Review of Image Enhancement Techniques

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Abstract

Image Enhancement is one of the important and tough techniques in digital image processing. The main objective of image enhancement is to find out the hidden details in an image. Image Enhancement improves the quality of image for human presentation. Contrast increment, elimination of noise and blurring and enlightenment of details are examples of enhancement operation. Image enhancement is basically divided into two main categories such as spatial domain and Frequency domain. In this paper we discuss and compare these two techniques with their related techniques. Thus the contribution of this paper is to various image enhancement techniques.

1. Introduction

Image Enhancement is the processing of image to enhance some features of an image. Enhancement of image is basically improving the perception of information or interpretability in images for human viewers and providing better input for other automated image processing techniques. The image acquired from natural environment with high dynamic range includes both bright and dark regions. Due to increase in dynamic range of eyes sensing of human, those images are very difficult to perceive by eyes of human. Image enhancement is a technique to improve the quality of such images and modify attributes of an image to make it more suitable for a given task and specific spectator. It sharpens boundaries, edges, contrast for making display of image more helpful for analysis and display. The enhancement doesn't increase the data's content whereas it helps in increasing dynamic range of features that are selected for enhancing so that they can be easily detected. There are number of techniques which constitutes Image Enhancement process that require to improve the visual appearance of an image or to transform the image to form a better one that can be easy for human or machine to analysis. Figure1 shows the effect of image enhancement, it shows how the image is transformed form original image to enhanced image. Image enhancement is basically used when we want to remove noise from image, to enhance dark image and to highlights the object's edges in an image. For certain specific applications, the obtained result is more suitable than the original image.

Image enhancement techniques can be divided into two main categories:

1. Spatial Domain Method
2. Frequency Domain Method

Spatial domain method directly deals with the pixel values of an image. Whereas Frequency domain method operates on Fourier transform of an image for enhancement of an image.

Figure1. Showing the effect of image enhancement

In this paper we focus on different Image Enhancement techniques that come under spatial based domain techniques and frequency based domain techniques. This paper is organized as follows: Section 2 gives an overview of related work, Section 3, describes the various Enhancement techniques, In section 4, comparison between techniques is described with their

advantages and disadvantages. Finally Section 5 concludes the paper.

2. Related Work

The related work related to Image Enhancement Technique are discussed here, N.Mohanapriya and B. Kalaavati presented spatial domain enhancement techniques along with their algorithm and also analyzes their performance based on the image quality for medical images [1]. This paper have discussed about different enhancement techniques using MATLAB tool with relevant output. The results showed that improved image quality, structural appearance of input image. And also noises were removed from an image [1]. S.S. Bedi and Rati Khandelwal, presented an overview of image enhancement processing techniques in spatial domain. More specifically, they categories processing methods based representative techniques of Image enhancement [2]. Thus the contribution of this paper is to classify and review image enhancement processing techniques, attempt an evaluation of shortcomings and general needs in this field of active research survey [2]. Rakhi Chanana, Er.parneet Kaur Randhwa,Er.Navneet Singh discussed a practical implementation of various enhancement methods for Scanned Electron Microscope (SEM) images and their experimental results. SEM images lead to very dark and light areas in an image [3]. Adin Ramirez Rivera, Byungyong Ryu, Oksam Chae Proposed a content-aware algorithm that enhances dark images, sharpens edges, reveals details in textured regions, and preserves the smoothness of flat regions [4]. The algorithm produces an *adhoc transformation* for each image, adapting the mapping functions to each image's characteristics to produce the maximum enhancement [4]. Rajesh Garg, Bhawna Mittal, Sheetal Garg provide a frame work for image enhancement based on prior knowledge on the Histogram Equalization. Many image enhancement schemes like contrast limited Adaptive Histogram Equalization (CLAHE), Equal area dualistic sub image histogram equalization (DSIHE), Dynamic Histogram equalization (DHE) Algorithm has been implemented and compared[5]. The Performance of all these Methods has been analyzed and a number of Practical experiments of real time images have been presented. From the experimental results, it is found that all the three techniques yield different aspects for different parameters [5]. Komal R. Hole, Prof. Vijay S. Gulhane, Prof. Nitin D. Shellokar paper's gives a brief overview of the canonical genetic algorithm and it also reviews the tasks of image pre-processing. This paper introduces various approaches based on genetic algorithm to get image with good and natural contrast [6].This paper includes the definition of image enhancement and image segmentation and also the need of Image Enhancement and the image can be enhanced using the Genetic Algorithm and the Image Segmentation using Genetic Algorithm [6]. Arun R, Madhu S. Nair,R. Vrinthavani and Rao Tatavarti proposed paper which explores a new method by which alpha rooting can be used for enhancing even low contrast images[7]. In this paper they advocate complementing the transform domain technique with appropriate spatial domain techniques to eliminate the limitations of the conventional transform domain technique, thus improving the image enhancement process [7]**.** N.R.Mokhtar, Nor Hazlyna Harun, M.Y.Mashor, H.Roseline , Nazahah Mustafa, R.Adollah , H. Adilah, N.F.Mohd Nasir study proposes several contrast enhancement techniques which are local contrast stretching, global contrast stretching, partial contrast stretching, bright and dark contrast stretching[8]. All techniques are applied on the leukemia images.The comparison for the entire proposed image

3. Enhancement Techniques

As we discussed earlier, Enhancement technique is broadly divided into two categories. Thus we discussed each of them in brief with their sub techniques.

3.1. Spatial Domain Technique

The Spatial domain method is directly operated on pixels of an image. The pixel values are modified based on the problem domain. The objective of this method is to improve the perceptibility of information contained in an image and also enhancing the structural features can improve perceived image quality [1]. Spatial domain methods directly manipulate the image data array, either by point processing or area processing. Basically it deals with spatial frequency, i.e. difference between the highest and the lowest values of a contiguous set of pixels [2]. The technique regarding image enhancement using spatial domain methods can

be divide into two categories-
1. Global Image Enhancement
2. Local Image Enhancement

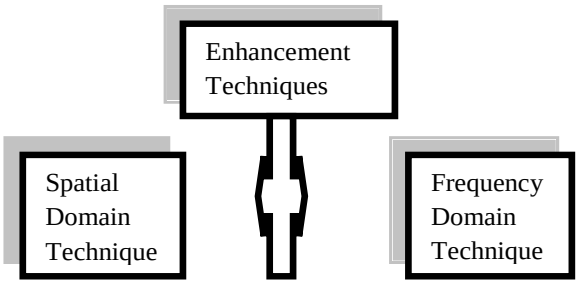


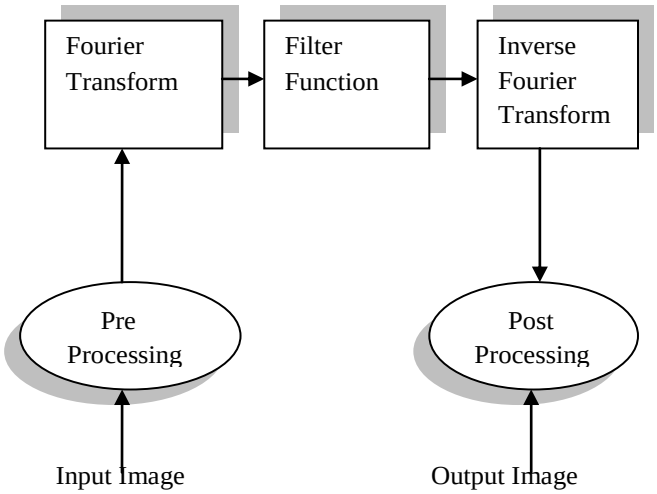
Figure2. Types of enhancement techniques

Global methods are mainly histogram modification that aims to exploit the full dynamic range of a rendering device by modifying the histogram of an image. The attractiveness is their simplicity and minor computational effort. However it is often necessary to enhance detail over a smaller area. So, the local image enhancement method plays a major role in those applications [2]. There are many spatial domain techniques that are divided according to global or local image enhancement. **Histogram Equalization** is global image enhancement which is one of the simplest and widely used techniques. Histogram equalization is the technique by which the dynamic range of the histogram of an image is increased. It assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast and the goal of histogram equalization is to obtain a uniform histogram [3]. In HE, the cumulative density function (cdf) of the histogram is used as the intensity transfer function; this method enhances the contrast by distributing the cdf across the entire dynamic range. However, this even distribution creates artifacts in the smooth regions of the image. Moreover, it does not consider the boundaries, which degrades the sharpness of the resulting image [4]. When the original histogram does not occupy the entire dynamic range of the image, HE produces washout effect which is the disadvantage of HE. Thus there are several techniques which based on HE has been proposed to overcome the disadvantages of original technique. One of the techniques is **Adaptive Histogram Equalization.** Adaptive histogram Equalization is local image enhancement. This is an extension to traditional Histogram Equalization technique. It enhances the contrast of images by transforming the values in the intensity image Unlike HE it operates on small data regions (tiles), rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the specified histogram. The neighbouring tiles are then combined using bilinear interpolation in order to eliminate artificially induced boundaries [5]. In AHE, histogram of image is divided into many modified to match across boundaries. It produces good result in dark images. The contrast, especially in homogeneous areas, can be limited in order to avoid amplifying the noise which might be present in the image. There are some other technique which based on spatial domain methods such as **Bi-histogram equalization** and Laplacian. BHE splits the histogram into two parts based on where the mean lies. Each part is then enhanced independently using HE. BHE maintains the intensity mean of the original image, which suppresses the over enhancement problem. Unnatural images are, however, still produced [4]. **Laplacian** is used to enhance the edges of an image thus it is edge enhancing algorithm. It perform local enhancement of the brightness levels of image pixels. Therefore the resultant image has increase in local contrast at boundaries rectangular domains, and then each domain is passed through the histogram equalization. Once this is completed the brightness levels are enhanced.

Table1. Summary of spatial domain technique

Techniques	Property
Histogram Equalization	Adjusting the global contrast of an image. It is most effective method for gray scale images.
Adaptive histogram Equalization	It is extension of HE and used within an image for local enhancement. It contains dark region and low contrast.

Bi-histogram Equalization	It maintains the intensity mean of the original image, which suppresses the over enhancement problem.
Laplacian	It is mostly used for edge enhancement.



3.2. Frequency Domain Technique Frequency domain method operates on the Fourier transform of an image. Image enhancement in the frequency domain is straightforward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter and take the inverse transform to produce the enhanced image. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value of the output image will be modified according to the transformation function applied on the input values [6]. The convolution theorem is the foundation of frequency domain techniques. Consider the following spatial domain operation: g(x,y)=h(x,y)*f(x,y)

The following frequency domain relationship given by the convolution theorem

G (u,v) = H(u,v) F(U,v)

Where g, f and h having Fourier transform G, H and F respectively. H is known as the transfer function of the process. Many image enhancement problems can be viewed in the form of the above equation. The main aim is to select a transfer function that changes the image in such a way that certain features of an image are enhanced. Examples edge detection, noise removal.

There are mainly three types of filters

1. Low pass filter
2. High pass filter
3. Band pass filter

In Low-pass filtering, sharp transitions and edges in the gray levels of an image contribute significantly to the high frequency content of its Fourier Transform. By attenuating a specified range of high-frequency components in the frequency domain, blurring is achieved. Through Low-pass filtering this task is performed. By High-pass filtering, Image sharpening can be achieved in the frequency domain. Low-frequency components will attenuated by high pass filter the without disturbing high frequency information. Band-pass filtering is a method in which the reflectance and illumination components can be filtered independently. The illumination component of an image is generally classified by slow spatial variation on the other hand the reflectance component of an image tends to vary abruptly. These characteristics lead to associating the low frequencies of the Fourier transform of the natural log of an image with illumination and high frequencies with reflectance thus it is filtered individually.

4. Comparison between spatial domain technique and frequency domain technique

- **Spatial domain** is manipulation of pixels of an image. It is the technique for changing the representation of an image and used in many field such as sharpening and smoothing

images. Whereas **Frequency domain** is the manipulation of Fourier transforms to enhance an image and perform purely with convolution theorem and it is used in changing the position of an image.

- The advantage of **spatial domain technique** is that it is simple to understand and the complexity of these techniques is very low which helps in real time implementation. Whereas **Frequency domain** technique having advantages which include low computation complexity, easy to view, manipulation of image's frequency composition and the special transformed domain property is easily applicable.
- The disadvantages of **spatial domain technique** is that it does not provides adequate robustness and perceivably. Whereas the disadvantage of **Frequency Domain** is that it cannot enhance properly every part of an image simultaneously and the automation of image enhancement is also very difficult.

Table2. Techniques with their area in which they applied

Techniques	Features
Spatial Domain Technique	It is used to alter the gray level value of individual pixels and hence the overall contrast of the entire image [7]. It is not possible to selectively enhance edges or other required information effectively [7].
Frequency Domain Technique	It is used to easily enhance edges and other subtle information because they are high frequency content and frequency domain operates on frequency content of an image. In this technique, all parts of an image are not enhanced in uniform manner

5. Conclusion

Image enhancement algorithm provides a wide variety of approaches for enhancing or modifying images to provide a better view. It is not possible to say which technique is good because the image enhanced by using such technique if it is looks good to user then it is good. The choice of such technique is depend on the requirements. In this paper, we provides an overview of image enhancement techniques, which can be divide into two main categories such as spatial domain enhancement technique and Frequency domain enhancement technique. Spatial domain technique is operate on pixels of an image, thus it enhances the overall contrast of an image. Whereas Frequency domain technique is operates on Fourier transform of an image, thus it helps in enhancing edges and other information of an image. This survey provides detailed information about the different image enhancement techniques and their related method. And also discuss their advantages and disadvantages.

6. References

[1] N.Mohanapriya,B.Kaalavati, "Comparative Study Of Enhancement Techniques For Medical Images",IJCA,vol.61, No.20, January 2013.

[2] S.S. Bedi, Rati Khandelwal, "Various Image Enhancement Techniques-A Critical Review", Department of Computer Science and Engineering, Banasthali Vidyapith, Jaipur, India, IJARCCE, vol. 2, Issue 3, March 2013.

[3] Rakhi Chanana, Er. Parneet Kaur Randhawa, Er. Navneet Singh Randhawa, "Spatial Domain based Image Enhancement Techniques for Scanned Electron Microscope(SEM) Images",Adesh Institue of Engineering and Technology, Fridkot, Punjab, India, IJCSI, vol.8 , Issue 4, No. 2, July 2011.

[4] Adin Ramirez Rivera,Byungyong Ryu and Oksam Chae, "Content-Aware Dark enhancement Through Channel Division", IEEE Transaction on Image Processing,vol.21, No. 9, September 2012.

[5] Rajesh Garg, Bhawna Mittal, Sheetal Garg, "Histogram Equalization Techniques for Image Enhancement",IJECT, vol.2,Issue1,March2011.

[6] Komal R. Hole, Vijay S. Gulhane, Nitin D. Shellokar, "Application of Genetic Algorithm for Image Enhancement and Segmentation", IJARCET, vol.2, issue. 4, April 2013.

[7] Arun R, Madhu S. Nair, Member, IAENG, R. Vrinthavani and Rao Tatavarti, "An Alpha Rooting Based Hybrid Technique For Image Enhancement", Engineering Letters, 19:3,EL_19_3_03.

[8] N.R.Mokhtar, Nor Hazlyna Harun, M.Y.Mashor, H.Roseline, Nazahah Mustafa, R.Adollah, H.Adilah, N.F.Mohd Nasir, "Image Enhancement Technique using

Global, Local, Bright, Dark and Partial Contrast Stretching For Acute Leukemia Images", WCE, vol.I, July 2009, London, U.K.