A Review on basics of Digital Image Processing

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***Abstract*— This paper presents basics of digital image processing. Image Processing is very popular topic in the field of research and development. Image processing is a large research area to improve the visibility of an input image and acquire some valuable information from it. In Image processing any form of signal processing for which the input is an digital image; the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Image processing were developed in 1960s and in 2000 digital image processing has become the most common form of image processing due to its versatility and low cost. In broader sense, Image processing is divided into two major branches; image enhancement and image restoration. Fourier transform is most popular image transforms. The Fourier Transform is used in a wide range of applications. Image Processing is the act of examining images for the purpose of identifying objects and judging their significance. An image analyst studies the remotely sensed data and attempt to detect, identify, classify, measure and evaluate the significance of physical and cultural objects, their patterns and spatial relationship through logical processes.**

Keywords*— *Image processing, Fourier Transform, Image Enhancement, Image restoration.

I. IMAGE PROCESSING

Basically Image processing can be defined as manipulation of images such as refining of images. Digital Image Processing is a most emerging field with many growing applications in field science and engineering. The goal of this manipulation can be divided into three categories such as[1]:

Image Processing image in -> image out
Image Analysis image in -> measurements out
Image Understanding image in -> high-level description out

In broader sense, Image processing is divided into two major branches; ***image enhancement*** and ***image restoration***. Image enhancement is to improve the quality of image and to produce image that is different from the original. Whereas image restoration, is to recover the original image after degraded by many unknown effects. In Image processing techniques, does not reduce the amount of data present but rearranges it which gives better quality of image. Basically images are stored in 2D array[1]. This 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] as shown in figure 1[2].

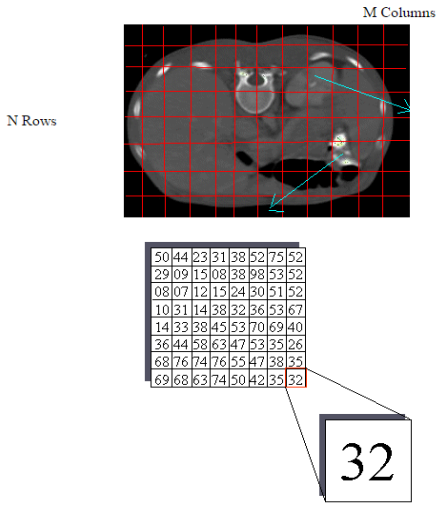

Fig. 1 Representation of an Image in an 2D array.

Black and white images can be stored in two ways. One way is to store each pixel as a single bit i.e. 0 and 1 where 0 shows black and 1 shows white. Second way is to store each pixel as a byte i.e. 8 bits, In this way the maximum value of pixel is 255.The values in this range make up the different shades of gray. To represent colour images, separate red, green and blue components must be specified for each pixel.

II. HISTORY OF IMAGE PROCESSING & ITS APPLICATIONS

Image processing or widely called digital image processing were developed in 1960s and among the earliest developers are Jet Propulsion Laboratory, MIT and Bell Labs[3]. It was originally developed with application to satellite imagery, medical imaging, character recognition and photo enhancement. When third generation digital computers began to offer the speed and storage capabilities required for practical implementation of image processing algorithms. The area of digital image processing has experienced tremendous growth. Now, in 2000s, with developed technologies of fast computers and signal processors digital image processing has become the most common form of image processing due to its versatility and low cost[3].

Some of the major fields in which digital image processing is widely used are mentioned below

1. Image sharpening and restoration
2. Medical field
3. Remote sensing
4. Transmission and encoding
5. Machine/Robot vision

6. Color processing
7. Pattern recognition
8. Video processing
9. Microscopic Imaging
10. Others

III. IMAGE TRANSFORMS

Image transforms can be simple arithmetic operations on images or complex mathematical operations which convert images from one representation to another. Mathematical Operations include simple image arithmetic, Fourier, fast Hartley transform, Hough transform and Radon transform[2,3,4].

Fourier transform is most popular image transforms. The Fourier Transform is used in a wide range of applications, such as image analysis, image filtering, image reconstruction and image compression. The output of the transformation represents the image in the Fourier or frequency domain, while the input image is the spatial domain equivalent. In the Fourier domain image, each point represents a particular frequency contained in the spatial domain image. Here in figure 2(a) shows a grey colour image of nature and its Fourier transform is shown in figure 2(b).

Fig. 2(a) A grey colour image of nature.

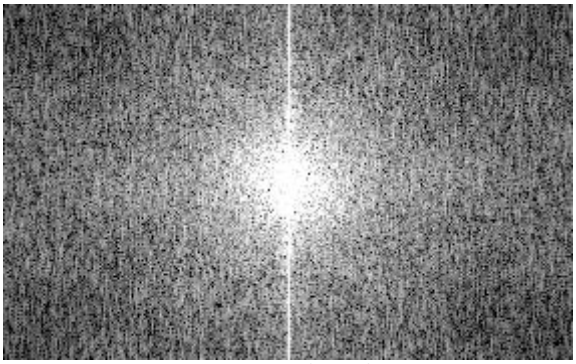

Fig. 2(b) A Fourier transform of above image

IV. IMAGE ENHANCEMENT

The principal objective of enhancement is to process a given image so that the result is more suitable than the original image for a specific application. It sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis purpose. The greatest difficulty in image enhancement is quantifying the criterion for enhancement and, therefore, a large number of image enhancement techniques are required to obtain satisfactory results. Image enhancement methods can be based on either spatial or frequency domain techniques[5,6].

Spatial domain enhancement methods: Spatial domain techniques are performed to the image itself and they are directly manipulate the pixels of an image. The operation can be formulated as

$$g(x,y) = T[f(x,y)] \text{-----(1)}$$

where g is the output, f is the input image and T is an operation on f defined over neighbourhood of (x,y).

Frequency domain enhancement methods: These methods enhance an image f(x,y) by convoluting the image with a linear, position invariant operator. The 2D convolution is performed in frequency domain with DFT. Consider the following spatial domain operation

$$g(x,y)=f(x,y)*h(x,y) \text{------(2)}$$

The convolution theorem states that the following frequency domain relationship holds:

$$G(u,v) = H(u,v)F(u,v) \text{----(3)}$$

where G, H, and F are the Fourier transforms of g, h, and f respectively. H is known as the transfer function of the process.

1) Image Enhancement by Point Processing

a) Intensity Transformations: Input pixel value, I, mapped to output pixel value, O, via transfer function T.

i) **Image Negatives**

This type of transformation simply negates all of the values in image and adds the value of the maximum (absolute) intensity to all pixels in the image.

ii) **Contrast Stretching**

This type of transformation is used to enhance low contrast images. Contrast stretching boost the lighter pixels to a higher intensity level.

iii) **Grey Level Slicing**

A grey level slicing function can either emphasize a group of intensities and diminish all others.

b) Histogram Processing: Histogram is a plot of frequency occurrence of an event. The histogram of a digital image with gray levels in the range [0,L-1] is a discrete function p(rk)=nk/n, where rk is the kth gray level, nk is the number of pixels in the image with that gray level, n is the total number of pixels in the image, and k=0,1..L-1. Figure 3 shows the histogram of various types of images. The shape of the histogram of an image gives us useful information about the possibility for contrast enhancement. A histogram of a narrow shape indicates little dynamic range and thus corresponds to an image having low contrast.

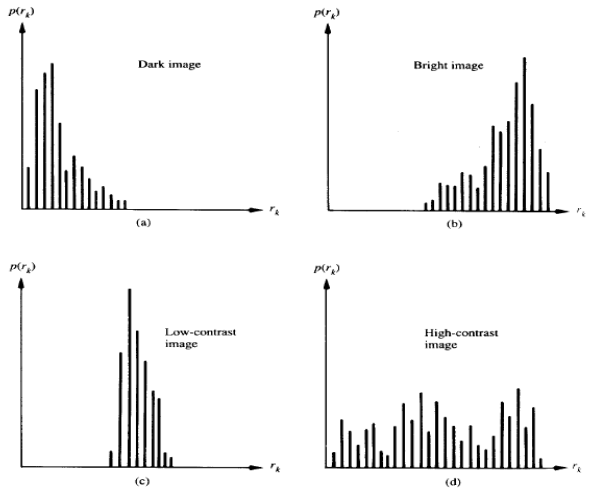

Fig. 3 Histogram of Various Digital Images

c) Image Subtraction: The technique is basic subtracting the grey level intensities of one image from another in a pixel-wise fashion.
d) Image Averaging: Image averaging is an effective way to remove noise from a series of noisy images

2) Spatial Filtering

Spatial filter[7] is an image operation where each pixel value I(u; v) is changed by a function of the intensities of pixels in a neighbourhood of (u; v). Figure 4 shows the typical example of spatial filtering.

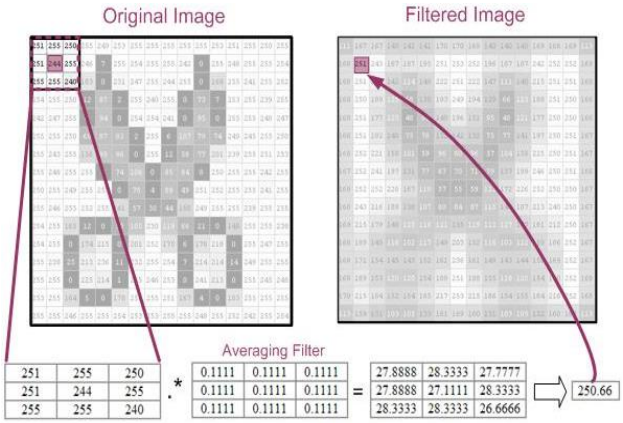

Fig. 4 Example of spatial filtering

V. IMAGE RESTORATION

Image restoration means to compensate or undo defects which degrade an image. Degradation may occur due to various reasons such as motion blur, noise, and camera misfocus. There are four different ways of restoring the image.

I. Inverse Filter: In this method we look at an image assuming a known blurring function. We will see that restoration is good when noise is not present and not so good when it is.

II. Weiner Filtering: In this technique image restoration is taking place using wiener filtering, which provides us with the optimal trade-off between de-noising and inverse filtering. The result is in general better than with straight inverse filtering.

III. Wavelet Restoration: Here three wavelet based algorithms to restore the image.

IV. Blind Deconvolution: In this method, nothing is assumed about the image and no information is present about the blurring function or on the additive noise.

VI. CONCLUSION

The focus of this study is to highlight the Basics of Digital Image Processing. Image Processing is the act of examining images for the purpose of identifying objects and judging their significance. An image analyst studies the remotely sensed data and attempt to detect, identify, classify, measure and evaluate the significance of physical and cultural objects, their patterns and spatial relationship through logical processes. In this paper, discussion on the elements of Digital Image Processing are highlighted to help the beginners in this field. It will also help them to analysis and classify the data using various techniques. In future this work can be extended by implementing these techniques over various digital images.

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