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Research Paper

A SURVEY ON IMAGE ENHANCEMENT TECHNIQUES

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Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. In this paper, I present an overview of image enhancement processing techniques in spatial domain. More specifically, we categorize processing methods based representative techniques of Image enhancement. 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 and in last we will point out promising directions on research for image enhancement for future research.

Keywords: Frequency domain techniques, Image enhancement, Spatial domain techniques, Histogram equalization

INTRODUCTION

Image enhancement 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 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. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. There exist many techniques that can enhance a digital image without spoiling it. The enhancement methods can broadly be divided in to the following two categories:

1. Spatial Domain Methods
2. Frequency domain methods

In spatial domain techniques (Bhabatosh Chanda and Dwijest Dutta Majumder, 2002), we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency

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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 (intensities) of the output image will be modified according to the transformation function applied on the input values.

Image enhancement 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,

$$s = T(r) \quad ...(1)$$

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. So, the results are mapped back into the range [0, L-1], where L = 2^k, *k* being the number of bits in the image being considered. So, for instance, for an 8-bit image the range of pixel values will be [0, 255]. I will consider only gray level images. The same theory can be extended for the color images too. A digital gray image can have pixel values in the range of 0 to 255.

SPATIAL DOMAIN METHODS

Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization are based on the direct manipulation of the pixels in the image. Spatial techniques are particularly useful for directly altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results. It is not possible to selectively enhance edges or other required information effectively. Techniques like histogram equalization are effective in many images.The approaches can be classified into two categories: Point Processing operation (Intensity transformation function) and Spatial filter operations. An overview of some of the well known methods is discussed here. Point processing operations (Intensity transformation function) is the simplest spatial domain operation as operations are performed on single pixel only. Pixel values of the processed image depend on pixel values of original image. It can be given by the expression $g(x, y) = T[f(x,y)]$, where *T* is gray level transformation in point processing.

Figure 1: Shows the Effect of Image Enhancement

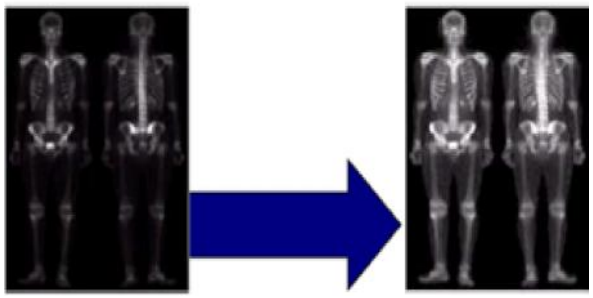
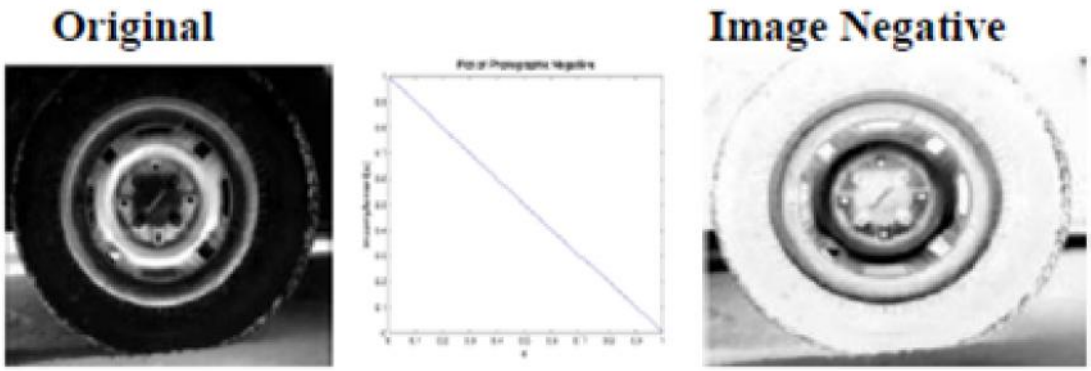


Figure 2: Original Image and its Negative



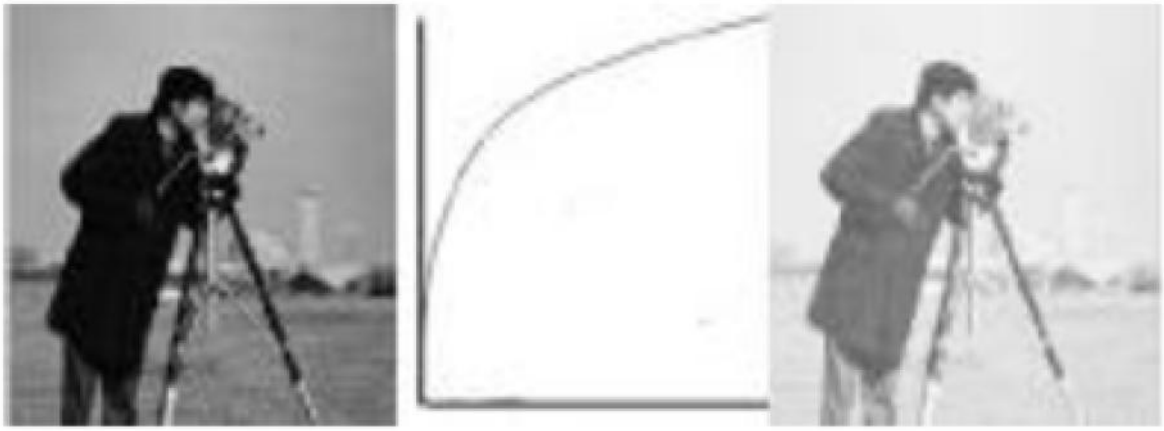
The Point processing approaches can be classified into four categories as Image Negatives in which gray level values of the pixels in an image are inverted to get its negative image. Consider an 8 bit digital image of size M x N, then each pixel value from original image is subtracted from 255 as $g(x, y) = 255 – f(x, y)$ for $0 \leq x \leq M$ and $0 \leq x < N$. In a normalized gray scale, $s = 1.0 – r$. Negative images are useful for enhancing white or gray detail embedded in dark regions of an image.

Another technique is Image Thresholding transformation in which let rth be a threshold value in $f(x, y)$. Image thresholding can be achieved as in a normalized gray scale As pixel values of threshold image areeither 0's or 1's, $g(x, y)$ is also named as binary image. These are particularly useful in image segmentation to isolate an image of interest from back ground. Moon image can be isolated from black ground in binary image as shown in Figure 3.

Next kind of transformation is the Log transformation which maps anarrow range of low gray levels into a wider range of gray levels, i.e., expand values of bright pixels and compress values of dark pixels. If C is the scaling factor, then log transformation can be achieved as $s = C \log (1 + |r|)$. Logarithmic image of a cameraman reveal more detail as shown in Figure 4.

Figure 3: Original Image and its Threshold Image

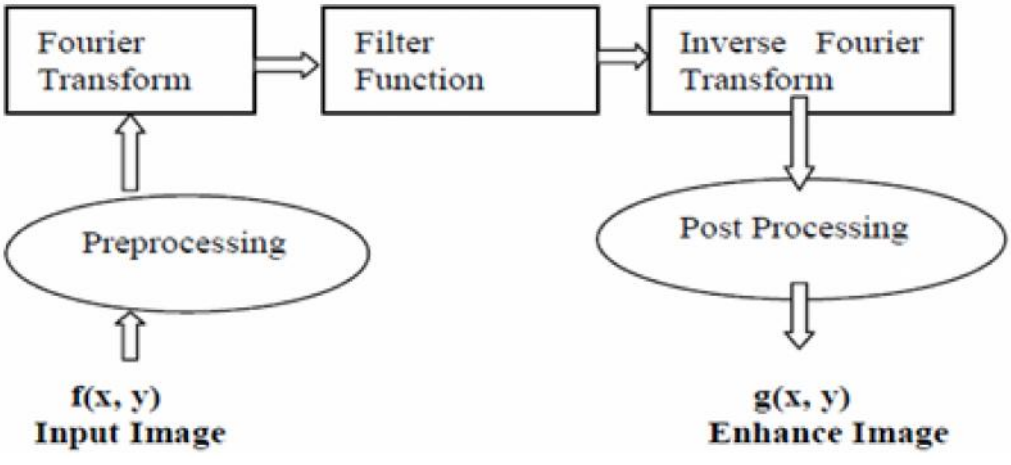
Figure 4: DFT of an Image and its Logarithm



FREQUENCY DOMAIN TECHNIQUES

Frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are suited for processing the image according to the frequency content. The principle behind the frequency domain methods of image enhancement consists of computing a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform. The orthogonal transform of the image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The usual orthogonal transforms are discrete cosine transform, discrete Fourier transform, Hartley Transform etc. The transform domain enables operation on the frequency content of the image, and therefore high frequency content such as edges and other subtle information can easily be enhanced.

Figure 5: Image Enhancement Using Fourier Transform



Frequency domain which operate on the Fourier transform of an image.

1. Edges and sharp transitions (e.g., noise) in an image contribute significantly to high frequency content of Fourier transform.
2. Low frequency contents in the Fourier transform are responsible to the general appearance of the image over smooth areas. The concept of filtering is easier to visualize in the frequency domain. Therefore, enhancement of image $f(x, y)$ can be done in the frequency domain based on DFT. This is particularly useful in

Table 1: A Brief Survey on Histogram Enhancement Techniques

Author	Year	Operating Domain	Model	Processing Techniques	Application
Agaian S S	2007	Spatial domain	HE based Logarithmic transform LTHS	Log reduction zonal magnitude technique; Logarithmic transform histogram shifting	Traffic monitoring; Security Surveillance
Hao Hu	2010	Spatial domain	Content adaptive video processing model	Content classification and adaptive processing	Computer vision
Tarik Arici	2009	Spatial domain	HE based modification	Histogram modification framework, content adaptive algorithm	LCD display device; Low quality video
Sangkeun Lee	2007	Spatial domain	Dynamic range compression	Discrete Cosine Transform (DCT); Retinex theory	Image/video compressing
Viet Anhnguyen	2009	Spatial domain Transform domain	Cauchy distribution model; AC transform coefficient	Video reconstructed from multiple compressed copies of video content	Compression video
R C Gonzalez	2008	Spatial domain	HE	Global Histogram Equalization	Image/Video Security Surveillance
Xuan Dong	2010	Spatial domain	Image Inverting Model	Inverting the input low lighting video; dehaze algorithm	Traffic monitoring; Medical imaging
Shan Du	2010	Spatial domain	ARHE model	Adaptive Region based Method	Face Recognition
A A Wadud M	2007	Spatial domain	Dynamic Histogram Equalization	Dynamic Histogram Equalization Technique	Medical Image, Low quality video
Boudraa A O	2008	Spatial domain	2DTKEO model	2D Teager-Kaiser Energy Operator	Medical image; Satellite image
David Menotti	2007	Spatial domain	MHE model	Multi histogram equalization Methods	Image processing
Sara Hashem	2010	Spatial domain	Improve HE	Genetic algorithms	Compute high dynamic range image processing
George D	2009	Spatial domain	Improve HS and HE	Histogram based image enhancement	Image processing

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 enhanced image.

APPLICATIONS

Image enhancement is used for enhancing a quality of images. The applications of image enhancement are Aerial imaging, Satellite imaging, Medical imaging, Digital camera application, Remote sensing, Image Enhancement techniques used in many areas such as forensics, Astrophotography, Fingerprint matching, etc. The better result for Image enhancement has also used in real time enhancement of neuro evolution of augmenting. IE techniques when applied to pictures and videos help the visually impaired in reading small print, using computers and television, and face recognition. Color contrast enhancement, sharpening and brightening are just some of the techniques used to make the images vivid. In the field of e-learning, IE is used to clarify the contents of chalkboard as viewed on streamed video; it improves the content readability. Medical imaging uses this for reducing noise and sharpening details to improve the visual representation of the image. This makes IE a necessary aiding tool for reviewing anatomic areas in MRI, ultrasound and x-rays to name a few. In forensics IE is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims.

OBSERVATIONS

The point processing methods are most primitive, yet essential image processing operations and are used primarily for contrast enhancement. Image Negative is suited for enhancing white detail embedded in dark regions and has applications in medical imaging. Power-law transformations are useful for general purpose contrast manipulation. For a dark image, an expansion of gray levels is accomplished using a power-law transformation with a fractional exponent. Log Transformation is useful for enhancing details in the darker regions of the image at the expense of detail in the brighter regions the higher-level values. For an image having a washed-out appearance, a compression of gray levels is obtained using a powerlaw transformation with ¥ greater than 1. The histogram of an image (i.e., a plot of the gray level frequencies) provides important information regarding the contrast of an image. Histogram equalization is a transformation that stretches the contrast by redistributing the gray-level values uniformly.

CONCLUSION

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. The review of Image enhancement techniques in Spatial domain have been successfully accomplished and is one of the most important and difficult component of digital image processing and the results for each method are also discussed. Based on the type of

image and type of noise with which it is corrupted, a slight change in individual method or combination of any methods further improves visual quality. In this survey, we focus on survey the existing techniques of image enhancement, which can be classified into two broad categories as spatial domain enhancement and Frequency domain based enhancement. We show the existing technique of image enhancement and discuss the advantages and disadvantages of these algorithms.

Although we did not discuss the computational cost of enhancement algorithms it may play a critical role in choosing an algorithm for real-time applications. We also have described recent developments methods of image enhancement and point out promising directions on research for image enhancement in spatial domain for future research.

The future scope will be the development of adaptive algorithms for effective image enhancement using Fuzzy Logic and Neural Network.

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