NOISE CANCELLATION FROM LOW LIGHT IMAGES USING NON-LOCAL MEANS DENOISING

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This Report Presented in Partial Fulfillment of the Requirements for the Degree Bachelor of Science in Computer Science and Engineering

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DHAKA, BANGLADESH

JUNE 2021

APPROVAL

This Project titled "**Noise cancellation from low light images using Non local means denoising**", submitted **by NASIM UDDIN** and **SOMIA JAHAN JHILIK** and **NAJMUN NAHAR** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on May 2021.

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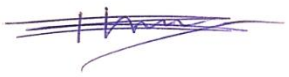

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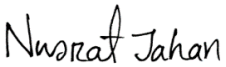

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Aniruddha Rakshit, Senior Lecturer, Department of CSE,** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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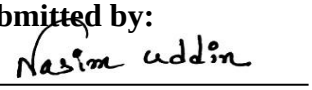

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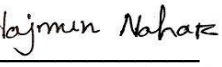

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ACKNOWLEDGEMENT

First, we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes us possible to complete the final year project/internship successfully.

We really grateful and wish our profound our indebtedness to **Aniruddha Rakshit, Senior Lecturer**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of "*Digital Image Processing*" to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stage have made it possible to complete this project.

We would like to express our heartiest gratitude to **Prof. Dr. Touhid Bhuiyan**, **Head**, Department of CSE, for his kind help to finish our project and also to other faculty member and the staff of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

Noise is often present in digital images during the steps of image acquisition, coding, transmission and processing. Low-light is also a challenging area for image processing, either for enhanced visibility and efficiency, or for application-oriented tasks such as detection. In image processing, denoising images and object detection is a fundamental issue. In this paper we will try to give an overview on how we are going to do with the help of Non local means denoising algorithm and image sharpening for edge defining more significantly.

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CHAPTER 1

Introduction

1.1 Background

Digital image processing means processing a image by computer. Where camera and hardware a fail to improve much, but computer does. After processing, the picture becomes much clearer and more visually pleasing. Since it is possible to process the image digitally, it is possible to make it look better and better. As good a picture as it is today and is being processed well, it was never possible to get such good results before. Before there was no good hardware or good process system. Today's visually pleasing pictures are the result of the hard work and patience of many people.

In the early 1920s Newspaper Company used submarine cable to transmit data to London to New York. They saved they were able to transmit data in three hours where it took a week. They used Bart lane cable picture transmission system which was invented by Harry G. Bartholomew and Maynard D. McFarlane [1]**.** The picture quality was not so good then. This method can be used to display the image at 5 gray levels. In 1929 it was upgraded to 15 gray level scales. It is able to enhance the information of the picture even more. During that period, Introduction of a system for developing film plates via light beams that ware modulate by the coded picture tape improved the production process. This is the thing to go one step more forward to make processing image easer.

Those are impotent to made image digitally process. But by the definition of digital image processing those were not digitally process by the computer. John von Newman invented digital computer in 1940. In 1950 is the most important and historical year for digital image processing and in 1951 they were succeeded to store data into magnetic disk.

There is a image of a Russell Kirsch's son which is taken as first digital image ever. In 1964 US Spacecraft took a photo of the moon for the first time. Time between 1960 to 1970 is the highest time for digital image processing. Improving that time's methods took significant applications for human being as for medical sectors, scientific sector, film media and in newspaper or news salivation [2].

1.2 Significance of denoising in Bangladesh

Bangladesh is a developing country. Keeping pace with the times, Bangladesh, like other countries, has come a long way in terms of technology. But it is still lagging behind in some places. Bangladesh is a densely populated country with a population of about 160 million people. With the increase in population, the tendency of people to commit crimes has also increased. As a result, the use of technology in crime suppression has increased equally. Now almost everyone has a mobile phone and as soon as a crime is organized, it comes to the fore. The culprit can be easily identified through pictures. But it is as easy during the day as it is difficult at night. Due to the low light at night, the picture is not clear so it is not easy to identify the human face. Denoising can easily make these images clearer. Basically, the job of our system is to clean up this dirty picture. Just as this system can be used by ordinary people, our law enforcement, night guards can also use this system for various purposes. [10]

1.3 Problem Statement

- Demand in medical research.
- Demand in security cameras.
- Demand in astronomy researches.

1.4 Business Model

In this age of digital, the use of digital image processing is much more noticeable. Digital images are available in everything, one of the aspects of the business is:

- Scientists and engineers feel the need for good quality digital images for their research work. Finding solutions to various problems centered on him.
- Image processing is required in the huge projects that astronomers work on with the planets, satellites, stars, various objects in space, their distances, locations and structural elements.
- In military work, border security requires a better image of the government for the security of the country
- It is used in investigative work such as taking good quality pictures taken by drones.
- It has been used extensively in medicine since the 19th century. Such as taking pictures of the medial bone of the body with X-rays, CT scans of soft tissue and midwifery.
- The use of pictures in newspapers, news TV and also in personal life is noticeable.
- The people of the 20th century have been introduced to another new system, online business.

In addition to these sectors, people are now using digital pictures in their daily work. In all these cases it can be considered as a business aspect. [3]

1.5 Scalability

Nowadays, face recognition is a very important issue. Researchers have been researching this for a long time. Noise is a huge obstacle for face recognition [5]. So there is no alternative to denoising and image filtering to eliminate this, but the demand is increasing day by day. As a result, new ways of using image denoising is emerging.

CHAPTER 2

Theory and Literature review

2.1 Denoising Architecture

Denoising and the use of nonlocal means are discussed in depth in this study. The process of eliminating noise or irregularities from an image is known as image denoising [6]. If other organizations need it, image denoising may be used for flexible, distant identifying, and shared designs. The difficulties that have been encountered when picture denoising with various forms of noise are discussed. Here we address the issues that arose during the implementation process. A review of image noise reduction applications in various fields is provided, along with an evaluation of the effect it would have in various fields.

2.2 Noises

Noise in image is an unwanted signal in image, it is the random various color or brightness in the image and it is a general aspect of electronic noise. It would be occurred by the sensor of circuit or image. The sources are_

- Insufficient Lighting.
- Environmental Conditions.
- Sensor Temperature.
- Transmission Channels and
- Dust Factors.

We need 100 present accurate lighting, good environment, friendly temperature and dust prove place. But when we are taking a picture, we cannot get all of them in perfect way. So, noise is occurring and it is common for us.

$$A(X, Y) = H(X, Y) + B(X, Y). \quad \textbf{(1)}$$

Where, A (X, Y) = Function of noisy image, H (X, Y) = Function of noise and B (X, Y) = The Original image.

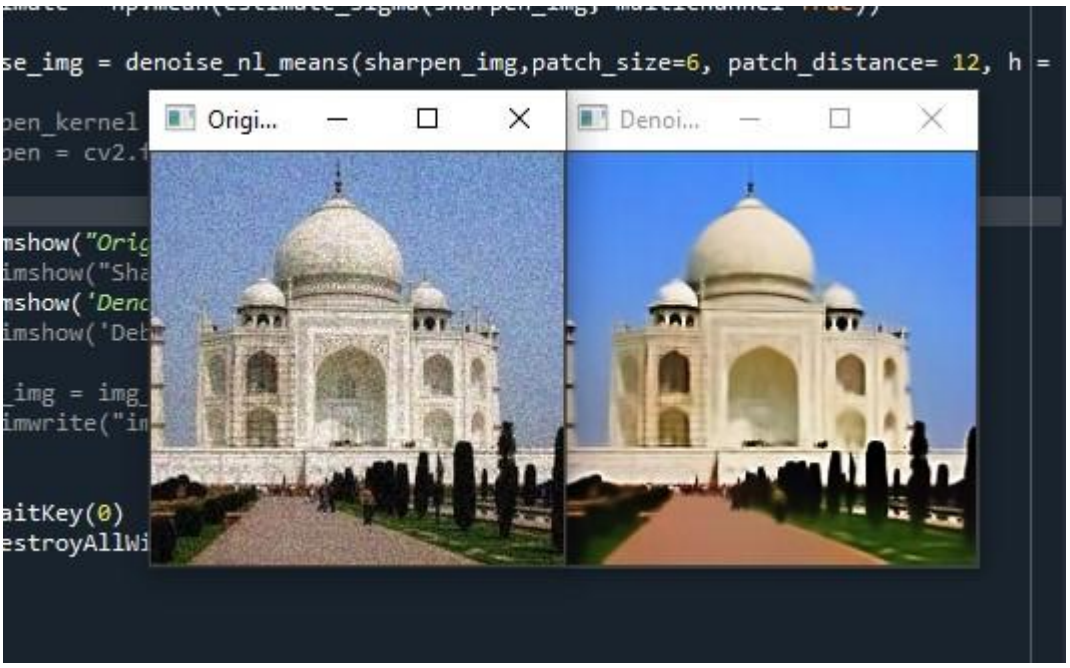

Figure 2.2.1: Example of Noise

We can divide them in three group.

1. Photo-Electronic.
   (i) Photon Noise
   (ii) Thermal Noise
2. Impulse.
   (i) Salt
   (ii) Paper
3. Structured.

Photo-Electronic:

2.3 Photon Noise

This noise is related with Photon. It's called photon noise or Shot noise.

When we capture an image by camera, we have to capture sufficient photon, but if captured image's number of photons is not sufficient in any how that type noise is called Photon noise or poison noise [7]**.**

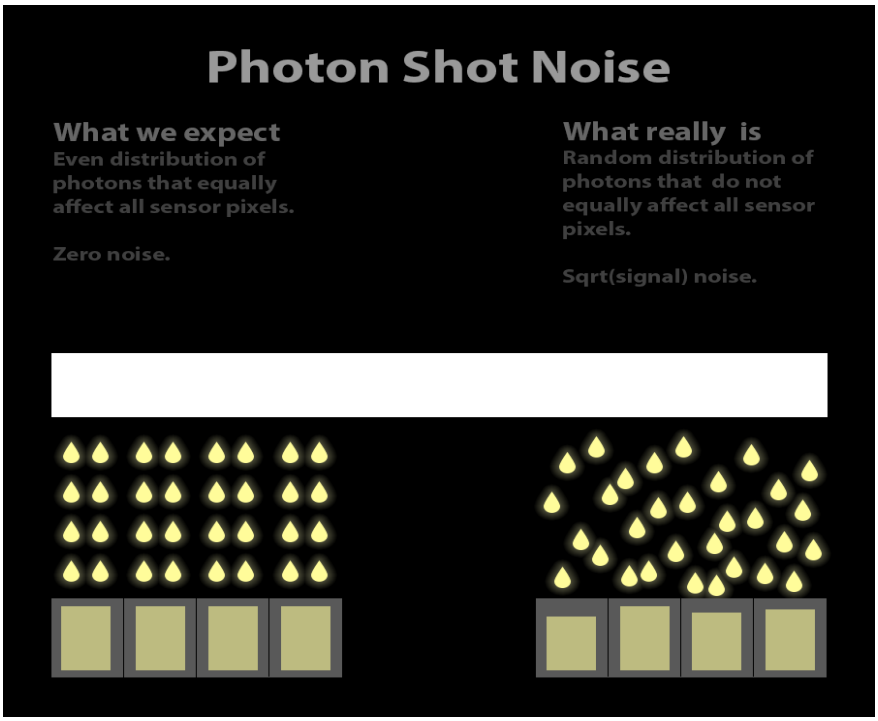

Figure 2.3.1: Photon Shot noise

2.4 Gaussian Noise:

Gaussian noise is considered as statical noise which is normal distribution equal to having a probability density function. This image is generated by adding random gaussian function to Image function. It is also called electronic noise because of appears in detectors. The temperature and thermal vibration of photon and the radiation of warm object is the main reason of gaussian noise [8].

We can compare it in the statistical math, probability distribution function. This problem solved by the, probability distribution function. In that case the carve is look like a bell.

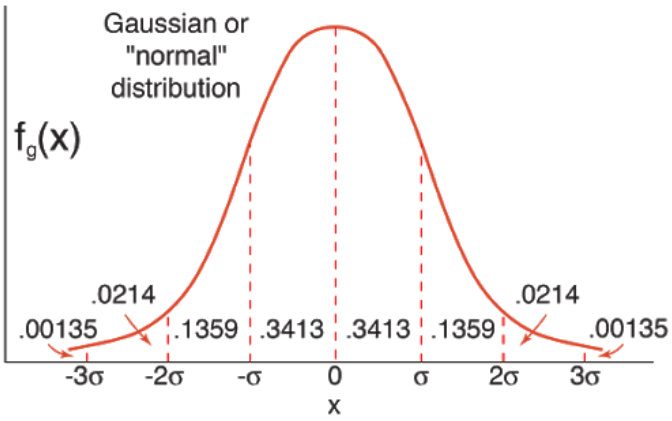

Figure 2.4.1: Graph of Gaussian distribution.

$$PG(z) = 1\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(z-\mu)^2}{2\sigma\pi}} \quad \textbf{(2)}$$

Where, **z** the grey scale level, μ mean grey value and σ it's standard deviation.

This gaussian noise is reduced by using some special filter as spatial filter.

2.5 Impulse Noise:

Researchers have been working on Impulse Noise for a long time. They have come up with many models and many solutions. The main reason for impulse noise is the missed transmission of the signal. Found in many surveys for incorrect storage locations or the mole fractioning pixel in the camara. Impulse noise is also known as independent Noise. If there is total noise density is p, then the salt noise and paper noise density will p/2. [9]
In simply we can say,
Pt=Ps+Pp.

Where the Pt= total noise, Ps= salt noise and Pp= Paper noise.

Actually, there are Two types of impulse Noise. They are-

1. Salt Noise.
2. Paper Noise.

And when these two types are attendant in same image then it called salt and paper noise.

Salt Noise: We can see in the real-life salt which is look white and bright. In image we can see random bright doted which is looks like salt in the image. That white doted values almost 255,255,255 in RGB scale.

Paper Noise: As we see salt in image there are also adding black doted points. In RGB scale its value is 0,0,0.

Salt and Paper Noise: When bright white and dark doted randomly arise together in a image it is called salt and paper Noise.

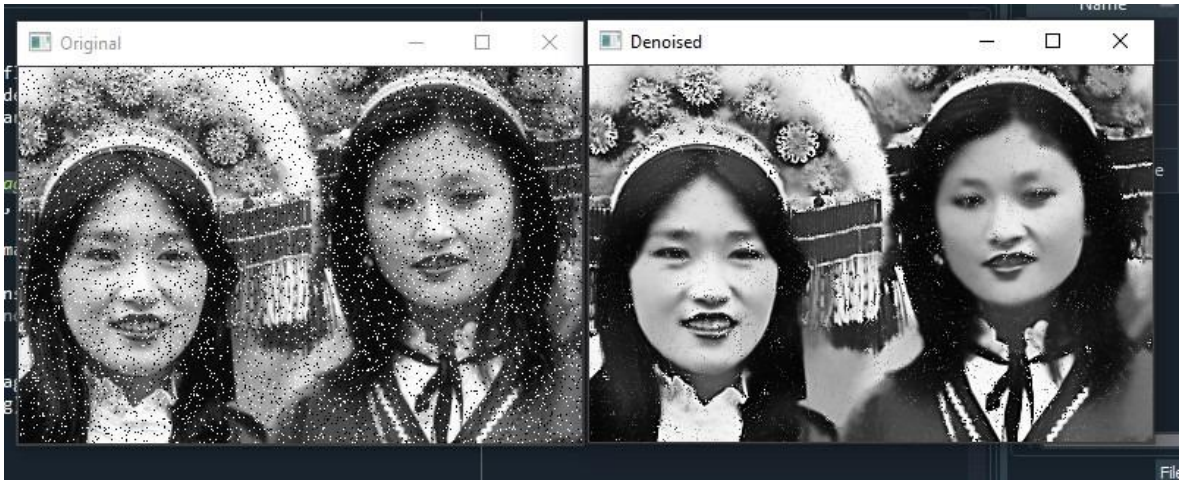

Figure 2.5.1: Salt and paper noise

2.6 Related Works:

2.6.1 Introduction

Other than Non-Local means denoising, noises can be reduced by some other methods too. Among them the most common filters are Gaussian Filter and Median filter. These two filters are briefly described in this topic.

2.6.2 Gaussian Filter

Gaussian filter has been used for blurring images while reducing the noise. The gaussian formula is-

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \quad \textbf{(3)}$$

The two-dimensional Gaussian function is necessary when working with images.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad \textbf{(4)}$$

Here σ is the distribution's standard deviation. The distribution's mean is considered to be zero. To store continuous Gaussian functions as discrete pixels, we need to divide them. [17]

The Gaussian filter uses a point-spread function based on the 2D distribution. The image is convolved with the 2D Gaussian distribution function to achieve this. A discrete approximation of the Gaussian function is required. The Gaussian filter is basically A non-uniform low-pass filter. As you move out from the kernel's center, the kernel coefficients get smaller. The weighting of central pixels is greater than that of peripheral pixels. The broader the peak, the larger the value of that means it will be blurrier. To keep the filter's Gaussian nature, the kernel size must increase with increasing σ. The value of depends on the Gaussian kernel coefficients. Coefficients at the mask's edge must be close to zero. [18]
Image brightness can be lost while using Gaussian filters. Though noise can be removed using Gaussian filtering, although it is ineffective in reducing heavy noises like salt and pepper noise. [16]

The output of before and after reducing noise from some noisy images have given below:

Figure 2.6.2.1: Before and after reducing salt n pepper noise by Gaussian filter

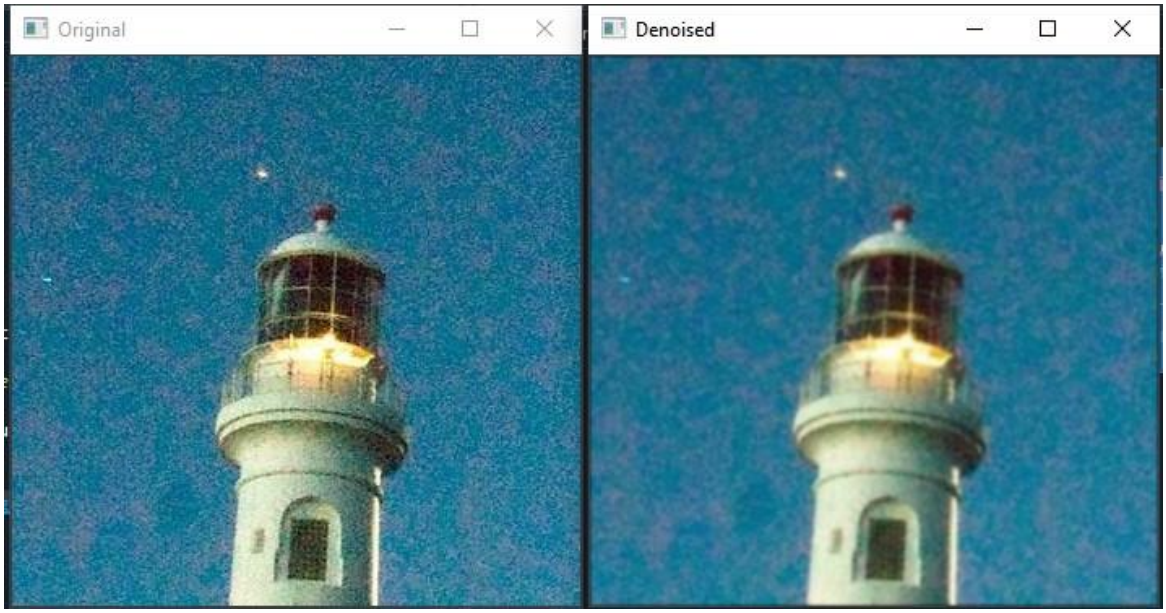

Figure 2.6.2.2: Before and after reducing noise by Gaussian filter

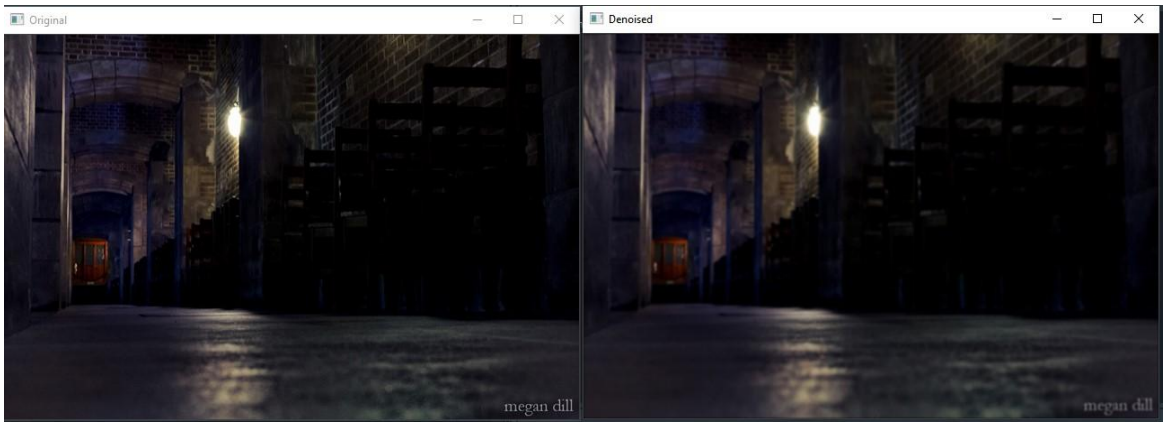

Figure 2.6.2.3: Before and after reducing noise by Gaussian filter on a dark image.

2.6.3 Median Filter

For reducing noises in Image Processing, the Median Filter is almost same as the Mean Filter which is used to minimize noise. But it does a better job of keeping significant detail in the image than the mean filter. The Median Filter is a basic but effective non-linear filter that gives much better result than the Gaussian Filter. It's a technique for decreasing the amount of intensity variance between two pixels. The median value is used to replace the pixel value in this filter. The median is computed by sorting all of the pixel values in ascending order, then replacing the calculated pixel with the middle pixel value. [19]

The median filter looks at each pixel in the image one by one to see if it is representative of its surroundings. It replaces the pixel value with the median of nearby pixel values rather than the mean. The median is derived by sequentially ordering all of the pixel values in the surrounding neighbourhood and then replacing the pixel in consideration with the middle pixel value. [20]
With this filter, heavier noises can be removed including salt and pepper noise. Though it heavy noises can be removed with this, but the result is not so good and images are not that much clear compare to non-local means denoising filter.

The output of before and after reducing noise from some noisy images have given below:

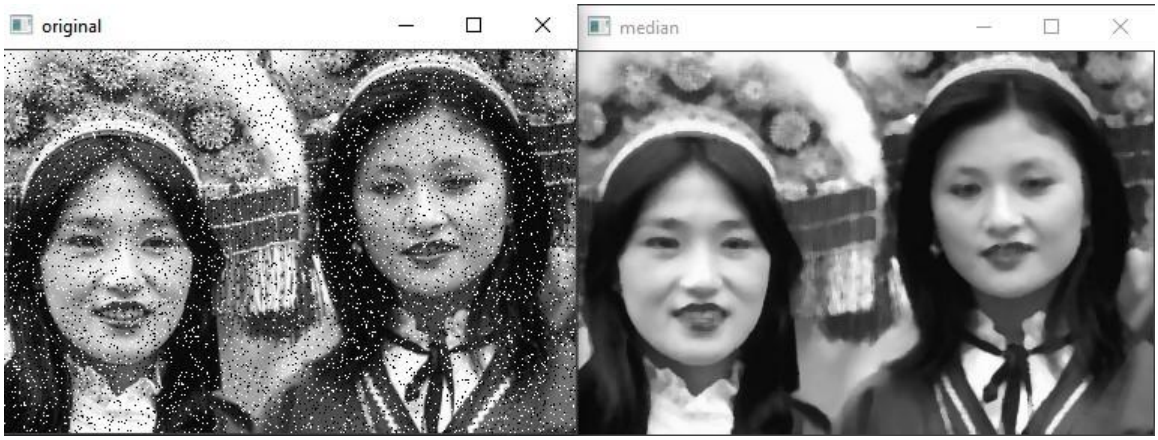

Figure 2.6.3.1: Before and after reducing salt n pepper noise by Median filter

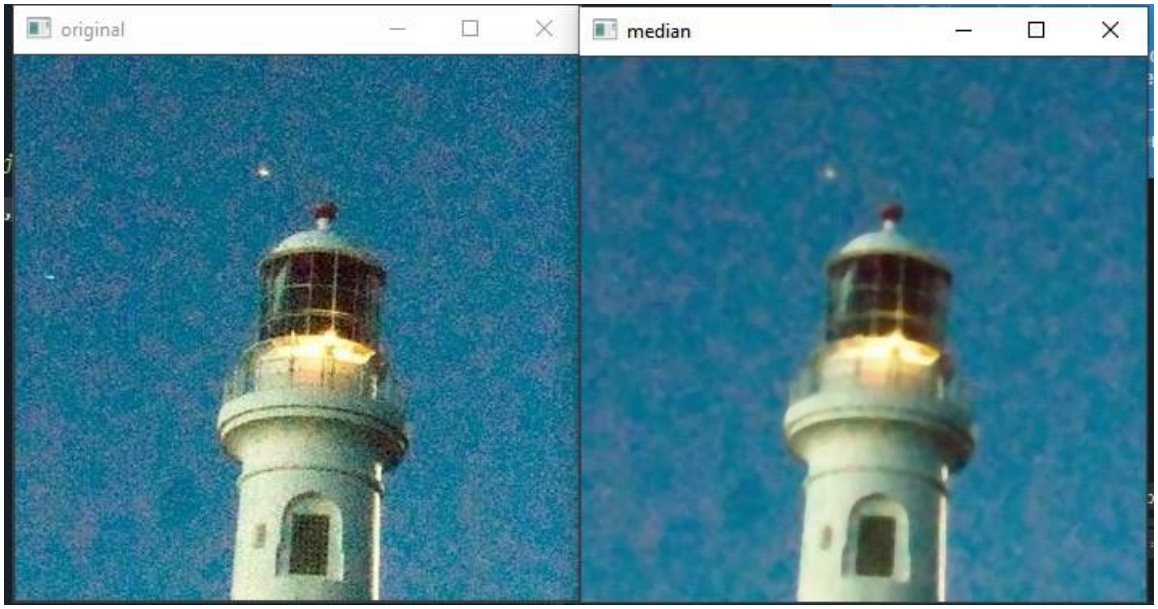

Figure 2.6.3.2: Before and after reducing noise by Median filter.

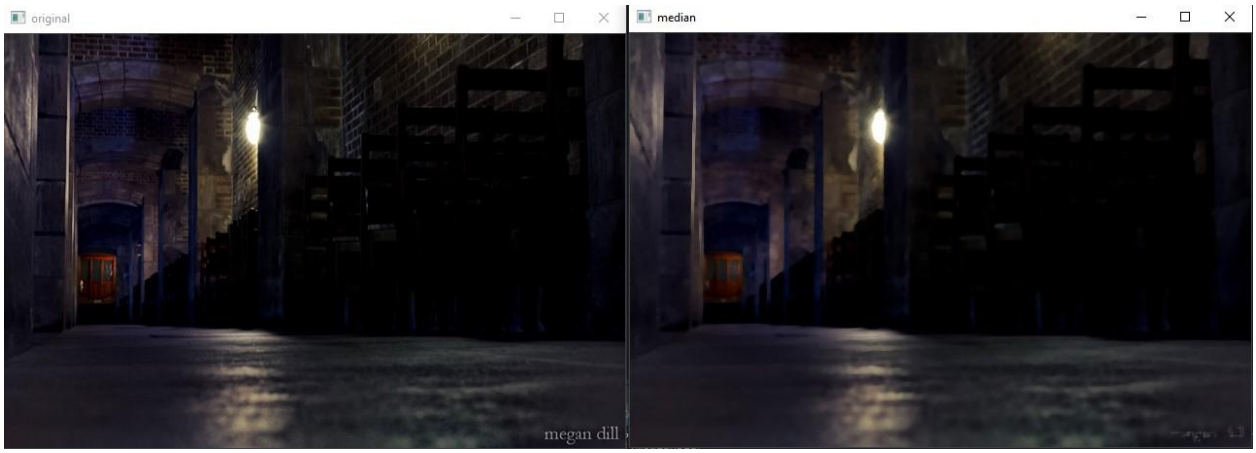

Figure 2.6.3.3: Before and after reducing noise by Median filter on a dark image.

2.7 Non-Local means denoising Algorithm

The main idea of Non-Local mean is, instead of looking at averages in the local neighborhood we are going to look at averages in the whole image.

Formula:

$$\mathbf{NL[v](i) = \sum_{j \in I} w(i, j)v(j)} \qquad \mathbf{(5)}$$

So as the name suggests, it calculates the mean of a bunch of pixels. And non-local means it's not just doing the local mean, it's actually looking at this means into another region, not just locally.

The estimated value at a given pixel is the weighted average of all pixels in the image which is similar to local mean but the difference is, the family of weights depend on the similarity between the pixels i and j.

So here, similar pixel neighbourhoods give larger weights.

For example-

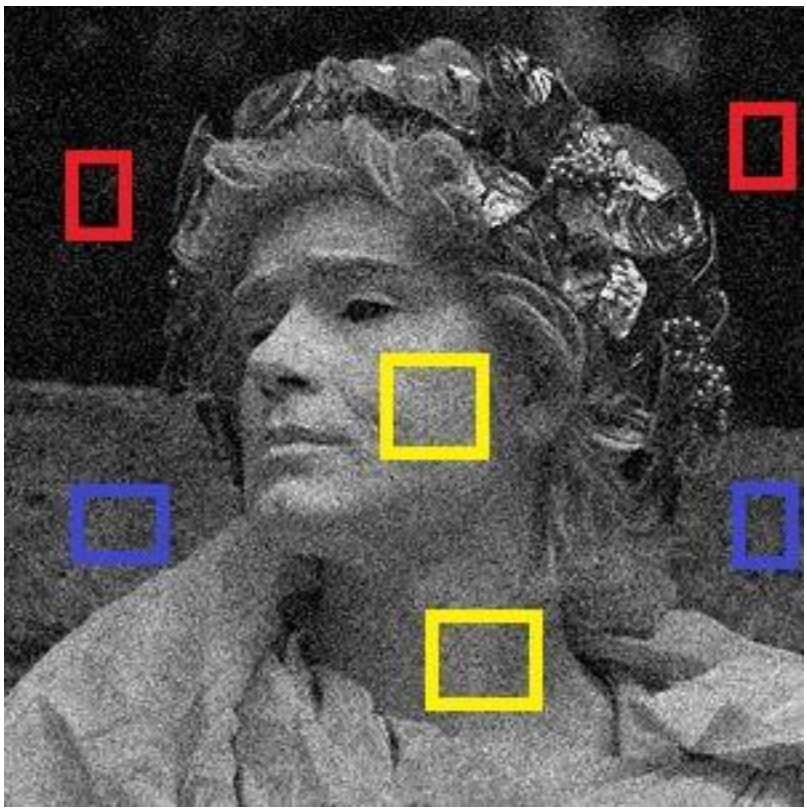

Figure 2.7.1: Similar patches detection from noisy image.

Every image has areas that have similarities between them. In this image there have a lot of darker patches that look similar and also have a lot of similar brighter patches. Here, the red patches are similar so they have heavy weight compare to other patches, same goes for blue and yellow patches too. The algorithm in the background is calculating where the similar patches calculate where the similar patches are then assigning the weights accordingly.

2.8 Image Sharpen

Though a sharp image means noisier image, but image sharping is important for denoising in terms of blurry images. If we sharp our blurry image a bit, the edges will be clearer than before. If we first sharp the blurry noisy image then performs denoising, it will give a better result. For this purpose, we will use the filter called unsharp_mask. [11]

The basic principle of the filter unsharp_mask:

Basically, the term "unsharp" means smooth or the opposite of sharpening. At first the image is going to be unsharp or smooth using some filter, and then that filtered image gets subtracted from the original image. For example-

Sharpen image (Final Image) = Original image + (Original image-blurred image) * amount

Let's describe this equation mathematically:

Let,

Original image = f (x, y)

Certain amount = K

Blurred image = g (x, y) [if we use Gaussian blur]

So,

$$f(x, y) = f(x, y) + K * (f(x, y) - g(x, y) \quad \textbf{(6)}$$

CHAPTER 3

Implementation

3.1 Introduction

Image denoising tools are designed to recover the original image from a noisy image. Although denoising has been a research focus for a long time, there is still room for enhancement, especially denoising the picture [12]. Several methods have been proposed to eliminate the noise and recover the true image, but to do so we have used non-local means algorithm to denoise. As there is a trade-off between noise reduction and the preservation of real image characteristics, noise reduction is a dynamic and difficult process for images. In our research in order to preserve the quality of the original image we have first used a filter called “unsharp_mask” [11]. The filter “unsharp_mask” is applied first in order to sharpen the image then the non-local means algorithm is applied. For this purpose, a filter of non-local means algorithm has been used. This helps to restore the quality of the image.

3.2 Flowchart

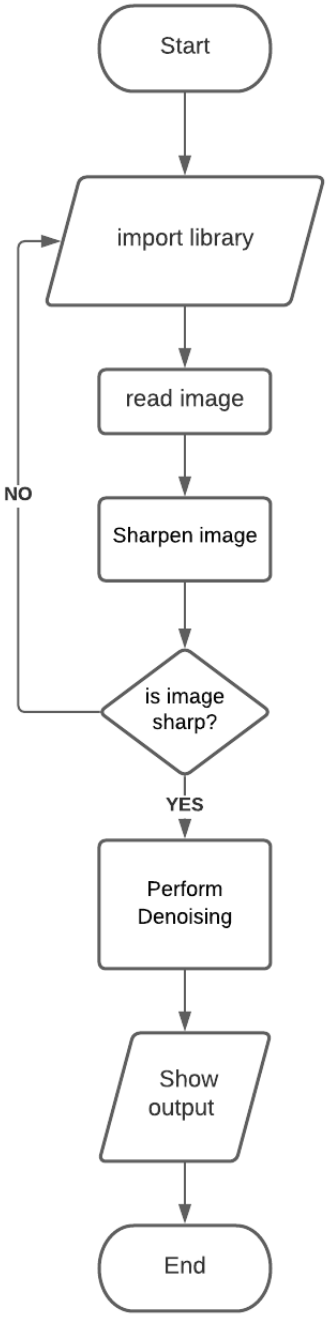

Figure 3.2.1: Flowchart of the system.

3.3 Working Procedure

First of all, we will import some essential libraries. Here, we will be import –

1. Open CV (cv2),
2. NumPy,
3. From Scikit-image: img_as_float,
4. from skimage_restoration: denoise_nl_means, estimate_sigma
5. from skimage.filters import unsharp_mask

Here,

- cv2 is imported for showing output of the images.
- numpy is imported for calculating mean and sigma estimation.
- From skimage, img_as_float is imported because skimage read images as floating-point numbers.
- The algorithm we are using here is a part of skimage.restoration module. ''denoise_nl_means'' will perform the main task here, estimate_sigma is used for estimating sigma from a noisy image which gives a starting point and also this is a part of the input parameter for "denoise_nl_mean" filter. [13]
- Apart from the algorithm, one extra filter ''unsharp_mask'' has been used for sharping the images.

Now,

We read the noisy image by using a variable "img",

Then the variable "sharpen_img" is used for performing sharpen the noisy picture a bit. The filter ''unsharp_mask'' has been used for that.

The variable "do_estimate" is used to calculate the means after estimating sigma of the image.

The variable "denoise _img" is used for denoising the image by "denoise_nl_filter".

In “denoise_nl_means” filter the parameters we have been used – image (noisy image), patch_size, patch_distance, h(which is h * the variable of estimate sigma). The value of h smooths the patches, which means the higher value of h gives more smoothing effect. [15]

Then ‘’cv2.imshow’’ has been used for showing the output. [14]

Lastly, “cv2.waitKey(0)“ is used for performing pause. Which means execution is paused until a key is pressed, otherwise the image will be displayed but the window will be closed within no time so we will not be able to see the result. And the last line “cv2.destroyAllWindows()” is used for closing all the windows. [14]

3.4 Source code

```
import cv2
import numpy as np
from skimage  import img_as_float
from skimage.restoration import denoise_nl_means, estimate_sigma
from skimage.filters import unsharp_mask
#Read noisy Image
img = img_as_float(cv2.imread("images/nightview.png"))

#Sharpen the image
sharpen_img = unsharp_mask(img, radius=3, amount=1.3)
#sigma calculates
do_esimate = np.mean(estimate_sigma(sharpen_img, multichannel=True))
#estimate denoise filter
denoise_img =  denoise_nl_means(sharpen_img,patch_size=6, patch_distance= 12, h = 2.7 * do_esimate, multichannel=True, fast_mode=True)
cv2.imshow("Original", img)
cv2.imshow('Denoised’, denoise_img)
cv2.waitKey(0)
cv2.destroyAllWindows()
```

3.5 Output

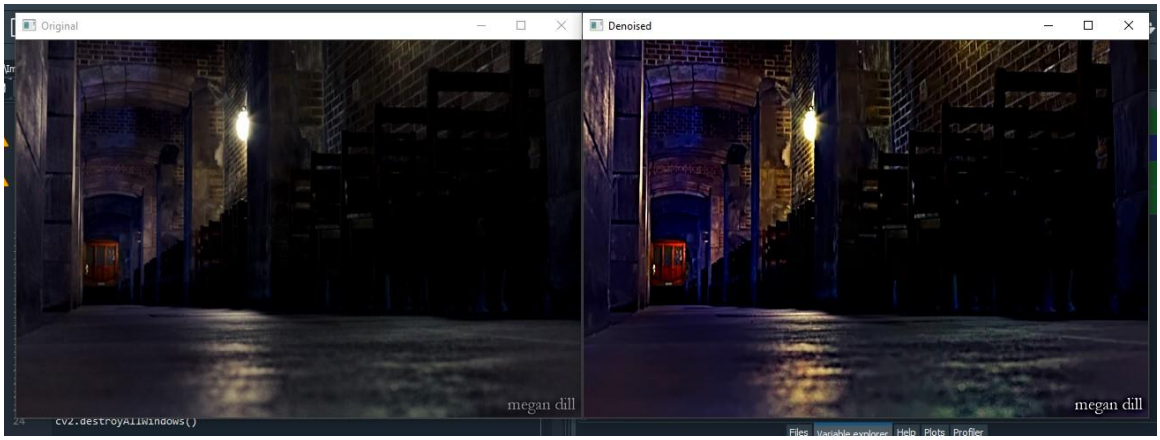

Figure 3.5.1: Noise and denoise of night view.

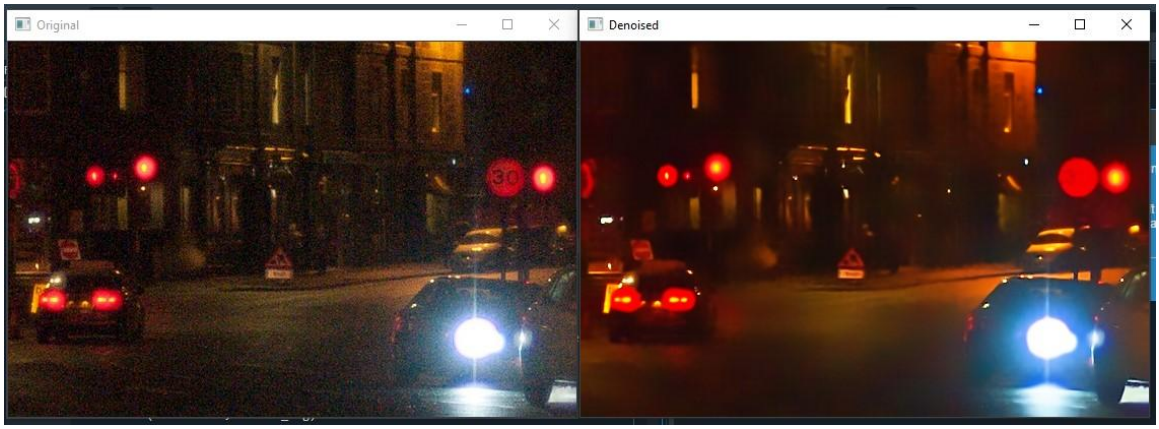

Figure 3.5.2: Noise and denoise in low light.

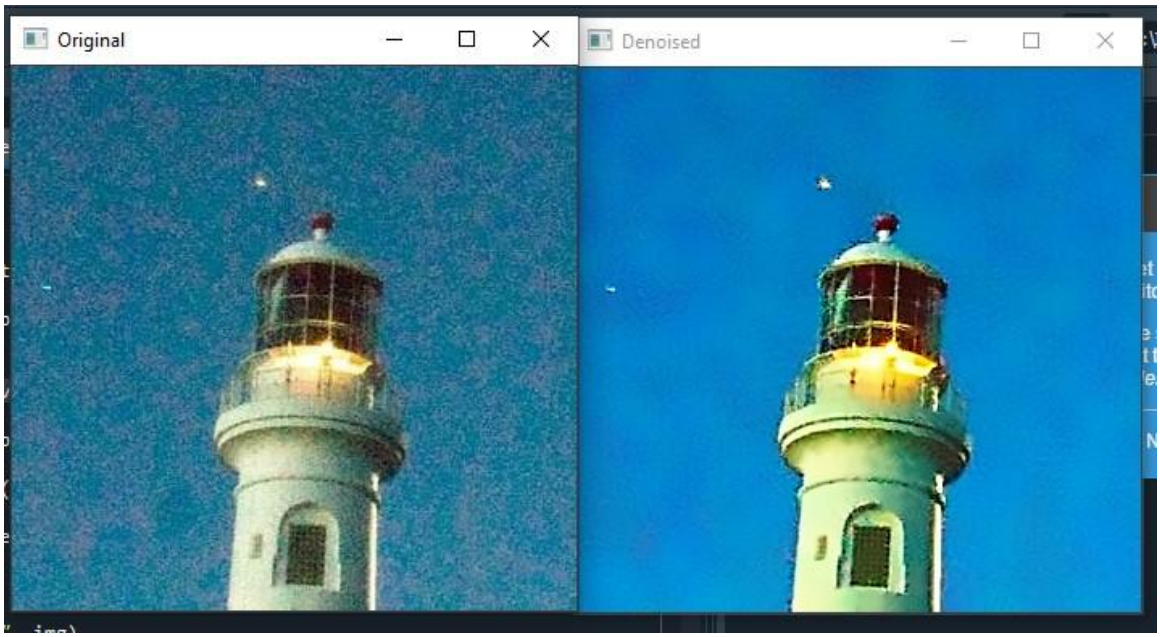

Figure 3.5.3: Noise and denoise in low light.

3.6 Tools used

- Spyder IDE from Anaconda for writing code,
- Python framework.
- Open CV,
- Scikit image,
- NumPy,
- Non local means denoising algorithm,
- Sharping filter ‘’unsharp mask’’,
- Some noisy images.

CHAPTER 4

Operation

4.1 About our system

We hereby consent to the use of our personal details, which we have given in the contact form, to obtain information in order to denoise photographs. Users have the ability to revoke their constant at any time, but this would have no effect on the consistency of data processing prior to the revoked constant. Their private data will not be distributed among third parties.

4.2 Services

Our service is to provide clear images which can be used to identify various crimes and image restoration. Any intelligence team can easily get a clear image with our system. Ordinary people can also use it easily. The goal of image restoration is to eliminate noise or blemishes that degrade an image. People can easily restore images by using our system

4.3 Methodology

Our system uses Non local means algorithm to remove noise from images. Non-local means filtering takes a mean of all pixels in the image, weighted by how close these pixels are to the target pixel, as opposed to "local mean" filters, which use the mean value of a group of pixels surrounding a target pixel to smooth the image.

We also used unsharp mask to sharpen the image. Unsharp masking (USM) is a method for sharpening images that is commonly used in digital image processing software. The concept's name comes from the fact that it creates a mask of the original image using a distorted, or "unsharp," negative image [11]. The image can be saved from the system into user pcs. It is made using python framework so it is very user friendly.

CHAPTER 5

Conclusion

5.1 Merits of the system

The main advantage of our system is it is very easy to use, all you have to do is insert the image and it will reduce the noise. It is simple and relatively cheap to build. It can produce fairly accurate image. Only some white noise can be found after denoising, but it doesn't hamper the quality of the image. Any unprofessional / non-technical person will be able to use our system and can be benefited. Our system can be used for security purposes so easily.

5.2 Limitations of the system

The major limitation is too much noise can make the image restoration very difficult. The original loses its sharpness when it is deblurred. Sometimes heavy noisy images can be so smooth for the uses of the filters that the edge detection can be difficult for that images.

5.3 Result

Our system gives almost clear images every time. Our system is easy to use and pretty cheap. For noise reduction we used Non-Local Mean algorithm which gives much better result than other conventional algorithms. For deblurring the image, we use unsharp mask which gives a better sharpness to the image.

5.4 Conclusion

Our main goal of this thesis is to develop a system which will help to reduce Gaussian noise and salt and pepper noise. Images are cleaned using Non-Local means algorithm and unsharp mask filter. Noise is an inevitable image degradation that must be taken into account in image restoration, particularly image deblurring. We tried to show how easy it is to use our system.

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