De-noising an Image Using Deep Learning Techniques

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Overview

- Introduction – Deep learning
- Paper – Key ideas
- Image denoising – basic ideas
- Possible solutions
- Deep learning solution for image denoising
- Image denoising with MATLAB
- Additional performance tests
- Conclusions

Introduction - Deep Learning

- Deep learning is a subset of machine learning in AI world.
- This field is also known as deep neural learning or deep neural network
- Used in various fields such as:
  - Audio recognition & speech recognition
  - Image recognition & computer vision
  - Machine translation, bioinformatics, designing of drugs
  - Self-driving cars
  - Machine translation
  - Mobile advertising & military
- It is an emerging field and clearly very beneficial for future as long as it is controlled and kept within the manageable risk level associated with this technology.

Paper – key ideas

- Image denoising is a traditional task in image processing field
- The need to improve denoising performance is a continuous challenge
- This paper presents key ideas that can improve image denoising
- Also discusses:
  - The limitations of traditional fully connected multilayer perceptions
  - Currently used approach in this field known as convolutional neural networks
  - Related Matlab toolboxes on image Processing and deep neural networks
  - Existing framework is tested under real condition
    - The output confirm two of the major claims behind Matlab DnCNN: the blind denoising capabilities and low time used in the denoising task

Image denoising – basic ideas

- A digital image usually given by matrix of pixel values.
- Each pixel value comes from a light intensity measurement
- Due to unavoidable natural noise sources, these measures are taken under noisy conditions.
- This leads to an output (or measured) matrix with values different to the original image values.
- If **X** is the output image matrix of light intensity values and **Y** is the real image matrix. The relationship between these matrices is as follow

$$\mathbf{X}=\mathbf{Y}+\mathbf{E}$$

- We usually don't know either **Y** or **E** matrices,
  - Only have access to **output and noised matrix X**.
  - How to obtain a close estimate to the real **Y** matrix from the given **X** matrix?
    - This inverse problem is the image denoising task.

Possible Solutions

- The problem of image denoising has several solutions previously published.
- Filtering point of view using:
  - A frequency domain representation of the measured matrix **X**
    - Fast Fourier transform > low pass filter under the basic assumption
      - That image signal and noise have enough separation in the **X**-spectra
- Smoothing techniques
- In this paper we
  - Develop the denoising task using the deep learning techniques
    - With the help of existing toolboxes in Matlab.

DnCNN architecture and features

- The input of a DnCNN is a noisy image.
- Focuses on the problem of learn a function $F(\mathbf{y}) = \mathbf{x}$ to estimate the true clean image.
- The DnCNN approach adopt the residual learning strategy to train a residual estimate function $R(\mathbf{y}) = \hat{E}$
- The true clean image estimate is then $\mathbf{x} = \mathbf{y} - R(\mathbf{y})$.
- The averaged mean squared error between the true residual images and estimates residual from noisy image.
- This is the mean square error function used to learn the DnCNN parameters.

$$\mathrm{MSE} = \frac{1}{N}\sum_{i=1}^{N}\left\|\hat{E}_i - (y_i - x_i)\right\|^2$$

Image denoising with Deep Learning in Matlab

1. Image Testing Procedure

- True Image Selection
- Transform the original image to gray scale.
- Set a noise level
- Develop a sequence of noised images
- Denoising with DnCNN
- Error Image Estimation
- Performance Measures

2. DnCNN Image Denoising Testing

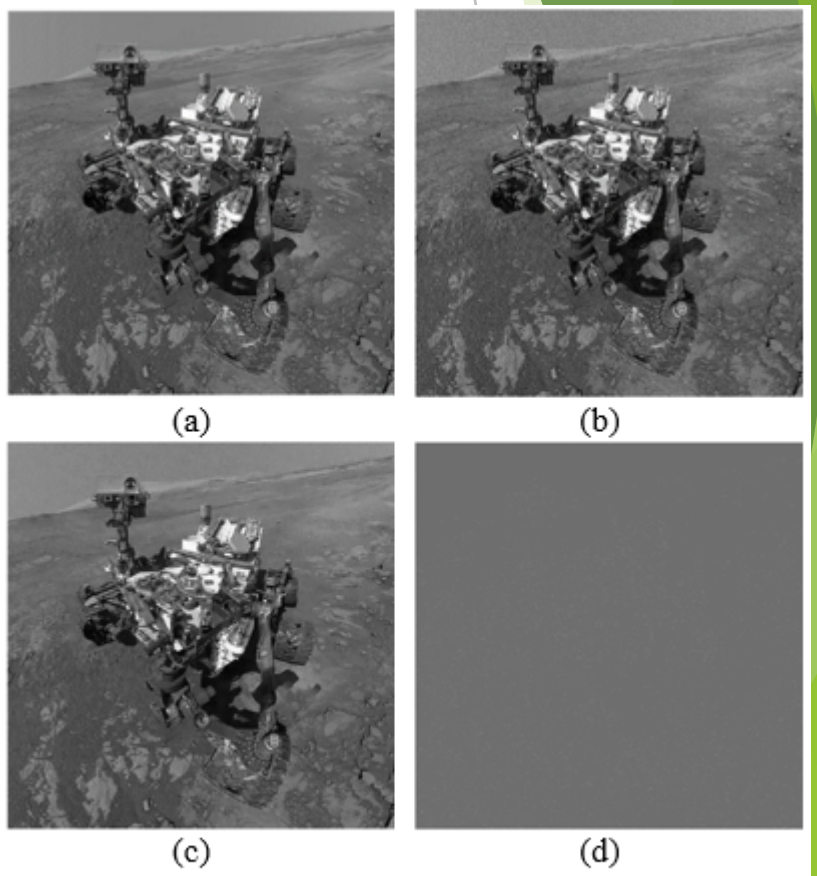


Fig. 1. a) Original Image, b) Noised Image, c) Denoised Image, d) Error matrix

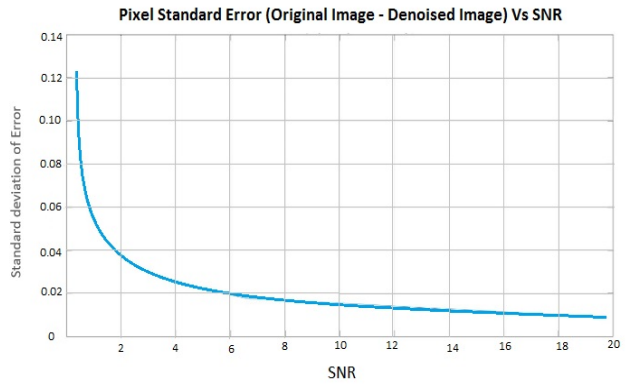
Additional performance test

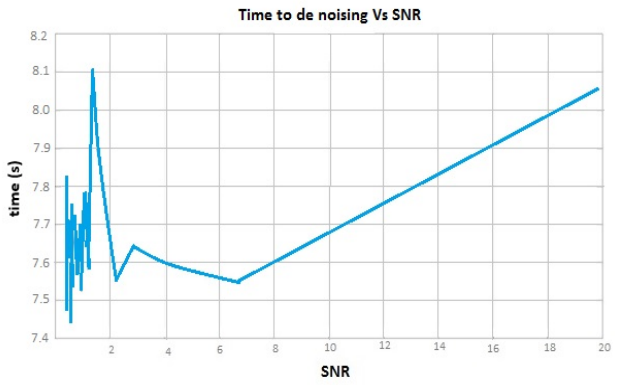
Two major claims of the DnCNN are:

1) The robust performance under different and unknown noise levels known as “blind denoising”,
2) The reduced time spent in the denoising process.

Denoising task was performed:

- Under a wide range of *SNR* levels
- Time spent to perform each image denoising was measured





Conclusions

- Presented the main ideas behind the theoretical framework of denoising image
  - With convolutional neural networks and its implementation in Matlab.
- The test results show that the DnCNN has promising performance behavior under:
  - Different range of noise levels
  - Blind Gaussian noise, and
    - Use a relatively short time to perform the image denoising task.
- For very small noise component the DnCNN is not suitable to performs image denoising.
- If the noise signal is very small, the DnCNN must spend more time to perform the denoising task.

Thank you for listening

Any Questions?