Image denoising with multi-layer perceptrons

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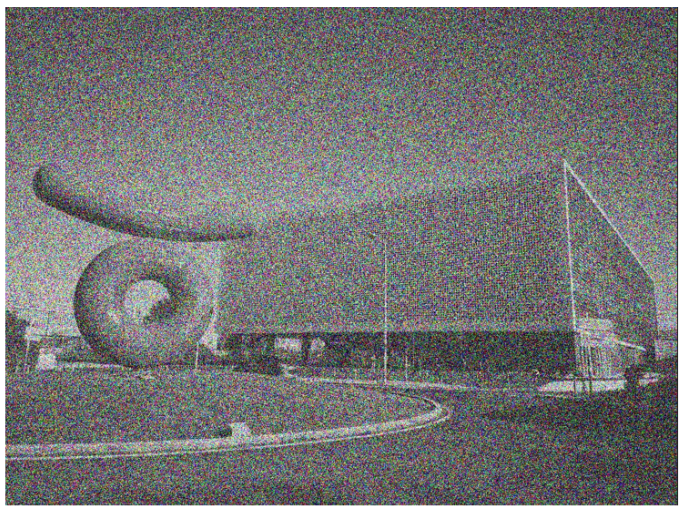
Clean image



Noisy image

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Context

Aim

Problematic : Mapping a noisy image (image pixels undergo random fluctuations) to a noisy-free image.

Existing algorithm

Suggested in the article : Using patches with a MLP-based method.

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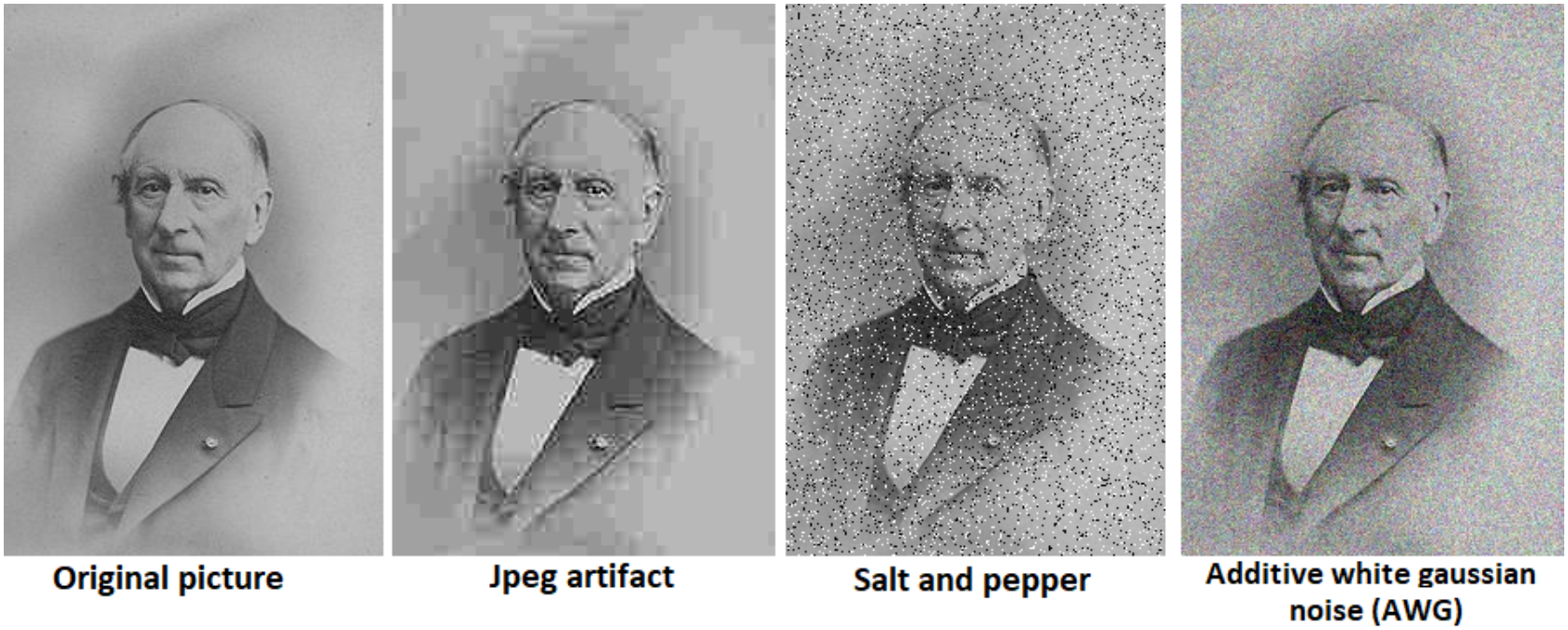

Figure – Representation of Augustin Louis Cauchy with different noise

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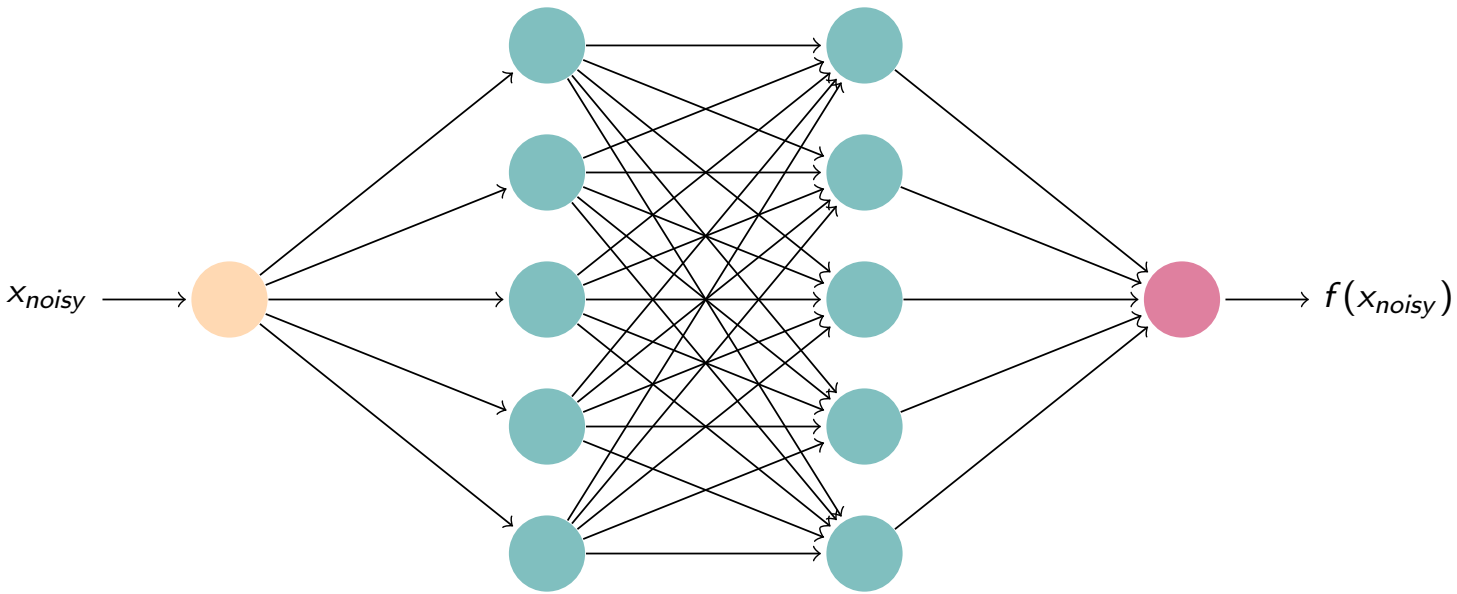
MLP-based method



where x_{noisy} is a noisy version of a clean patch x and $f(x_{noisy})$ represents an estimate of x.

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Weight initialization for MLP-based method

Weights w are sampled from an uniform distribution :

$$w \sim \left[-\frac{\sqrt{6}}{\sqrt{n_j + n_{j+1}}}, \frac{\sqrt{6}}{\sqrt{n_j + n_{j+1}}} \right]$$

Loss function

The loss function used is the MSE :

$$MSE = \frac{1}{n} \sum_{i=1}^{n} (f(x_i) - x_i),$$

where $f(x)$ the estimation x and x is a clean patch.

Peak Signal-To-Noise Ratio (PSNR)

PSNR $= 20 \times \log_{10} \left(\frac{m}{\sqrt{\text{MSE}}} \right)$ (dB), where m is the maximum possible pixel value of a given image.

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Results for AWG noise

Definition

Additive white Gaussian noise (AWG) : Mimics the effect of many random processes that occur in nature.

Figure – Comparaison BM3D and MLP (AWG noise $\sigma = 25$)

Other type of noise

We begin by Strip noise, see result of denoising with BM3D and MLP.

Figure – MLP and BM3D denoising strip noise

Other type of noise

For Salt and pepper noise, we compare MLP with median filtering methode. This method was the stat-of-the-art for this type of noise.

Figure – MLP and median filtering denoising salt and pepper noise

Other type of noise

For JPEG articact, we compare MLP againt the state-of-the-art.

Figure – MLP JPEG Artifact

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Bounds

Clustering-based bounds

There exist inherent limit on denoising quality for images with rich geometric structure.

Bayesian framework

How well any denoising algorithm can perform, which depends on the patch size.

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Block-matching

Block-matching

Idea : Find the patches most similar to a reference patch.

Combine MLP and block-matching

Train MLPs that take as input a reference patch and its nearest neighbors (similar patches).

Results

Block-matching MLPs provides better results on images with repeating structure than plain MLPs.

However, BM3D and NLSC still provide better results on this kind of images.

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Conclusion