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Review of Image Enhancement in Spatial Domain

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Abstract: **Digital Image Processing is a process in which digital images are processed by the means of digital computer. Its main application is to improve the pictorial information for human interpretation. Almost all of the digital images contain noise. To improve a digital image, a number of enhancement techniques are available. Filtering is one of the common techniques used to remove unwanted information (noise) from the image. Image enhancement plays a vital role in every field particularly where images need to be closely examined and understood. Different images like satellite images, medical images, aerial images, microscopy images and even the real life photographs contain poor noise and a difference in lightness, brightness and/or hue between two colors that makes them more or less distinguishable. It is also used for image sharpening and smoothening. The problem of is considered as a quality improvement problem. Digital images contain various types of noises which reduce the quality of images. Noises can be removed by various enhancement techniques. Digital images can be either spatial domain or frequency domain. This paper investigates various techniques used in spatial domain image processing.**

Keywords: **spatial domain; filter; smoothing; sharpening; noise.**

I. INTRODUCTION

An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows. A **Digital image** is a 2D light intensity function in which each element is called pixel.

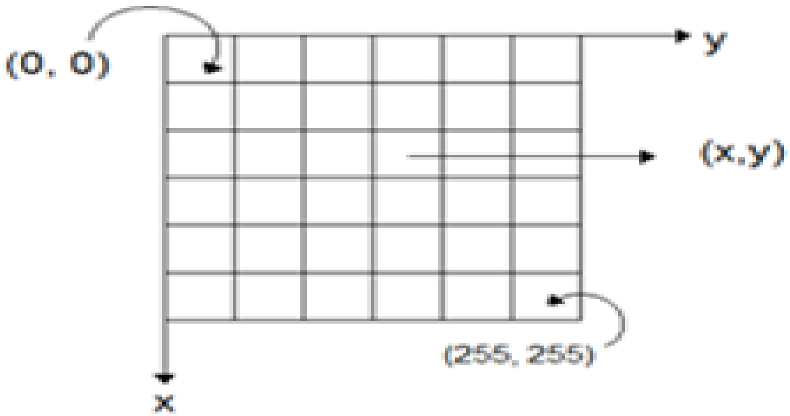


Fig 1: An 8 bit Digital Image

When an image is acquired by any imaging system such as camera, the visual system for which it is planned is unable to directly use it. The steps involved in Digital Image processing are image acquisition, image enhancement, image analysis, image reconstruction, image restoration, image compression, image segmentation, image recognition, and visualization. In digital image processing, the major sources of noise are at the image acquisition and image transmission.

Image processing is a process which transforms a degraded image into an image of better quality so as to facilitate its later interpretation. Image processing techniques can be then applied in order to facilitate the interpretation of images by further using certain computer vision algorithms. The major applications of image processing are following:

- Photography and printing
- Machine Vision
- Satellite image processing
- Microscope image processing
- Medical image processing
- Face detection, feature detection, identification
- Car barrier detection

II. METHODOLOGY

Image Enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without the knowledge of source of degradation. If the source of degradation is known, one calls the image restoration step. Both the iconic processes, viz. input and outputs are images. The enhancement approaches fall into two broad categories:

1. Spatial domain method
2. Frequency domain method

Spatial domain methods directly modify the image pixels to achieve desired enhancement in spatial domain.

Frequency domain methods perform the enhancement operations to Discrete Fourier Transform (D F T) of an image in frequency domain. Inverse Fourier transform of spectrum is found to get the enhanced image in which pixel values will be modified.

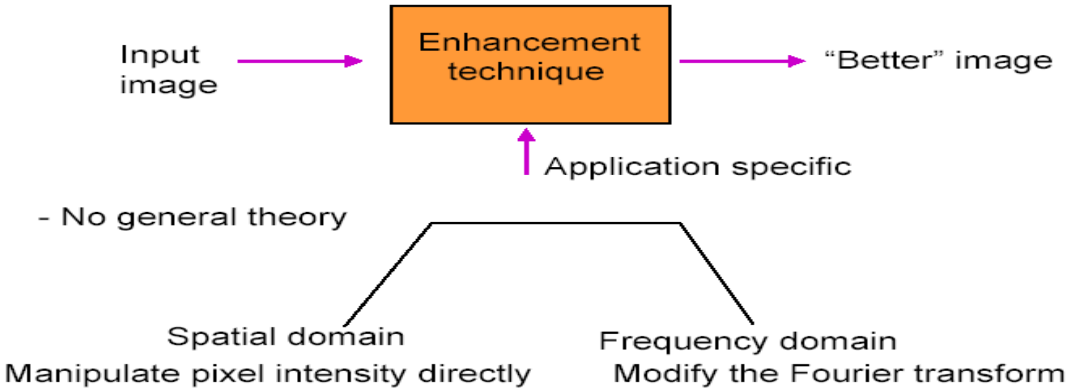


Image enhancement techniques in Spatial Domain

Some of the common image enhancement techniques in spatial domains for grayscale images are:

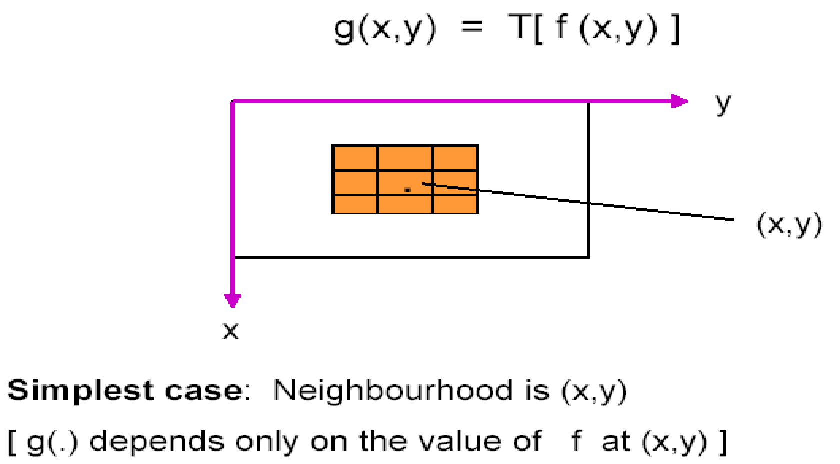
1. Point processing operations
2. Spatial filter operations
3. Histogram processing operations
4. Pseudo coloring operations

I. Point Processing Technique

In this technique, we work on asinge pixel at a time i.e. T is 1 x 1 operator. The new image formed after depends on this transform T on the original image.

Some examples or techniques of point processing are as follows:

- Digital Negative
- Contrast Stretching
- Thresholding
- Gray level slicing
- Bit plane slicing
- Dynamic range compression



1) Digital Image Negative:

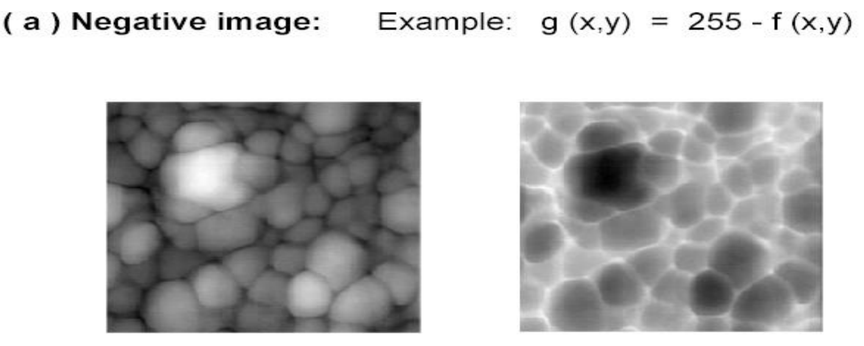
It is useful in a number of applications. eg. X-ray images. The term Negative means inverting the gray levels.

Digital Negative can be obtained by:

$s = 255 - r$ (where, $r_{max} = 255$)

when, $r = 0$; $s = 255$ & if $r = 255$; $s = 0$

Generally, $s = (L-1) - r$ where, L – total number of gray levels (e.g. 256 for 8-bit image)



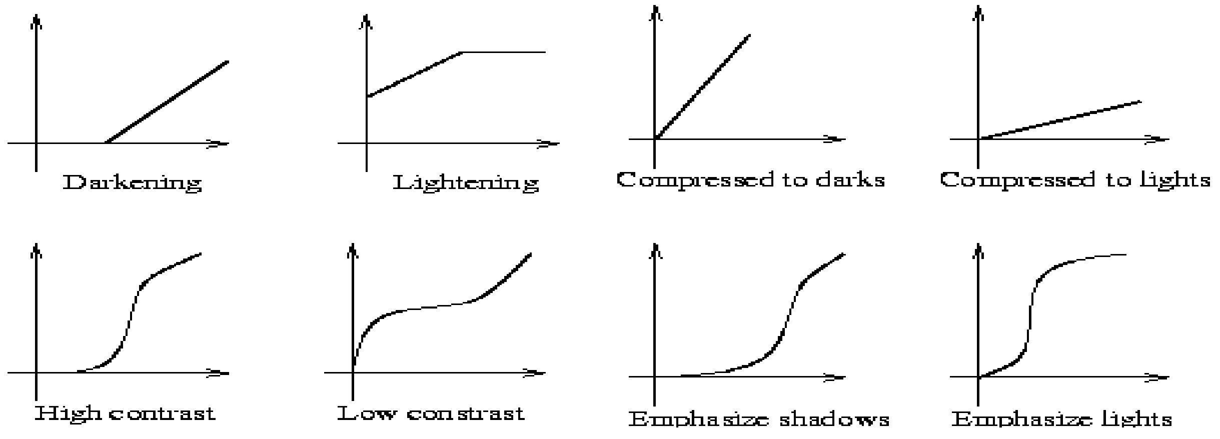
2) Contrast Stretching

This is done when the captured image has poor Illumination or lens aperture has been placed wrong. Idea behind contrast stretching is to make dark portion darker and bright portion brighter.

Formula is: $s = l.r$; for $0 \le r \le a$

$= m(r-a) + v$; for $a \le r \le b$

$= n(r-b) + w$; for $b \le r \le L-1$



3) Thresholding

Extreme Contrast Stretching yields Thresholding.

If $r1 = r2$, $s1 = 0$ & $s2 = L-1$ Then we get thresholding function.

Expression becomes:

$s = 0$; if $r \leq a$

$s = L - 1$; if $r > a$ where, L is number of Grey levels.

Thresholded images have maximum contrast as there are only BLACK & WHITE grey values.

4) Grey Level Slicing

Thresholding splits the image in 2 parts. But at times we need to highlight a specific range of grey levels.eg. X-ray scan, CT scan. Grey level slicing looks similar to thresholding except that we select a band of grey levels in this technique.

5) Bit Plane Slicing

In bit plane slicing, each bit contributes to the formation of final image.

Let us consider a 256x256 image with 256 grey levels. For eg- Black is represented as 00000000 and White as 11111111. Steps to find grey level:

- Consider LSB value of each pixel & plot image. Continue till MSB is reached.
- All 8 images will be binary.

Observing the images we conclude that

- Higher order images contain visually sufficient data.
- Lower order bits contain suitable details of image.

Example of bit plane slicing is steganography

6) Dynamic Range Compression (Log transformation)

Sometimes, dynamic range of the image exceeds the capability of display device. Some pixel values are so large that the other low value pixel gets obscured.E.g. stars in day time are not visible though present due to large intensity of sun. Thus dynamic range needs to be compressed.Log operator is an excellent compression function.Thus, Dynamic range compression is achieved using log operator.

Formula used :

$s = C.\log(1 + |r|)$ where, C – normalization constant & r – input intensity

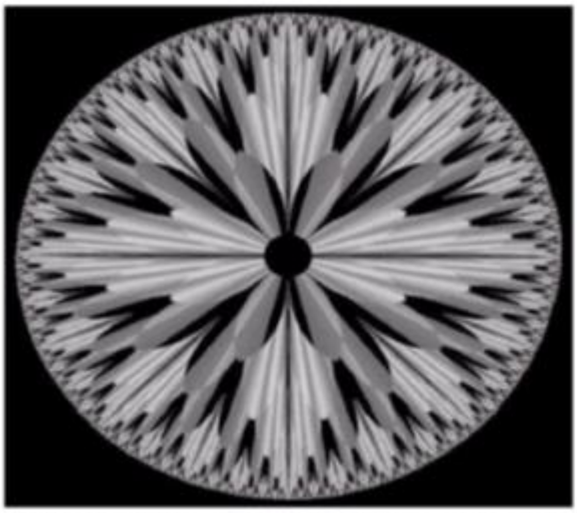
7) Power Law Transform

Power Law Transform can be used to increase dynamic range of image.

II. Spatial Filtering Technique

Spatial filtering term is the filtering operation performed directly on the image pixels. Theprocess simply consists of moving the filter mask from one point to another in an image. At every point (x,y), theresponse of the filter can be calculated using certain predefined relations.

Spatial filter can be classified into i) smoothing spatial filters and ii) sharpening spatial filters. These filterscan be either linear or nonlinear. In linear filter each value of pixel in the output image is a weighted sum of thepixel in the neighborhood of the corresponding pixel in the input image. Nonlinear filtering operation is based on the pixel values in the neighborhood. Nonlinear filter can be effectively used in noise reduction



An 8-bit fractal image. (A fractal is an image generated from mathematical expressions). (Courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA.)

Smoothing Spatial Filters

Smoothing filters are used for reduction of noise and blurring operations. Each pixel of a digital image is represented by red, green, and blue chromatic intensities. Blurring can be used as an initial step for other image processing operations. By taking neighboring pixels into account, extreme noisy pixels are filtered out. Unfortunately, extreme pixels can also represent original details, which were lost due to smoothing process.

$\frac{1}{9} \times$

1	1	1
1	1	1
1	1	1

$\frac{1}{16} \times$

1	2	1
2	4	2
1	2	1

Sharpening Spatial Filters

The main aim in sharpening an image is to highlight every fine detail of the image, or to enhance the blurred pixels (perhaps due to noise or motion). It is done by adding the edges to the input digital images.

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Example:

−1	−1	−1
−1	8	−1
−1	−1	−1

III. Histogram Technique

It is a graph of the frequency of occurrence of each gray level in an image. If nk is the number of pixels having a gray level rk, in an image of size MxN, then probability of occurrence of rk is given by

Where k=0, 1, 2…L-1 and for a normalized histogram k varies from 0 to 1. Even though histogram of an image contains no spatial information, image processing operations can be done based on histograms.

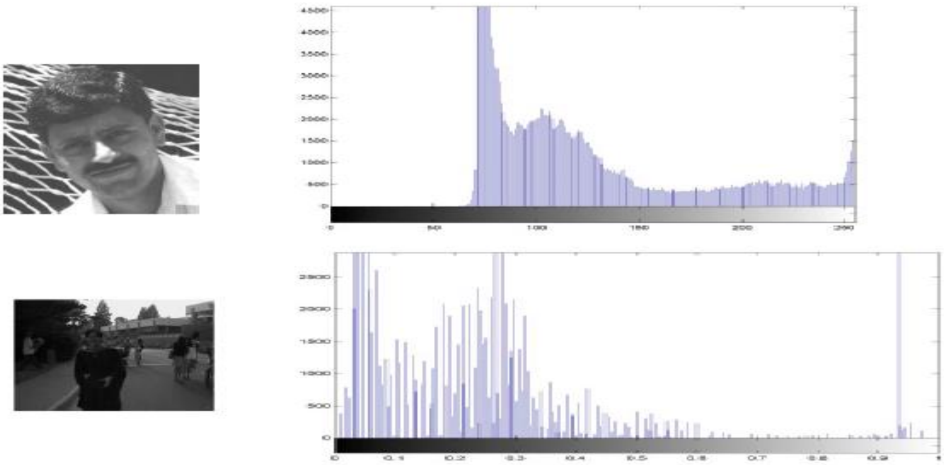
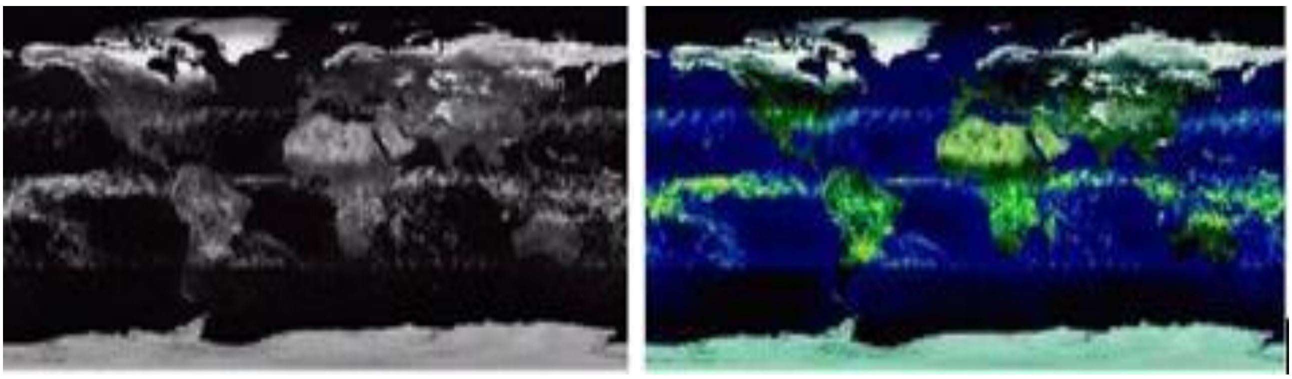


Fig. Original image and its histogram equalized image along with histograms

IV. Pseudo Coloring Technique

Humans are able to distinguish many colors other than grey levels. Greyscale images can be artificially colored by using a proper color map. Pseudo coloring process assigns colors to gray level values of pixel based on specified criterion. This coloring process highlights the rainfall levels as shown in Fig.



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III. CONCLUSION

In the time of digital images, the major issue is the huge amount of data. Statistical parameters can provide information about an image using just a few numbers. Many statistics are used to characterize image qualities like brightness, contrast etc and are used as a basis for digital image processing algorithms to improve the quality of displayed digital image. Local enhancement methods discussed in this paper using statistical parameters are used to enhance images in every area. Mean and variance methods are used as the basis for making changes in each pixel in the image. This helps in enhancing details over small areas in an image. The images enhanced through this method are most satisfactory when bringing out the desired detail is concerned.

Future Scope

There is ample scope for future work in this research work to further improve the performance of the Local Image Enhancement Method.

• Automation of this method will help getting the combination of satisfactory parameters faster.

• Adaptive approach to neighborhood calculation will increase the efficiency of image enhancement process.

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