University of Science and Technology of Hanoi

Information and Communication Technology Department

Master Thesis

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NOISE EVALUATION AND REDUCTION

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presented by

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ATTESTATION

I hereby, HOANG DUC VIET, certify that my report doesn't contain plagiarism (copy/paste) from other sources.

In case of plagiarism in my report, I know the consequences and I understand that my report won't be evaluated. In this case, my M2 internship will be noted as "fail".

Date 15/09/2017

Signature HOANG DUC VIET

Acknowledgements

I would like to .....

Asbtract

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Chapter 1

Introduction

1.1 Context

Noise pollution is the disturb or loud noise may effected the activity or health of peole or animal in life. Most of outdoor noise is mainly caused by machines and transportation systems, motorbike engines, airplanes, and trains. Outdoor noise meaning is the environmental noise: Urban planning or industrial areas are representation examples Nowdays, noise levels can be main cause by cardiovascular illness or coronary artery in human. For animals, noise can increase the count of death ,bad effected to reproduction and hearing loss

Moreover, noise also appears in the images. Image noise is created by the sensor and circuitry from scanner or digital camera. Film grain and noise of an ideal photon detector are one of cause. So brightness or color information in images will be changed. Image noise is unlike by product of image capture that have many different information.

Next, it is quality of camera. Although camera technology is very improve over the past decade, it still has not totally remove noise for images. So now, researchers still find to way which improve about camera to help us have image is better. Noise can appear in our photo for different reasons. Noise signal increases with the light signal when high ISO is used, therefore our camera will capture more light to illuminate the scene, but graininess will be more apparent. When an image sensor became heats up, photons separate from the images and destroy other images. Long exposures also give our image greater risk of showing image noise, since the sensor is left open to gather more image data and this includes electrical noise.

After we have an overview of the noise, what will help us deal with the noise in the image. Denoise is a process of remove noise to images. There are ways to noise removal an image, data and so on. With image denoise model is completely remove noise and protect edges. Basically, there are two types of models : linear and non-liner. Good feature of linear noise removing models is the speed also as limitations of itself. Models are not able to complete of preserve edges for images. So, blur edges could appear in images.

On the other hand, non-linear models can solve edges problem is much better than linear models. We suppose non-linear image denoising model use the Total Variation (TV)- filter. Denoise a degraded image X by X = S + N, meaning sum of S (original image) and N (Gaussian noise) with unknown values(σ) . This example is one of noise removal method, we are going to research and improve denoise method in report.

1.1.1 Internship context

One of the major problems in document digitalization is noise. Image noise is random (not present in the object imaged) variation of brightness or color information in images. It can be generated in many scanning steps, such as grayscaling or thresholding. It can also be caused by image lossy compression algorithms, such as JPEG's discrete cosine transformation and thresholding. Noise is one of the main factors contributing to degratation of accuracy in optical character recognition of the scanned documents, a process aiming at providing a high semantic description of the content of the document. At ICTLab, we have been dealing with scanned document in the context of project ARCHIVES. A good noise evaluation and reduction algorithm will improve our document analysis (including optical character recognition) results. We are going to research and improve different denoiseds after we obtain results. From this, we will compare result of methods as : Median filter, Average filter, Gaussian filter, Wiener filter and Sure-Let filter follow PSNR and MSE. Created comparison table and showed image result, finally we will know method is the best. Although, images processing have many method to remove noise but due to limited time, many other methods can not be explored and the results are only relative. So we only evaluate which method is best in this Internship.

1.2 Problematic

We have two problem in this topic:

- Noise
- Denoise

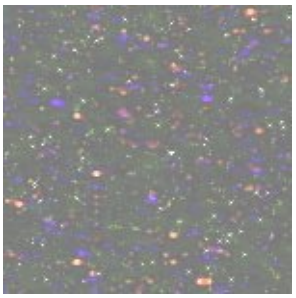
1.2.1 Noises

Noise is the cause of errors from image when in pixel values that do not reflect the true intensities of the real scene.

There are 3 type of noise:

- Fixed Pattern

  Fixed pattern noise appear during extremely long exposures. So when the camera is working for long periods of time and it heats up, the sensor starts to produce these strange dots of color in our image. And our camera is hotter, more fixed pattern noise will appear.



- Random Noise

  Random noise maybe the most common image noise. Random noise appear whenever were using high ISO values. Cameras has good at reducing the amount of random noise that is seen in photographs through technology. The noise reduction feature on some cameras which remove random noise. So when technology continues to improve, we can shoot in low light situation.

- Banding Noise

  Banding noise is dependent on what type of camera we are using. With high end camera, we have never seen banding noise. Some banding noise will appear when lower quality photograph are shot with higher ISO value. There are causes help banding noise appear: in the dark of photos or increase exposure too much and digitally make a photograph too bright . We may also see more banding noise in certain white balances.

1.2.2 Denoise

Noise removal is very important task in image processing. It will help image restoration is to remove the noise from the image in such a way that the original image is the best quality. In modern digital image solution for photography or improve the image was degraded.

Filtering is technique which can be decreasing or increasing an image. It's the processed value for the current pixel which depends on both itself and surrounding pixels. So filtering is a neighborhood operation, it mean that the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel.

Follow Image Processing, there are 4 type of filtering :

- Median Filter.

  The median filter is a nonlinear digital filtering technique. So median filtering is very widely used in image processing and it preserves edges while removing noise under certain conditions.

- Average Filter.

  The type of average filtering is simply to replace each pixel value in an image with the average value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their environment. Average filtering as a convolution filter.

- Gaussian Filter.

  In electronics and signal processing, filter whose impulse response is a Gaussian function (or an approximation to it). Gaussian filters have feature of having no overshoot to a step function input while minimizing the rise and fall time.

- Wiener Filter

  The main aim of this technique is to filter out noise that has corrupted the signal. It is kind of statistical approach. For the designing of this filter one should know the spectral properties of the original signal ,the noise and linear time-variant filter whose output should be as close as to the original as possible. The Wiener filter minimizes the mean square error between the estimated random process and the desired process.

1.3 Report organization

This part must explain how the report is organized.

Chapter 2

State of the art

2.1 Noise Removal in Image Processing using Median

This paper "Noise Removal in Image Processing using Median, Adaptive Median and Proposed Median Filter and Respective Image Quality Comparison" was written by Monika Kohli and Harmeet Kaur. Authors research and analyze median filter. From this, the filter is compared with median and Adaptive median filter.

Types of noise

- Impulse noise (Salt & pepper noise)
- Amplifier noise (Gaussian noise)
- Quantization noise (Uniform noise)
- Multiplicative noise (Speckle noise)
- Periodic noise(Stationary noise)

After image noise can be classified as above, characteristics of each type are specified. Next to analyse algorithm of filters : Median filter, Adaptive median filter, Proposed Median Filter.

Result Comparison of filters:

For: Salt and Pepper noise as 0.01 and 0.02 respectively.

	Median Filter	Adaptive Median Filter	Proposed Median Filter
LENA(0.01)	27.85	28.62	29.17
LENA(0.02)	26.92	27.37	27.65

Finally, result Comparison of filters when used PSNR to calculate quality of images. We obtained result show that the proposed method is the best.In futher, result can be improved by different noise such as : Gaussian noise, Speckle noise etc

2.2 The Sure-Let Approach to Image Denoising

The paper was written by Thierry Blu, Senior Member, IEEE, and Florian Luisier. It's a new approach to image denoising, based on the image-domain minimization of an estimate of the mean squared error(MSE).

- A new approach to image denoising,based on the image-domain minimization of an estimate of the mean squared error: Stein's unbiased risk estimate (SURE)
- The denoising process can be expressed as a linear combination of elementary denoising processes: Linear expansion of thresholds (LET)
- Evaluate this denoising performances by comparing PSNR
- Combined 3 step above to SURE-LET Approach

We have SURE-LET Formula as below :

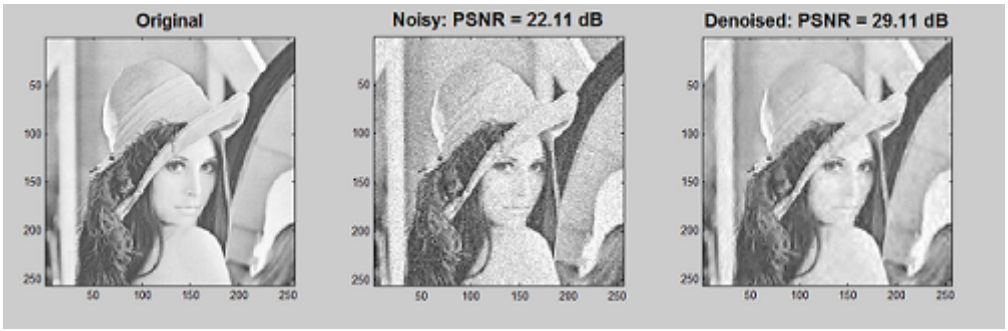
$$\sum_{l=1}^{K} \underbrace{F_k(y)^T F_l(y) a_l}_{[M]_{k,l}} = \underbrace{F_k(y)^T y - \sigma^2 div\{F_k(y)\}}_{[c]_k}$$

$$for\ k = 1, 2...K$$

$$\Updownarrow$$

$$\mathbf{Ma{=}c}$$

Result:



- Input PSNR : 22.11[dB]
- Output PSNR : 29.11[dB]
- Elapsed time : 0.55[s]

With $PSNR = 10 * log_{10}(255^2/MSE)$, we have :

- Input PSNR : 22.11[dB] $\Rightarrow$ Input MSE = 4.00
- Output PSNR : 29.11[dB] $\Rightarrow$ Output MSE = 3.22

Conclude:

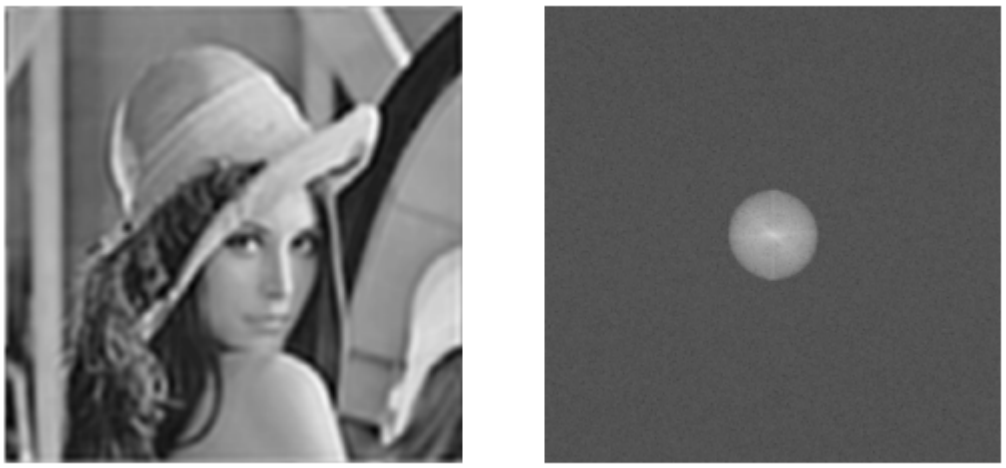
Follow SURE-LET program in Matlab, input MSE is compare between noisy image and original image, output MSE is compare between denoise image and original image. So we use output MSE result to table of Comparison Of The Results.

2.3 Study on Methods of Noise Reduction in a Stripped Image

Author's this paper: Chi Chang-yan, Zhang Ji-xian, Liu Zheng-jun

Noise is one of image quality problem in the image processing major. Noise reduction is necessary for us to do remove noise and description useful information more prominent. The Gray Value Substitution and Wavelet Transformation are methods in noise removal. Finally, MSE and PSNR are evaluated the processed image suitable in this paper.

2.3.1 Low pass filter



TLPF processed image and its Fourier spectrum

Noise is high frequency signal, so we used low pass filter to reduce it. The trapezium low pass filter (TLPF) we choose has certain advantage to smooth transition band. After processing, the image is blur than that before. Low pass filter can remove noise is meaning detailed image information is also removed. So it is not good at image which needs much spectral information.

2.3.2 Gray Value Substitution

Image processing results of gray value substition

We can see from this image, most noise line is changed and it is not affected by this method. However, some small noise still appear, and the brightness after processing is stronger than that before.

2.3.3 Wavelet transformation

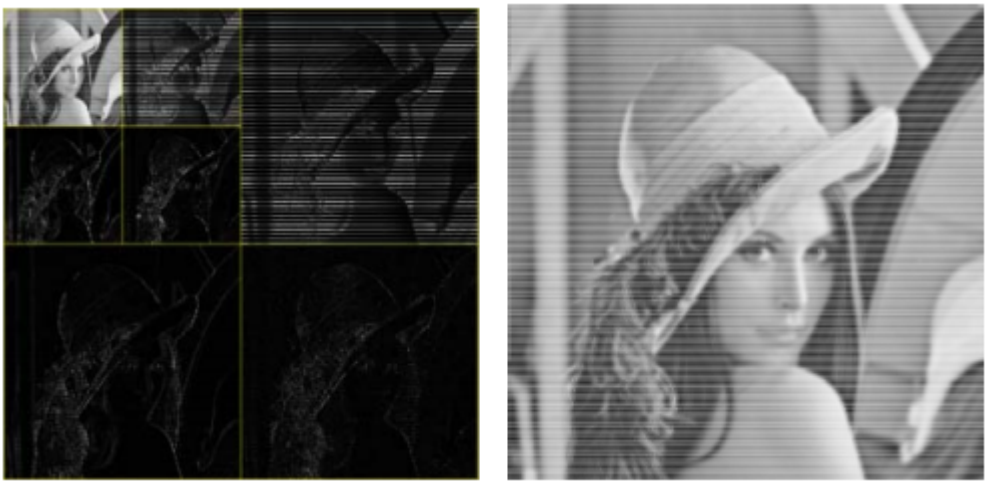


Image decomposition using Wavelet and usual wavelet denoising result

Wavelet method haven't solution remove noise which still exists in the horizontal domain, the vertical and cross part of this image does not have much noise.

2.3.4 Results and comparisons

Noisy Image	MSE	PSNR
Low Pass Filter	1260.8	17.1242
Gray Value Substitution	28.0140	33.6571
Wavelet transformation	8.8177	38.6773

Results and comparisons of MSE and PSNR

From result tables, we can see that, low pass filter can't use to remove noise. And the other two methods is relatively accepted

2.4 Different Noise Types and Digital Image Processing

(Gursharan Kaur, Rakesh Kumar, Kamaljeet Kainth)

As we know, image is used in various fields like medical and education.But noise is bad problem to image.So noise reduction is the main focus to retain the quality of the image.This paper is review problem to types of noise and solution.

2.4.1 TYPES OF NOISE

- Gaussian noise
- Salt and pepper noise
- Poisson noise

2.4.2 DIFFERENT TYPES OF LINEAR AND NON-LINEAR FILTERS

- Mean Filter: Mean filter is a type of linear filter that computes average value of the corrupted image.
- Median Filter: Median filter is a type of non-linear filter. It used to reduce the amount of intensity variation between one pixel and the other pixel.

2.4.3 CONCLUSION AND FUTURE SCOPE

In this paper, different techniques are used to remove noise from the image.Techniques that are already using may not be able to find the best result so in the future we may find the techniques that provide optimum solution to the noise.

2.5 Impulse Noise Reduction methods in Digital images

"A comparative study of Impulse Noise Reduction methods in Digital images", Authors: Himani Goel, Seema Rani. As paper title, we'll review this paper about denoise. From this, compare results by PSNR and MSE to obtain best result.

2.5.1 Linear Filters

- Mean filter
- Wiener filter

2.5.2 Non Linear filters

- Adaptive median filter
- Improved progressive switching median filter

2.5.3 Conclusion

Filter Types	MSE	PSNR
Mean filter	169.52	25.12
Average filter	169.52	25.12
Adaptive median filter	30.51	36.71
Improved progressive switching median filter	196.36	37.32

By the results from table above, we see the median filtering is better than mean or average filter to remove impulse noise but it affect the edge details.

Chapter 3

Contribution

In this part, you must explain your proposition to solve/address the problematic explained in the introduction chapter.

You must be as clear as possible, and you must use classical formalizations (Mathematical, software model, hardware model, Uml, etc) to explain your method/algorithm/system.

Chapter 4

Results

This part must contain the result of the method/algoritm/system developed during the internship.

This part must also include comparisons with the state of the art.

Use tables, figures, graphics to illustrate your results.

Comment your results, and explain the context used to obtain these results.

Chapter 5

Conclusion

You can recall the problematic of your internship and explain if you have solved all the problem or not.

Recall the methods used and your contribution.

Recall the results obtained and explain the quality of your results in comparison with the state of the art.

Give some perspectives of your work.

Bibliography

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[3] B. Hamidzadeh, D. Lilja, and Y. Atif. Dynamic scheduling techniques for heterogeneous computing systems. *Journal of Concurrency: Practice and Experience*, 7:633–652, October 1995.

[4] Christian Haubelt, Dirk Koch, and J.Teich. Basic os support for distributed reconfigurable hardware. In *Proc. of the Third International Workshop on Systems, Architectures, Modeling, and Simulation*, pages 18–22, Samos, Greece, 2003.

Appendix A

Detail about ...

In this part, you can add more details about some technical parts which need too much detailed impossible to include in the report body of your report

Appendix B

Mathematical demonstration

If necessary, you can add appendix to show mathematical demonstrations.