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Image Enhancement and its Techniques: A Survey

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Abstract

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. This paper surveys on image enhancement and its various techniques.

Keywords: *Enhancement, Spatial, Domain based techniques.*

1. Introduction

Image enhancement [1] is basically improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. The principal objective of image enhancement is to [1] modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task.

Image enhancement [1] is applied in every field where images are ought to be understood and analyzed. For example, medical image analysis, analysis of images from satellites etc. Image enhancement simply means, transforming an image f into image g using T (Where T is the transformation). The values of pixels in images f and g are denoted by r and s, respectively. As said, the pixel values r and s are related by the expression, $s = T(r)$.
Where T is a transformation that maps a pixel value r into a pixel value s. The results of this transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images.

The enhancement methods can broadly be classified in to the following categories:

a. Spatial Domain and Frequency Domain Methods

b. Locally Adaptive Threshold and Non-Threshold Based Methods

2. Spatial Domain and Frequency Domain Methods

2.1. Spatial Domain Method

Spatial Domain Methods which are operate directly on pixels. Spatial domain [2] refers to the image plane itself and approaches in this category are based on direct manipulation of pixels in an image. Histogram Equalization techniques are one of the spatial domain image enhancement techniques. This technique refers to the aggregate of the pixels composing an image. This process will be denoted by the expression given below.
$A(x,y) = T\,(f\,(x,y))$
Where $f(x,y)$ is input image, $g(x,y)$ is processed image and T is an operator on f, given
$g(x,y) = A(x,y)$.
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 [3]. The technique regarding image enhancement using spatial domain methods can be divide into two categories-

a. Global Image Enhancement
b. Local Image Enhancement

2.1.1. Global Image Enhancement

Global methods [3] 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. 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 [4].

2.1.2. Local Image Enhancement

Local image enhancement method [3] plays a major role in those applications where there is necessity to enhance the detail over smaller area. As global methods have dynamic range. 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.

2.2. Frequency Domain Method

Frequency domain processing techniques [2] are based on modifying 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 [3]. 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. The concept of filtering is easier to visualize in the Frequency domain. Therefore the enhancement of image $f(x,y)$ can be done in the Frequency domain based on DFT. This is particularly useful in convolution. If the spatial extent of the point spread sequence $h(x,y)$ is large then convolution theory.

$g(x,y) = h(x,y) * f(x,y)$

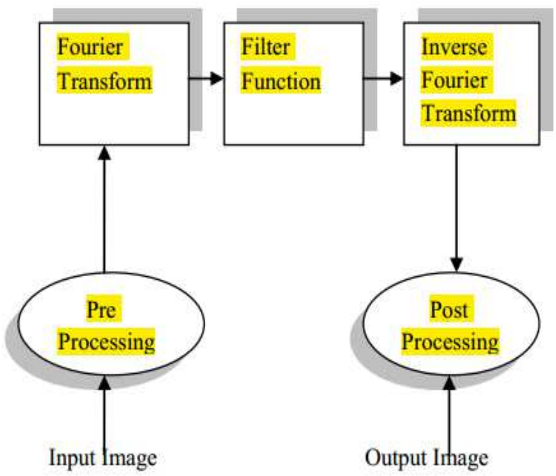
Where $g(x,y)$ is an enhanced image.

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.

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 [3]

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.
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.

3. Locally Adaptive Threshold and Non-Threshold Based Methods

3.1. Locally Adaptive Thresholding

Using this method, every pixel within a locality is applied an adaptive threshold value based on the local image characteristic [5]. Firstly, the gray level value $g(x,y)$ for every pixel (x,y) of a particular document image is calculated. The gray level is an intensity value within the range of [0, 255]. Then, the local adaptive threshold, $t(x,y)$ for every pixel (x,y), is formulated as:

$$f(x,y)=\begin{cases}0 & \text{if } g(x,y)\le t(x,y)\\ 255 & \text{otherwise}\end{cases}$$

In addition, a local adaptive thresholding, such as Sauvola's binarization method, the threshold $t(x,y)$ is computed using the mean, $m(x,y)$ and standard deviation, $s(x,y)$ of the pixel intensities in a window which is centered on the (x,y) pixel. The formula is as follows:

$$t(x,y)=m(x,y)\left[1+k\left(\frac{s(x,y)}{R}-1\right)\right]$$

Where R is the maximum value of the standard deviation and k is a parameter consists of positive values in between 0.2 and 0.5.

3.2. Non-Threshold Based Methods

Fuzzy logic method has been applied to old document recognition in [5]. The research investigated document damages such as distance between letter and tuner for thin and thick character styles. The Gabor Filter and Fuzzy Logic were used for feature extraction and classification techniques respectively. They claimed that Gabor filter is useful to extract local information of district environment in an image. Besides this information, the aspect ratio for each unknown character is also calculated. Lastly, the equality of classified character is derived as below:

$$S_{ij}(C)=\frac{\sum_{x,y}W_{ij}(x,y)a_{ij}(x,y)C_{ij}(x,y)}{\sum_{x,y}W_{ij}(x,y)}$$

And the rule for the aspect factor as:

$$r_j(C)=\min\left(\frac{ar(c)}{ar_j},\frac{ar_j}{ar(c)}\right)$$

Where $r_j(C)$ is the aspect ratio factor which to compare aspects of the image on the character C and the average aspect ratio of the group ar_j of letter j.

4. Conclusion

The image enhancement methods are discussed in detailed in this paper. 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.

Spatial Domain	Frequency Domain
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.	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.	Frequency domain technique having advantages which include low computation complexity, easy to view and the special transformed domain property are easily applicable.
The disadvantages of spatial domain technique is that it does not provides adequate robustness and perceivably.	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.

Table 1: Difference between Spatial Domain And Frequency Domain

References

[1] Raman Maini et. al., "A Comprehensive Review of Image Enhancement Techniques", JOURNAL OF COMPUTING, VOLUME 2, ISSUE 3, MARCH 2010, ISSN 2151-9617.

[2] G.Veena et. al., "Contrast Enhancement for Remote Sensing Images with Discrete Wavelet Transform", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277 -3878, Volume-2, Issue-3, July 2013.

[3] Ruchika Mishra et. al., "Review of Image Enhancement Techniques", International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 8, August – 2013.

[4] Rakhi Chanana et. al. ,"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.

[5] Sitti Rachmawati Yahya et. al., "Review on Image Enhancement Methods of Old Manuscript with Damaged Background", International Journal on Electrical Engineering and Informatics - Volume 2, Number 1, 2010.