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Design of Various Image Enhancement Techniques

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ABSTRACT:

Image Enhancement is very essential and important technique used in image processing. The role of image enhancement is to improve the content visibility of an image. Images in different fields like medical, satellite images, aerial images and even real life pictures suffer from poor contrast and high noise. It is important to only enhance the contrast and reduce the noise to increase image quality. The enhancement technique differs according to various aspects and they can be broadly classified into two categories: Spatial Domain and Frequency domain based techniques. This paper presents a review of image enhancement processing techniques in spatial domain. Also we have categorized processing methods based representative techniques of Image enhancement. Thus this paper helps to evaluate various image enhancement techniques

Keywords: ***Histogram Equalization, Frequency based domain enhancement, Spatial based domain enhancement, Image Enhancement.***

1 INTRODUCTION

The proverb ‘One picture is worth of thousand words’ expressing correctly the amount of information contained in a single picture. Pictures (images) play an important role in the organization of our society as a mass communication medium. Most media (e.g. news papers, TV, cinema) use pictures (still or moving) as information carriers. The tremendous volume of optical information and the needed for its processing and transmission paved the way to image processing by digital computers.

Interest in digital image processing methods stems from two principal application areas.

1) Improvement of pictorial information for human interpretation
2) Processing of scene data for autonomous machine perception

One of the first applications of image processing techniques in the first category was in improving digitized news paper pictures sent by submarine cable between London and New York. Introduction of the Bart lane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than three hours.

The relevant efforts started around 1964 at the Jet population laboratory (Pasadena, California) with the digital processing of satellite images coming from moon. Soon, a new branch of science called digital image processing enlarged. Since then, it has exhibited a tremendous growth and created an important technological impact in several areas, e.g. in telecommunication, TV broadcasting, the printing and graphic art industry, medicine and scientific research.

Digital image processing [6] concerns the transmission of an image to a digital format and its processing by digital computers. Both input and output of a digital image processing system are digital images. Digital image analysis is related to the description and recognization of the digital image component. Its input is a digital image and its output is a symbolic image description. In many cases digital image analysis techniques simulate human vision functions. Therefore, the term computer vision can be used as equivalent to (or the superset of) digital image analysis. Human vision is a very complex nuero – physiological process. Its

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characteristics are only partially known, despite the tremendous progress that has been made in this area in the past decades. Therefore, its simulation by digital image analysis and computer vision is a very difficult task. In general, the techniques used in the digital image analysis and computer vision differ greatly from the human visual perception mechanisms, although both have similar goals.

DIGITAL IMAGE DEFINITIONS

A digital image a[m,n] described in a 2D discrete space is derived from an analog image a(x,y) in a 2D continuous space through a sampling process that is frequently referred to as digitization. For now we will look at some basic definitions associated with the digital image. The effect of digitization is shown in Figure 1.1 . The 2D continuous image a(x,y) is divided into N rows and M columns. The intersection of a row and a column is termed a pixel. The value assigned to the integer coordinates [m,n] with {m=0,1,2,…,M–1} and {n=0,1,2,…,N–1} is a[m,n]. In fact, in most cases a(x,y)—which we might consider to be the physical signal that impinges on the face of a 2D sensor—is actually a function of many variables including depth (z), color (□), and time (t). Unless otherwise stated, we will consider the case of 2D, monochromatic, static images.

This techniques works on the principle of manipulating the transform coefficients. The advantages of frequency based image enhancement comprise of low complexity of computations, ease of visibility and manipulating the frequency composition of the image and the easy applicability of special transformed domain properties. The basic limitations are that, it cannot enhance all parts of image at once and also finds difficult to automate the image enhancement procedure. Image enhancement techniques like spatial domain methods can again be classified into two broad categories: Point Processing operation and Spatial filter operations. Traditional methods of image enhancement are to enhance the low quality image itself. It did not embed any high quality background information. The reason is that in the dark image, some areas are so dark that all the information is already lost in those regions. Even high illumination is unable to bring back lost information. Frequency domain methods can again be classified into three categories: Image Smoothing, Image Sharpening and Periodic Noise reducing.

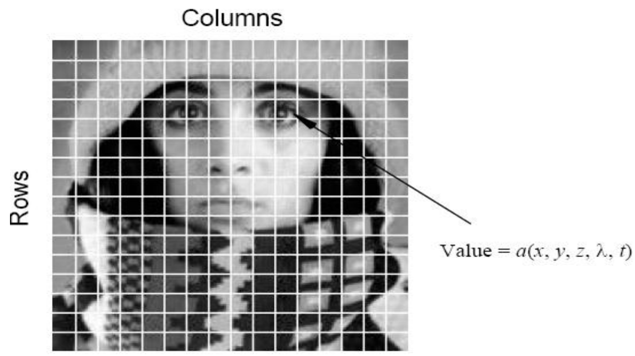

Figure: Digitization of a continuous image. The pixel at coordinates [m=10, n=3] has the integer brightness value 110.

The image shown in Figure has been divided into N = 16 rows and M = 16 columns. The value assigned to every pixel is the average brightness in the pixel rounded to the nearest integer value. The process of representing the amplitude of the 2D signal at a given coordinate as an integer value with L different gray levels is usually referred to as amplitude quantization or simply quantization. [3]

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

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categories: 1. Point Processing Operation (Intensity Transformation Function) 2. Spatial Filter Operations. 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. 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 a 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 $0 \leq x < M$ and $0 \leq x < N$. In a normalized gray scale, s = 1.0 – r. Negative images are useful for enhancing white or gray details embedded in dark regions of an image. Fig.1 shows an example of an image negative.

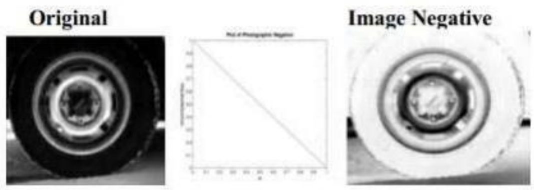

Fig. 1. Original image and its negative image

Image thresholding can be achieved as in a normalized gray scale as pixel values of threshold image are either 0's or 1's, g(x, y) which is also called binary image. These images are used 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 Fig 2.

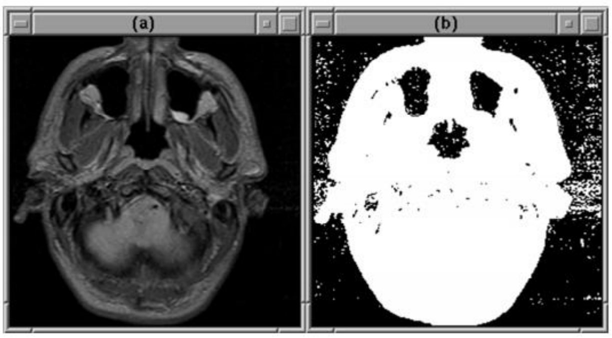

Fig 2. Original Image and its threshold Image

Log transformation is the one which aps a narrow 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 Fig.3

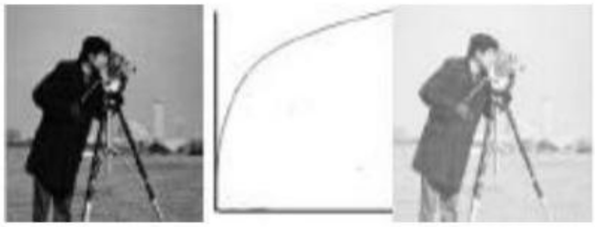

Fig. 3 DFT of Cameraman image and its logarithmic plot

Inverse logarithmic transformations map a wide range of gray level values into a narrow range of gray level values i.e. expand values of dark pixels and compresses values of bright pixels. Log and inverse log operations are particularly used when gray level values of an image have extremely large range and small range respectively. Logarithmic Transformations can be used to brighten the intensities of an image (like the Gamma Transformation, where gamma < 1). More often, it is used to increase the detail (or contrast) of lower intensity values. They are especially useful for bringing out detail in Fourier transforms. In Power Law (Gamma) transformation the relation between pixel values of f(x, y) and g(x, y) in this transformation is given by s =c r γ , where c and γ are positive constants. If γ < 1 power law transformation maps a narrow range of dark pixel values into a wider range and wider ranges of bright pixel values to a narrow range. Family of possible transformations on varying γ with c=1 is shown in Fig.4.

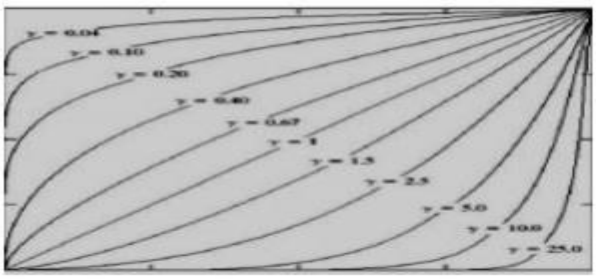

Fig 4. γ^{th} power and γ^{th} root curves for c=1.

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Based on setting of (r1, s1) and (r2, s2), different types linear transformations can be achieved.

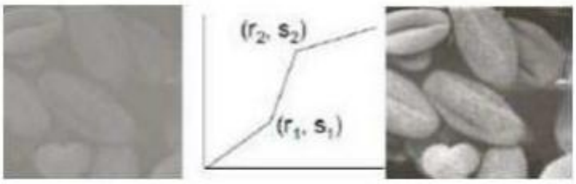

Fig. 5 Original image and its stretched image

There are three types of Piecewise linear transformations: 1. Contrast Stretching 2. Intensity level slicing 3. Bit plane slicing Contrast Stretching is one of image enhancement techniques involves processing an image to make it look better to human viewers. It is usually used for post processing by modifying contrast or dynamic range or both in an image. The aim of contrast enhancement process is to adjust the local contrast in different regions of the image so that the details in dark or bright regions are brought out and revealed to the human viewers. Contract enhancement is usually applied to input images to obtain a superior visual representation of the image by transforming original pixel values using a transform function of the form as g(x, y)=T[r(x, y)] where g(x, y) and r(x, y) are the output and the input pixel values at image position. This process improves the contrast by stretching the range of gray level values to span a desired range of gray level values. This transformation is also called as image intensity transformation or normalization. Let a, b be the minimum and maximum pixel values of f(x, y) and c, d be the minimum and maximum pixel values of g(x, y). Normalization can be achieved by scaling each pixel in original image value as s=(r-c) (b-a)/ (d-c) + a. The existing techniques of contrast enhancement techniques can be again sub divided into two groups: direct and indirect methods. Direct methods define a contrast measure and try to improve it. Indirect methods on the other hand, improve the contrast through exploiting the underutilized regions or the dynamic range without defining a specific contrast term.

Contrast Enhancement can be divided into 2 main categories: Histogram Equalization (HE) and Tone Mapping. Histogram Equalization is commonly used method which attempts to alter the spatial histogram of an image to closely match a uniform distribution. The main objective of this method is to achieve a uniform distributed histogram by using the cumulative density function of the input image.[4] Histogram Equalization HE suffers from retaining local detail due to its global treatment of the image small- scale details that are often associated with the small bins of the histogram are eliminated. Also it is not suitable in some applications such as consumer electronic products, where brightness preservation is necessary to avoid artifacts. The equalization result is usually an undesired loss of visual data of quality and of intensity scale. In this method, the shape of the histogram is specified manually and then a transformation function is constructed based in this histogram input image at gray levels. Image histogram is partitioned based on local minima and specific gray level ranges that are assigned to each partition. After partitioning, HE is applied on each partition. Tone Mapping is another approach of contrast enhancement techniques. In this method if we want to output high dynamic range (HDR) image on paper or on a display.

This technique is used in image processing and computer graphics to map a set of colors to another, often approximate the appearance of high dynamic range images in media with a more limited dynamic range. Tone mapping is done in the luminance channel only and in logarithmic scale. It is used to convert floating point radiance map into 8-bit representation for rendering applications. The two main aims of tone mapping algorithm: Preserving image details and providing enough absolute brightness information in low dynamic range tone mapped image. Intensity Level or Gray level Slicing is another technique of Piecewise linear transformation in which gray or Intensity level slicing high lights certain range of gray levels in the original image. These transformations permit segmentation of certain gray level regions from the rest of the image.[5] This technique is useful when different features of an image are contained in different gray levels. Bit plane Slicing is another form of Piecewise transformation is used for total image appearance by

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specific bits which used for pixel gray levels and determines the adequacy of number of bits used to quantize each pixel in image compression. Spatial Filter Operations are performed on a pixel and its immediate neighbors; this is also called as neighborhood operations. Spatial filters are classified into two categories: Linear and Nonlinear spatial filters. Linear spatial filter process involves convolving a mask with an image i.e. passing a weighted mask over the entire image. Mask is also referred as window, template, or kernel [6]. Nonlinear spatial filter are those filters in which enhanced image is not linearly related to pixels in the neighborhood of original image.

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.

Table 1. A Brief Survey of Histogram Enhancement Techniques

Author	Year	Operating Domain	Model	Processing techniques	Application
Agaian SS[7]	2007	Spatial domain	HE based Logarithmic transform LTHS	Log reduction zonal magnitude technique; Logarithmic transform histogram shifting	Traffic monitoring; Security Surveillance
Hao Hu[8]	2010	Spatial domain	Content adaptive video processing model	Content classification and adaptive processing	Computer vision
Tarik Arici[9]	2009	Spatial domain	HE based modification	Histogram modification framework, content adaptive algorithm	LCD display device; Low quality video
Sangkeun Lee[10]	2007	Spatial domain	Dynamic range compression	Discrete Cosine transform(DCT); Retinex theory	Image/video compressing
Viet Anhnguyen[11]	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[12]	2008	Spatial domain	HE	Global Histogram Equalization	Image/ Video Security Surveillance
Xuan Dong[13]	2010	Spatial domain	Image Inverting Model	Inverting the input low lighting video; dehaze algorithm	Traffic monitoring; Medical imaging
Shan Du[14]	2010	Spatial domain	ARHE model	Adaptive Region based Method	Face Recognition
A.A Wadud M[15]	2007	Spatial domain	Dynamic Histogram equalization	Dynamic Histogram Equalization technique	Medical Image, Low quality video
Boudraa A.O[16]	2008	Spatial domain	2DTKEO model	2D Teager- Kaiser Energy Operator	Medical image; Satellite image
David Menotti[17]	2007	Spatial domain	MHE model	Multi histogram equalization methods	Image processing
Sara Hashem[18]	2010	Spatial domain	Improve HE	Genetic algorithms	Compute high dynamic range image processing
George D[19]	2009	Spatial domain	Improve HS and HE	Histogram based image enhancement	Image processing

The orthogonal transform of the image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The phase is used to restore the image back to the spatial domain. 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. Frequency domain which operate on the Fourier transform of an image. • Edges and sharp transitions (e.g. Noise) in an image contribute significantly to high frequency content of Fourier transform. • 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 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.

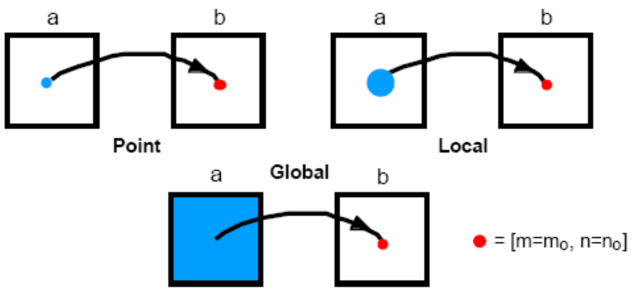

Figure 1.2: Illustration of various types of image operations

APPLICATIONS

Image enhancement is used for enhancing a quality of images. The applications of image enhancement are Aerial imaging, CCTV Footage, Satellite imaging, Medical imaging, Digital camera application, remote sensing and many more. 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 education, enhancement algorithms are used to clarify the contents of scanned documents. Medical imaging uses this for reducing noise and sharpening details to improve the visual perception of the image. This makes algorithms, a necessary aiding tool for reviewing anatomic areas in MRI, ultrasound and x-rays to name a few. In forensics enhancement algorithms are used for identification and evidence gathering. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims.

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.

All the techniques echoed are very easy to implement. They require no tricky evaluations and processing of the data is accomplished only intimacy integers, so there is no scope of loss of precision. The JPEG technique compel tricky evaluations. The processing takes place intimacy of real numbers where there is possibility of loss of precision.

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