Image Watermarking Using DWT and SVD

NLA project

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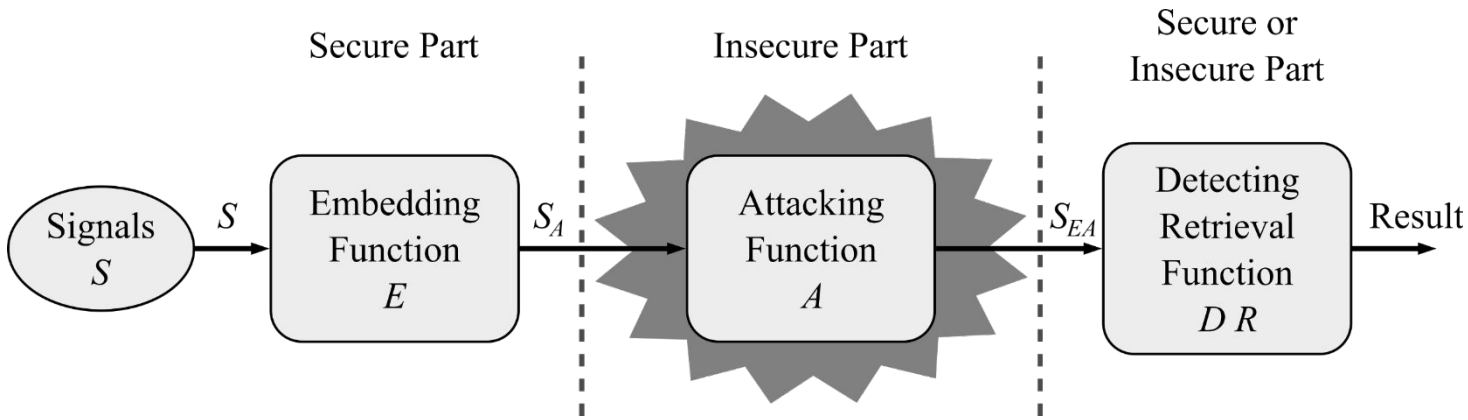
Digital watermarking

Applications

- Owner identification
- Source tracking
- Broadcast monitoring



Problem

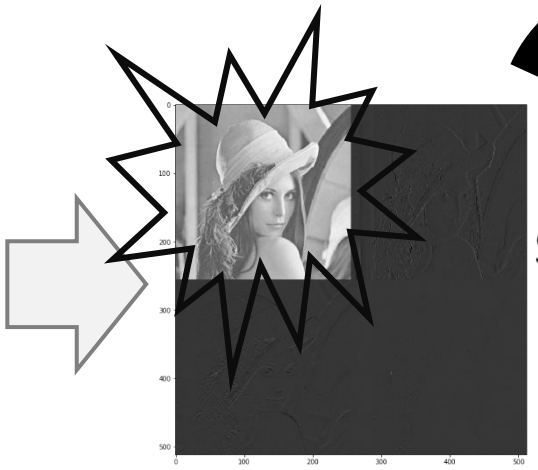
Proving uniqueness and identifying content even after distortions

Task

Creating a method for marking a content (image, sound, video) which is robust for deformations and visually transparent

DWT and SVD watermarking

Original Image

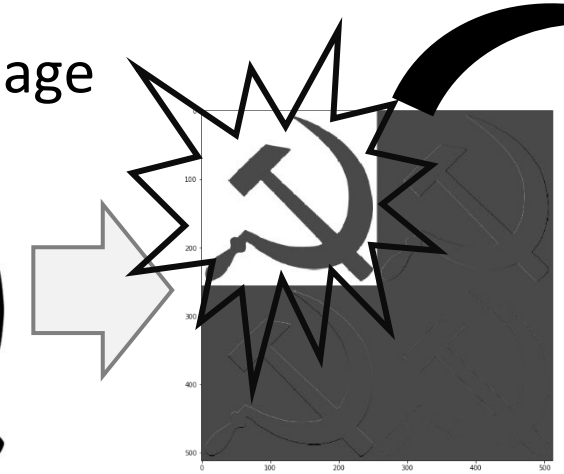


1-DWT transform

SVD transform

$$LL_{LENA} = U_{LENA}\Sigma_{LENA}V_{LENA}^{T}$$

Watermark Image



SVD transform

$$LL_{USSR} = U_{USSR}\Sigma_{USSR}V_{USSR}^{T}$$

Watermarking embedding

Watermark Embedding

$$\Sigma_{LENA}^{W} = \Sigma_{LENA} + r\Sigma_{USSR}$$

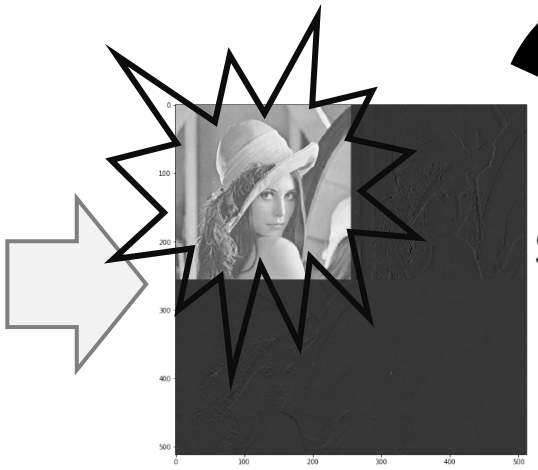
$$LL_{LENA}^{W} = U_{LENA}\Sigma_{LENA}^{W}V_{LENA}^{T}$$

1-DWT inverse transform

Watermarked Image

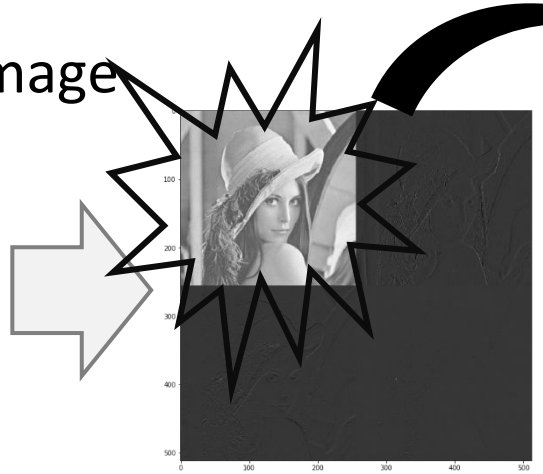
DWT and SVD watermarking

Original Image



1-DWT transform

Watermarked Image



SVD transform

$$LL_{LENA} = U_{LENA}\Sigma_{LENA}V_{LENA}^{T}$$

SVD transform

$$LL_{LENA}^{W} = U_{LENA}\Sigma_{LENA}^{W}V_{LENA}^{T}$$

Watermarking extracting

Watermark Extracting

$$\Sigma_{USSR}^{W} = \frac{\Sigma_{LENA}^{W} - \Sigma_{LENA}}{r}$$

$$LL_{USSR}^{W} = U_{USSR}\Sigma_{USSR}^{W}V_{USSR}^{T}$$

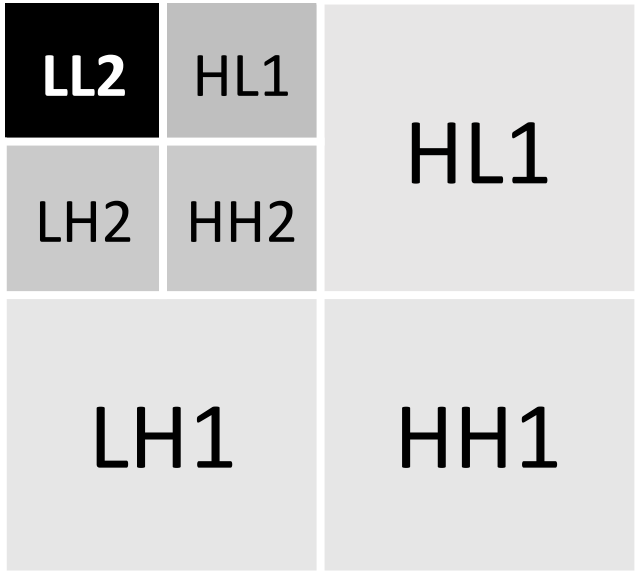
1-DWT inverse transform

Watermark Image

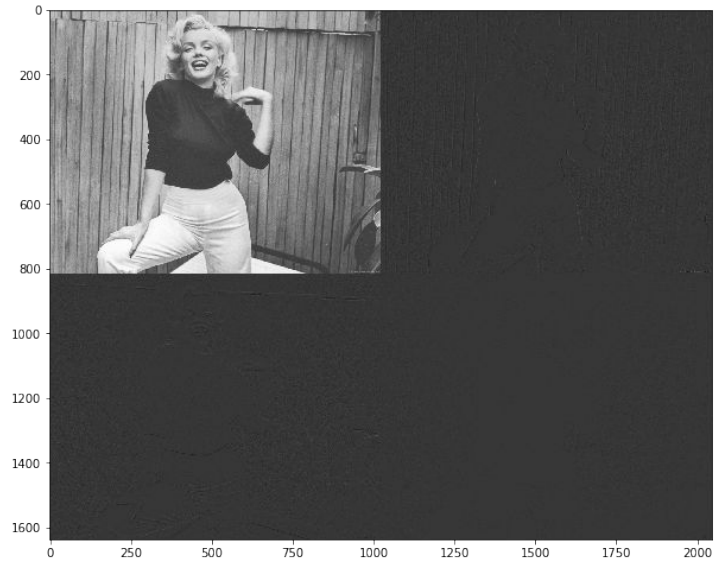
Haar Wavelet transform ($O(N^2)$)

$$H = \begin{pmatrix} \frac{1}{2} & 0 & \frac{1}{2} & 0 \\ \frac{1}{2} & 0 & -\frac{1}{2} & 0 \\ 0 & \frac{1}{2} & 0 & \frac{1}{2} \\ 0 & \frac{1}{2} & 0 & -\frac{1}{2} \end{pmatrix}$$

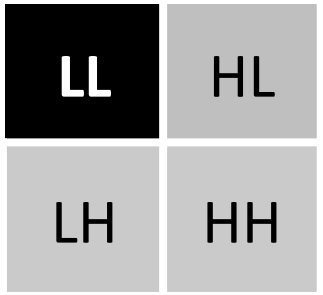
M =

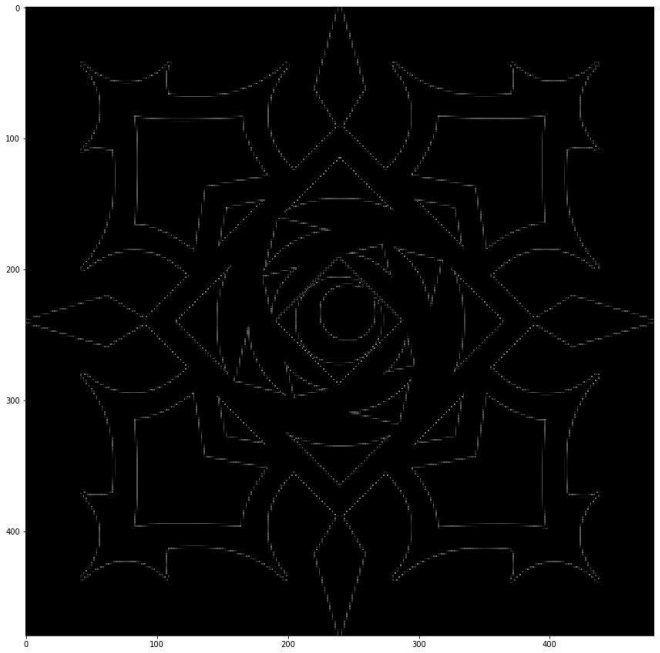


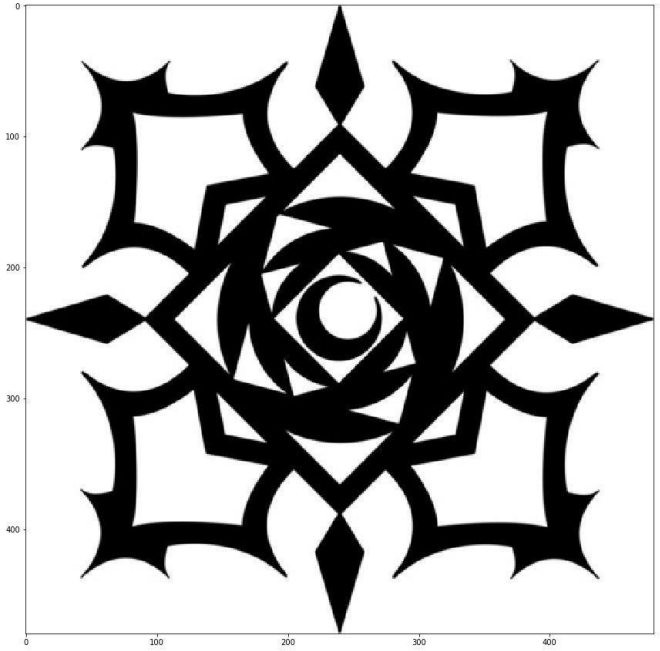
$H^T M H =$



Haar Image Compression: Experiments



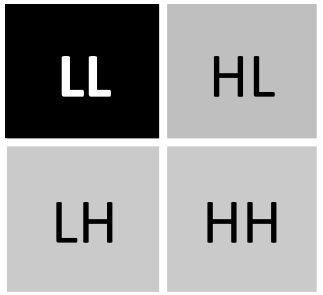




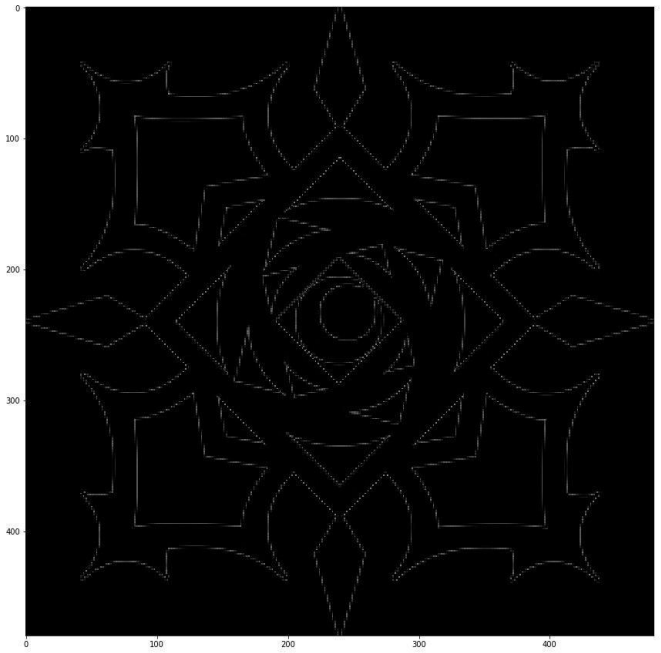
Haar Image Compression: Experiments

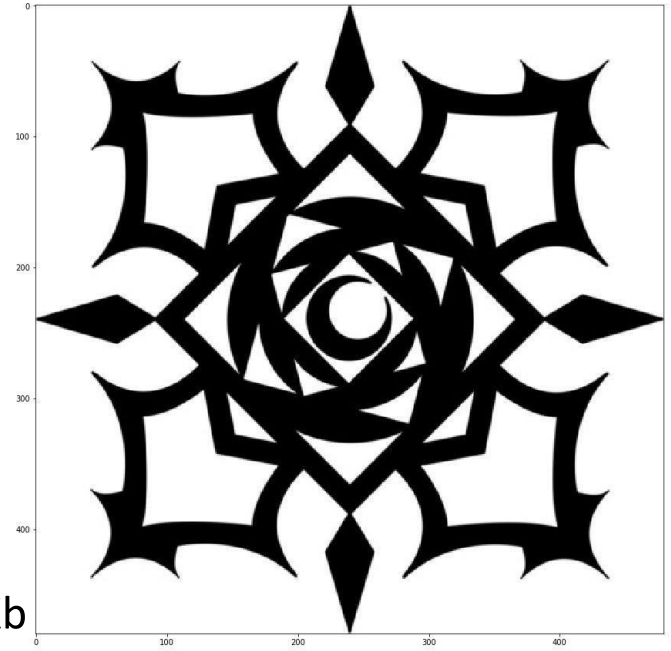
Initial Ivan weights 289 Kb

108 Kb



Ivan has lost weight to 45Kb





Watermark extraction: Experiments

$$MSE = \frac{1}{N^2}\sum\sum(USSR_{i,j} - USSR^{W}_{i,j})^2$$

$$PSNR = 10\log_{10}\frac{MAX^2_{USSR}}{MSE}$$

$$NCC = \frac{\Sigma^{T}_{USSR}\Sigma^{W}_{USSR}}{\|\Sigma^{T}_{USSR}\|\|\Sigma^{W}_{USSR}\|}$$

Watermarked Lena with distortions

Not distorted image	Gaussian blur	Contrast	Crop	Gamma correction	Histogram equalization	Noise	Pixelate	Rotate
	MSE=65.078 PSNR=29.996 NCC=0.997	MSE=113.554 PSNR=27.196 NCC=0.991	MSE=75.596 PSNR=26.223 NCC=0.711	MSE=73.086 PSNR=28.050 NCC=0.778	MSE=72.200 PSNR=29.545 NCC=0.969	MSE=40.996 PSNR=32.003 NCC=0.998	MSE=2.150 PSNR=43.756 NCC=0.999	MSE=74.145 PSNR=29.429 NCC=0.944

Extracted watermark

Conclusions

- Obtained method is robust to several types of attacks (blur, pixelization, noising, contrasting)
- Adding DWT provides transparency of obtained watermark in comparison with simple SVD watermarking

Future work

- Watermark embedding to higher order DWT transformations
- Apply DWT transformation not only to LL section of image, but also to other parts

References

- Malik, Vinita and Sukhdip Sangwan. “Digital Watermarking using DWT-SVD Algorithm.” (2017).
- Øyvind Ryan. “Linear Algebra, Signal Processing, and Wavelets - A Unified Approach.” (2018).
- Emir Ganic and Ahmet M. Eskicioglu. “Robust embedding of visual watermarks using DWT-SVD.” (2004).
- Bambang Harjito and Esti Suryani. “Robust Image Watermarking Using DWT and SVD for Copyright Protection.” (2016)