

Analysis the Impact of Filters in Spatial Domain on Grayscale Image

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ABSTRACT

Computer graphics is the branch of computer science which deals with the study of graphics and images. Advancement in the technology brings the development in the image processing techniques, which deals with the image acquisition, image enhancement, restoration etc. Different type of noise got added up to the image while image acquisition leading to the final corrupted image. The main objective of this paper is to remove noise from the gray scale images to better understand the contents of the original image by applying various filter algorithms to get the blurred free and noise free image. For this an algorithm is developed and presented in shape of flowchart. This paper compares the different filters used for the noise removal from an image. It studies various filters for noise removal and finds the opinion that which is best for every type of image. As every image processing algorithms works differently for different image, there are different methods to deal with different types of noise.

General Terms: Image Processing

Keywords: Image Enhancement, PSNR, Spatial Domain, Image Acquisition

1. INTRODUCTION

Images can be classified by analog and digital image. For an analog image the intensity can be represented on a normalized scale from 0 to 1 with infinite divisions, and spatially with an infinite number of coordinates [1]. A digital image is a discrete two-dimensional function $f(x,y)$, which has been quantized over its domain and range. Image Processing refers to a class of algorithms for modification and analysis of an image during image acquisition, image enhancement, image analysis, image reconstruction, image restoration, post-processing, rendering and visualization of image. Noise is a pixel value that shifts in an image. The main sources of the noise in a digital image come during the image acquisition and image transmission. There is also a peak signal to noise ratio often refer to as PSNR. It represents the ratio between the maximum possible powers of signal with the power of corrupting noise that affects the fidelity of its representation. PSNR is usually expressed in terms of the logarithmic decibel scale [2][1]. Image acquisition is the process of obtaining a digitized image from a real world source. Each step in the acquisition process may introduce random changes into the values of pixels in the image. These changes are called noise. The images are distorted during the image transmission because of the transmission channel. It can be assumed that when the image is transmitted with the help of wireless network it may be distorted because of lightening or some other atmospheric disturbance. An image may be affected by noise during the image acquisition process. The properties of the noise introduced at each capture

step are likely to vary. However, there are some standard noise models which give different types of noise encountered in most images such as: salt and peeper noise, Gaussian noise, additive, multiplicative, and Quantization noise. Fig 1.4 shows some of the types of noise affect a typical grayscale image.

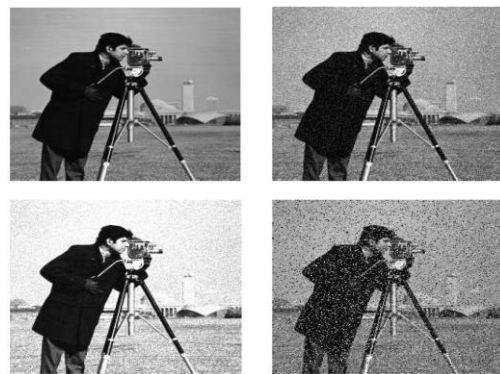


Figure 1: Different Types of Noises: (a) Original Image (b) Gaussian Noise (c) Multiplicative Noise (d) Salt and peeper noise

Image enhancement is the very first step in digital image processing. It is the improvement of digital image quality. In this original image is achieved by two domains: Frequency Domain and Spatial Domain. Frequency domain Method is used when the Fourier Transforms are applied to image enhancement. The filtering point is based upon modifying the transform an image in some manner through a filter transform function and then taking the inverse of the result to get the processed output image. Second is spatial Domain in image enhancement which refers to do the work in the given space in image and operates on the pixels. Let $g(x,y)$ be the original image where g is the grey level value and (x,y) are the image coordinates. For 8 bit image , g can take values between 0-255 where 0 represents black ,255 represents white and all intermediate values represents shades of gray.

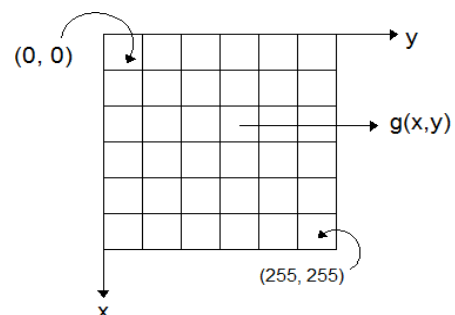


Figure 2: image of size 256 * 256, x and y can take values from (0, 0) to (255)

The modified image can be expressed by following equation $f(x, y) = T[g(x, y)]$. Here $g(x, y)$ is the original image and T is the transformation operator applied to get a new modified image $f(x, y)$. spatial domain enhancement can be carried out in two different ways: Point Processing and Neighborhood Processing. The point processing is concern with the work of a single pixel i.e. T is 1×1 operator which means the value $g(x, y)$ depends upon the operator T and present, $g(x, y)$. The neighborhood processing is also a spatial domain technique in which a pixel is considered with its immediate neighbors. The value of a pixel $g(x, y)$ based on the values of its neighbors as shown in Figure 3.

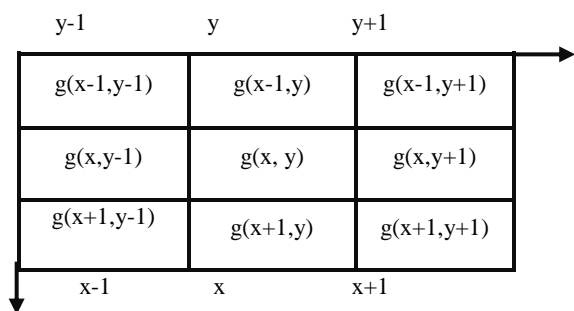


Figure 3: A 3x3 neighborhood

Below Figure 4 shows mask or a window or a template. If g is the original image and f is the modified image, then

$$f(x, y) = g(x - 1, y - 1) \times w1 + g(x - 1, y) \times w2 + g(x - 1, y + 1) \times w3 + g(x, y - 1) \times w4 + g(x, y) \times w5 \dots + g(x + 1, y + 1) \times w9 \quad (\text{Eq-2})$$

Once $f(x, y)$ is calculated, the mask is shifted by one step towards the right to the next pixel. The most important operations achieved using neighborhood processing is image filtering.

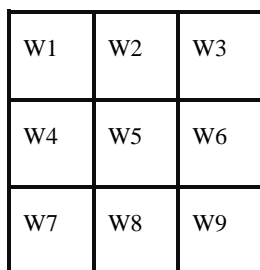


Figure 4: A 3x3 mask

2. TIFF IMAGE FILE FORMAT

Tagged Image File Format (TIFF) is a variable-resolution bitmapped image format developed by Aldus. TIFF is very common for transporting color and grayscale images into page layout applications, but is less suited to delivering web content [3]. The TIFF was designed from the ground up to alleviate the problems associated with fixed file formats. TIFF did not evolve from a de-facto standard. It was created to become the industry standard for image-file exchange. TIFF was a super-set of all existing graphics or image file formats. As a matter of fact, it is possible to store proprietary information in a TIFF file without violating the intent of the format. TIFF was designed with an eye toward the future, not just for use in the present. The designers of the TIFF file format had three important goals in mind: extensibility, portability and reversibility [4]. The correctness and the accomplishment of these goals is somewhat corroborated by the number of software vendors supporting the TIFF format.

Every major scanner manufacturer and every desktop publishing program supports TIFF. The TIFF format is controlled by a specification jointly written by the Aldus Corporation and Microsoft, although many other companies, in addition to these two, contributed to its formulation. Version 5.0 of this specification is dated April 1988. Although the specification document itself is copyrighted by the Aldus Corporation, the TIFF format is in the public domain. This means no fees or royalties are required to use the format.

2.1 The TIFF File Structure

The TIFF files consist of a header containing the following fields: byte ordering flag, TIFF file format version number, and a pointer to a table called an image file directory (IFD). The image file directory contains a table of entries of various tags in the file and their associated information. In tagged file formats, tags are used to keep all attribute information in a standard manner [5]. For example, the TIFF file format provides tags that store information about resolution color, the compression scheme used for capturing, the date and time of capture, and even the operator who created the file.

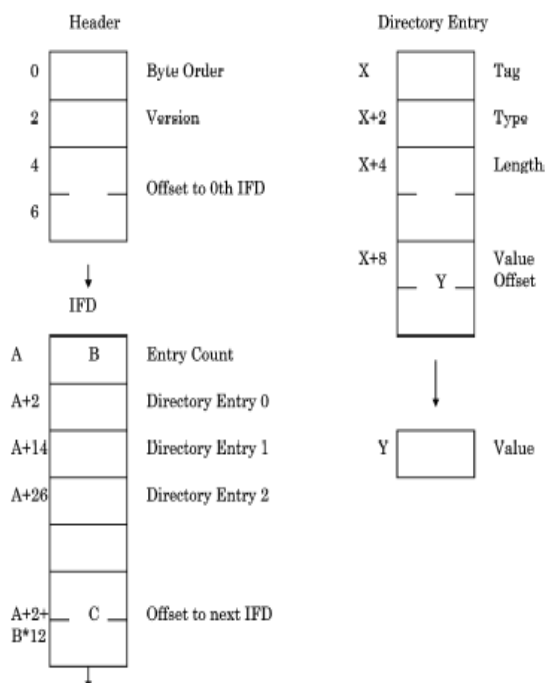


Figure 5: Structure of a TIFF File

3. METHODOLOGY ADOPTED

The main objective of this paper is to remove noise from the gray scale images to better understand the contents of the original image by applying various filters. This step is one of the many steps of the image enhancement. The main purpose is to get the blurred free and noise free image. For this an algorithm is developed and presented in shape of flowchart in below figure 6.

The type of image used here is TIFF image during all these enhancement techniques methods used. It depends upon the types of noise in the image.

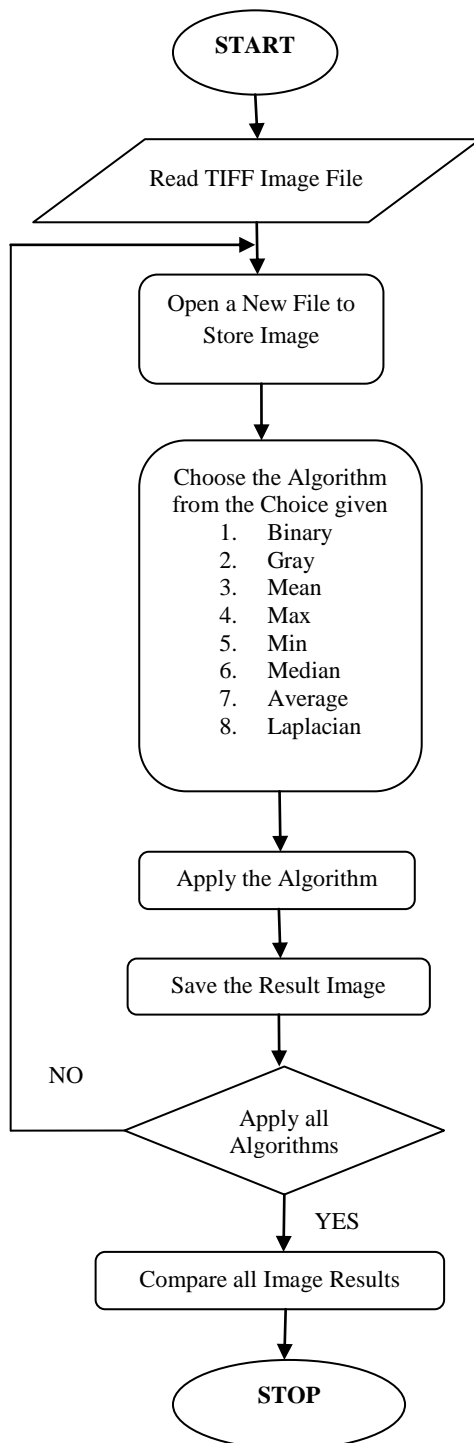


Figure 6: Flowchart of Methodology used

4. DESIGN AND IMPLEMENTATION

Spatial filtering is one of the principal tools based on the image enhancement field for a broad spectrum of application. The name filter is borrowed from frequency processing which refers to accepting passing or rejecting certain frequency components. Filtering creates a new pixel with coordinates of the centre of the neighborhood and whose value is the result of filter spatial. A processed image filter is generating centre filter which visit each pixel in put image. The image convolved with finite impulse response filter called spatial mask. Spatial Low pass filtering or smoothing is used to remove noise present in the image. Here each pixel is replaced

by weighted average neighborhood pixels that is $f(x,y) = \sum_{(k,l) \in W} a(k,l)g(x-k,y-l)$ where $g(x,y)$ and $f(x,y)$ are the input and output images, respectively. W is a suitably chosen window and $a(k,l)$ is the filter weights [6]. Spatial filtering works on the following steps.

1. An image of 64×64 is taken.
2. A 3×3 mask is developed as discussed in figure 4 is developed.
3. Than the given spatial filters such as Mean Filter, Max Filter etc have been used.
4. Resultant Values for the point is placed on the image pixels.

Spatial filtering is used for noise smoothing, low pass filtering and sampling of images. Suppose the observed image is given as $f(x,y) = g(x,y) + \mu(x,y)$ Where $\mu(x,y)$ is white noise with zero mean and variance σ_n^2 . For advanced image processing and analysis program, the programmer also need to consider the software's native programming language such as C, C++, Visual Basic, as well as its flexibility to accommodate code from other languages. Each programmer has his or her own favorite coding language, but the best image analysis programs provide methods for programmers to work in familiar surroundings, regardless of the platforms native language. For instance, a program may be based on the object/class structure common to C++, but if the system also includes Active X functionality, this mid-level language can act as a go between to allow the programmer to work in Visible Basic, Borland, Visual C++, and C++ Builder. In this work, Microsoft's Visual C++ 6.0 under Windows environment is used. This environment provides flexibility and ease of understanding the file format details, code specification and modular approach for various functions used. Microsoft Visual C++ also known as MSVC is an integrated development environment product engineered by Microsoft for the C, C++ and C++/CLI programming languages. It has tools for developing and debugging C++ code, especially that written for the Microsoft Windows API, the DirectX API and the Microsoft .NET Framework. When typing the C++ program source code no elements will be highlighted since the editor treats the source code as a text file at this point. After typing the C++ source code it should be saved as a .cpp file. The name should not include lab1.cpp or program1.cpp or assignment.cpp. The .cpp extension is necessary for the following steps to work correctly since the compiler expects that extension for source files it should compile. This paper implements the Image Processing algorithm as a program which runs in the Microsoft's VC++ window as shown in figure 7 and execution snapshot of project in figure 8.

As it has been earlier discussed that the how TIFF file format store an image and its Meta data to retrieve the information about an image. First of all read a TIFF image and collect the required tag information to be used in the image processing algorithm. An input image file is being open in the workspace of the project. After that we create an output file path for the same. Reading the TIFF file gives the information details stored in the Image File Directory (IFD) to be used later in the program for image processing.

```

Microsoft Visual C++ - [filter.cpp]
#include <iostream.h>
#include <stdio.h>
#include <conio.h>
#include <malloc.h>
#include <process.h>
#include <math.h>

#define width 3
#define pi 3.141592653

void Read_Tiff_File(void);
void display_error( Char *message);
// This following function may be used later

unsigned long ImageWidth, ImageLength, StripOffsets,
RowsPerStrip, StripsPerImage, ImageWidthByte, ImageSize, StripByteCounts;
int m, n, i[64][64], h[64][64], temp[66][66], g[64][64], a[3];
int min, max, sec, k, a, t;

short int BitWhite;
short int ResolutionUnit, BitsPerSample;
unsigned long Resolution, TResolution, NoOfStrips;
void *imageBuffer;
asin()
{
    Read_Tiff_File();
    return(0);
}

void Read_Tiff_File()
{
    long int n, sum, sh[256], g[256];
    unsigned long i, j, temp1, k, p;
    short unsigned int byte_order, TIFF_identifier;
    unsigned short int no_of_entries, tag, field_type, temp;
    unsigned long offset_address, count, value, so, sbc, StripAddress, StripSize;
    unsigned long file_position;
    unsigned char *IB, itea;
    unsigned char *ib;
    unsigned char in_filenames[14], out_filenames[14], pic_byte;
    float fvalue;
    FILE *infile_ptr, *outfile_ptr;
    // Open the input file for processing
}
    
```

Figure 7: source code of Filter program in Microsoft's Visual C++

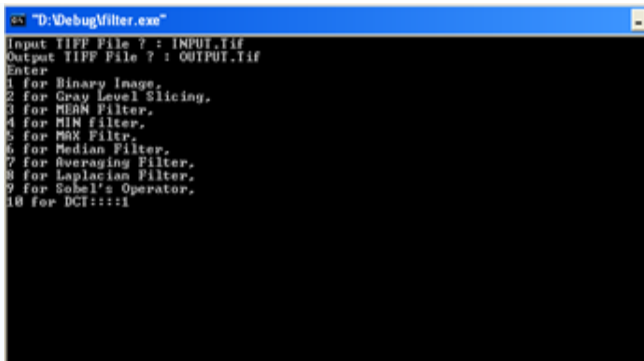


Figure 8: Execution of project in command window

5. RESULT AND DISCUSSION

The noise removal techniques are discussed by using various filters. Each filter is compared to get the result that which is better for removal of noise. The filters used in this work are Median Filter, Average Filter, Min Filter, Max Filter, and Laplacian Filter. The Results are then compared to each other. The 64*64 input images shown in the Figure-9(a) is given as the input image and the output images after applying various types of filters based on the different algorithms is shown in figure-9 (d) to (h). These five filters are discussed one by one with their equation below.

Binary Image: In the binary image each pixel is just black or white as there are only two possible values for each pixel, only one bit per pixel is needed. Such images can therefore be very efficient in terms of storage. Images for which a binary representation may be suitable include text, fingerprint, or architectural plans.

Gray Level Slicing: Each pixel is a shade of grey, normally from 0(black) to 1(white). It means that each pixel can be represented by eight bits or exactly one byte. Other grayscale ranges are used, but generally they are a power of 2 and indeed 256 different grey levels are sufficient for the recognition of most natural objects.

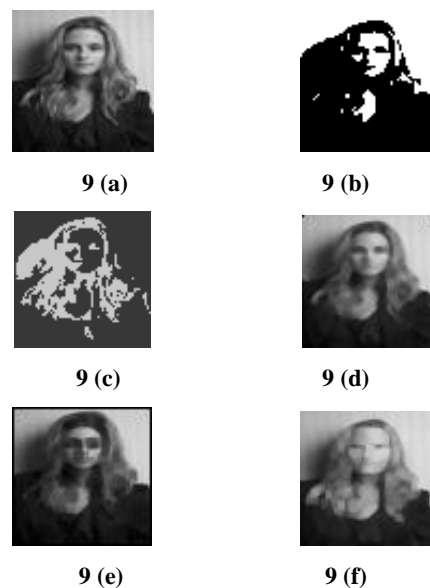
Min Filter: Min filter is used to locate the darkest point in an image. It is the 0th percentile filter. It reduces salt noise because of the min application of it. The equation for Min filter is $f'(x, y) = \min_{(s,t) \in S_{xy}} \{g(s, t)\}$.

Max Filter: Max Filter is used to locate the brightest point in an image. It is the 100th percentile filter. The equation for Max filter is $f'(x, y) = \max_{(s,t) \in S_{xy}} \{f(s, t)\}$. as the pepper noise has quite low values, it is reduced by a max filter because of the max selection process in the sub image area S_{xy} .

Median Filter: Median filter comes under the category of order statistics filter. Order Statistics filter is the spatial filters whose response is based on ordering or ranking the pixels contained in the image area encompassed by the filter. It is used for removing salt and pepper noise. The response of the filter at any point is determined by the ranking result. The Mean Filter replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel. The equation for Median filter is $f'(x, y) = \text{median} \{g(s, t)\}$. In median filter the original value (x,y) of the pixel is included in computation of the median. They provide less blurring and effective in presence of unipolar and bipolar impulse noise.

Average Filter: Average Filter is the simpler version of the mean filters. Let S_{xy} represent the set of coordinates in a rectangular sub image window of size $m*n$, centered at point (x, y).The arithmetic mean filtering process computes the average value of the corrupted image $g(x, y)$ in the area defined by S_{xy} .The value of the restored image at any point (x, y) is simply the arithmetic mean computed using the pixels in the region defined by S. In other words, it can be represented by this equation $f'(x, y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g(s, t)$. this operation can be implemented using a convolution mask $m \times n$ in which all coefficients have value $1/mn$. Noise is reduced as a result of blurring.

Laplacian Filter: Laplacian Filter is used to detect the edges. If Laplacian filter is applied on a noisy image, the result is an edge image with many small edges that detract from the larger more meaningful edges. The Laplacian $L(x,y)$ of an image with pixel intensity values $I(x,y)$ is given by $L(x, y) = \frac{d^2I}{dx^2} + \frac{d^2I}{dy^2}$





9 (g)



9 (h)

Figure 9: Image after applying various Filters (a) Input Image (b) Binary Image (c) Gray level slicing (d) Median Filter (e) Min Filter (f) max Filter (g) Average Filter (h) Laplacian Filter

As the Spatial Domain is the Image Enhancement type and as the name suggest the original image is processed. It is purely a subjective technique so the results can be varied from person to person. So according to my view the average filter gives the best result. The noise removal techniques are discussed by using various filters. Each filter is compared to get the result that which is better for removal of noise.

6. CONCLUSSION AND FUTURE SCOPE

Noise is the main problem while acquiring the images. The noise deteriorates the quality of the image. It comes through various processes while acquiring the image or while the image is stretched or contrast. The Noise in these images can be removed by using filters. The paper uses five filters for this. This paper concludes that the average filter gives the best result for removing noise from grayscale image. The future scope can be extended to Adaptive Filter and result can be improved more by developing Adaptive filter. Fuzzy Logic can be used to improve the image quality in spatial domain.

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