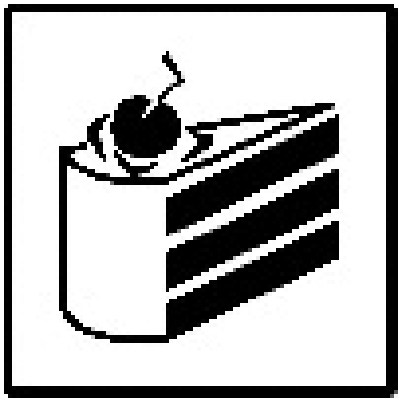
Secret (10kb)

Mask



Cover (30kb)



Recovered secret

100 x 100 grayscale Cover

References

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- Try it out for yourself!

  http://stego.mia.uni-saarland.de/
- Mainberger, M., Schmaltz, C., Berg, M., Weickert, J., Backes, M.: Diffusion-Based Image Compression in Steganography
- Schmaltz, C., Weickert, J., Bruhn, A.: Beating the Quality of JPEG 2000 with Anisotropic Diffusion
- Oxford dictionary
- Image Processing and Computer Vision – Lecture Notes 2011, J. Weickert
- An Implementation of Key-Based Digital Signal Steganography: Lecture Notes in Computer Science Volume 2137, 2001, pp 13-26
- http://compressionratings.com
- http://www.aishack.in