

Image Enhancement Techniques: A Review

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Abstract:- Primary aim of Image enhancement is to process the image by highlighting the features of interests in such a manner so that the output is visually more informative than original image, which can used in various fields such as Medical Field, Transmission and encoding, Remote Sensing, Video Processing, Pattern recognition, Geographic Information Systems and many more. Image enhancement techniques provide a number of algorithms for enhancing the images. Algorithm selection for enhancement is affected by the image acquiring methodology, job needing to be done and viewing conditions. In this paper, we will see for image enhancement with point and histogram processing techniques in spatial domain.

Keywords: Digital Image, Enhancement, Spatial Domain, Point Processing, Histogram Processing

1. INTRODUCTION

Image enhancement is a procedure of refining the visual nature of digital images by manipulating the pixel values so that the outcome is more appropriate for displaying or further image processing. Enhancement techniques are problem oriented as a method is quite good for enhancing the satellite images may not be a good method for enhancing the images acquired from other sources. In image enhancement, attributes of the input image are modified so that the results are more suitable for a given job or a viewer. The choice of attributes and the modification process is different for different types of images. The purpose of image enhancement is to improve the quality of the image, to remove noise from the image, to increase or decrease the brightness, to sharpen the image, and to improve the perception of the information for human viewers. Enhanced image helps in the feature extraction process in digital image processing. Image enhancement techniques are broadly divided into the two categories, namely spatial and frequency Domain.

The spatial domain refers to the image plane itself and spatial domain techniques are based on direct manipulation of the pixels in an image. There are two principal categories of spatial processing, namely intensity transformation and spatial filtering. Intensity transformation operates on single pixels of an image for contrast manipulation and thresholding. Spatial filtering deals with performing operations on every neighboring pixel in an image for image

sharpening. In frequency domain techniques, enhancement is applied to the Fourier Transform of the input image. The resultant image is obtained by applying Inverse Fourier Transform. Contrast and brightness manipulation of the input image is done in frequency domain techniques. Image enhancement can be defined as:

$$O(x, y) = T[I(x, y)] \quad (1)$$

Where $I(x, y)$ is digital image input and $O(x, y)$ is digitally processed image, T is the transformation that maps a pixel value $I(x, y)$ into a pixel value $O(x, y)$.



Fig.1. An example showing the effect of image enhancement [1]

2. POINT PROCESSING METHODS

Under the term point processing, we summarize all processing that can be done based on single image pixel. The output value replaces the input pixel on the image. The neighborhood of the pixel is simply the pixel itself. In point processing T in eq. (1) is referred as gray level transformation or point processing.

2.1 Image Negative

Linear operation in digital image processing on an input digital image with intensity level in the range $[0, R-1]$ is performed by using the negative transformation, which can be defined

$$O = R - 1 - P \quad (2)$$

Where 'P' is an input pixel and 'O' is the output pixel. In digital image negative, each pixel value is subtracted from $[R-1]$. To calculate the negative of gray scale images we have to subtract each pixel value of the original image from 255.

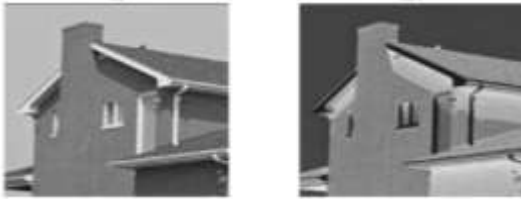


Fig.2. Images shows the original image and the resultant image after applying negative transformation [1].

2.2 Log Transformations

The general log transformation is given by the expression

$$O = c * \log(1 + P) \tag{3}$$

Where 'O' and 'P' are the pixel values of output and input image and c is a constant. In this transformation the dark pixels in the input image are expanded and the higher pixel values are compressed. The reverse is true of the inverse log transformation. We usually set c = 1.



Fig.3. Example showing effect of log transformation [1].

2.3 Power-Law (Gamma) Transformations

The general power-law transformation can be defined by the expression

$$O = c * P^\gamma \tag{4}$$

Where c and γ are positive constants. Equation (4) can be written as $O = c(P + \epsilon)^\gamma$ to make it measurable output when the input is zero. Narrow range of dark input image value is mapped into a wider range of output values of the fractional values of γ . The opposite is also true for higher values of input levels. This transformation is also known as gamma correction. γ varies the enhancement of the input image and its value is different for different display devices. There are two types of power-law transformation, namely n^{th} power and n^{th} root transformations.



Original image $c = 1 \gamma = .6$ $c = 1 \gamma = 2$

Fig.4. An example showing the effect of power-law transformation with different values of γ [1].

2.4 Thresholding transformation

Thresholding methods simply replace each pixel in an input image with a black pixel if the image intensity is less than fixed constant T or white pixel if the image intensity is greater than the constant T. Thresholding is a simple method of segmentation. We can convert a grayscale image into a binary image using thresholding. We use thresholding to isolate an object from a background in an input image.



(a) (b)

Fig.5. (a) Original image (b) resulting image after applying thresholding transforms [1].

2.5 Piecewise –Linear Transformation functions

The form of piecewise-linear function can be arbitrary complex. In piecewise-linear transformation we make use of user-defined transforms. The main disadvantage of piecewise-linear transformation functions is that their specifications require considerably more input from the user.

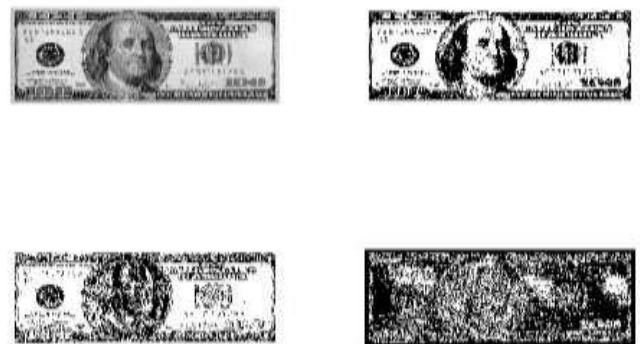


Fig.6. The example shows bit-plane slicing linear transform [1].

3. HISTOGRAM PROCESSING

Process of plotting the frequency of occurrence of gray level r_m in an input image is known Histogram processing. In histogram processing, image is enhanced by manipulating its histogram. The histogram of an image can be expressed as

$$h(r_m) = n_m \tag{5}$$

Where m^{th} intensity value is denoted by r_m and the number of pixels with intensity value r_m is denoted by n_m of an input image with intensity levels ranging between of $[0, R-1]$.

Normalization of histogram is done by dividing the number of pixels n_m with intensity r_m by the product of the number of rows and columns of pixels in the input image.

$$P(r_m) = \frac{n_m}{MN}, k = 0, 1, \dots, L-1 \quad (6)$$

Where $P(r_m)$ gives probability of occurrence of r_m .

3.1 Histogram Equalization

Histogram equalization is a method of manipulation of image histogram to enhance the contrast. It provides a technique to change the range and contrast of the input image get a histogram of desired shape. In histogram processing, the uniform distribution of intensity values is done.

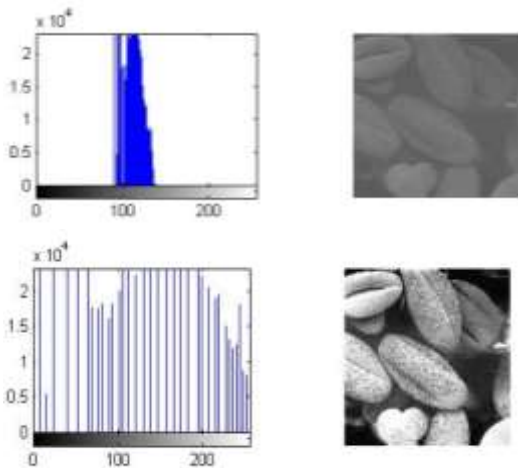


Fig.7. Shows the original image and its histogram, and the equalized one [1].

3.2 Histogram Specification

Histogram specification is a method of transforming the histogram of one image into the histogram of another image.

The method is implemented in following steps:

- In the first step, a particular histogram shape is specified or histogram of the target image is calculated.
- In the second step, histogram of the input image is calculated.
- In the third step, the cumulative sum of template histogram is calculated.
- In the fourth step, the cumulative sum of the target image is calculated.

- In the last step the mapping of pixels from one bin to another is done using the rules of histogram equalization.

The actual cumulative sum can be greater than or equals to the template cumulative sum. Matching of gray scale distribution of one image into another image is done in histogram matching.

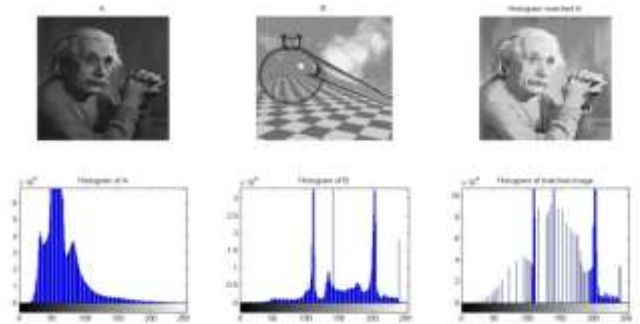


Fig.8. An example showing histogram matching different images [1].

3.3 Local Enhancement

Histogram equalization and histogram specification methods are global. So, the local enhancement is introduced. A rectangular mask is defined and the center is moved from pixel to pixel in the input image. For each neighborhood, a histogram of the neighborhood points is calculated. Histogram equalization/specification function is obtained. Mapping of gray levels in the neighborhood is performed. New pixels values and previous histogram can be used to calculate the next histogram.

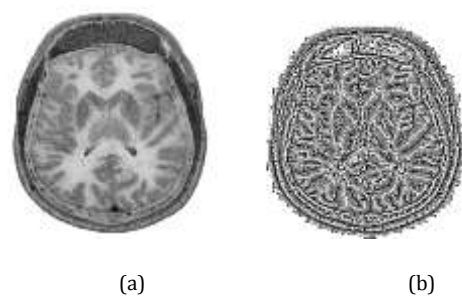


Fig.9. (a) Original image (b) resultant image after applying local enhancement [1]

3.4 Histogram Stretching

Histogram stretching is an image enhancement method in which the contrast of the input image is improved by stretching the intensity range that the input image contains to the span desired intensity range. Histogram stretching is also called as normalization. Linear scaling function to the pixel values of an image is applied to perform a less harsh enhancement. Before performing the histogram stretching, the upper and lower pixel intensity limits are defined over

which the input image is to be normalized. Normalization is commonly to enhance the contrast in an image without changing relative gray level intensities too much.

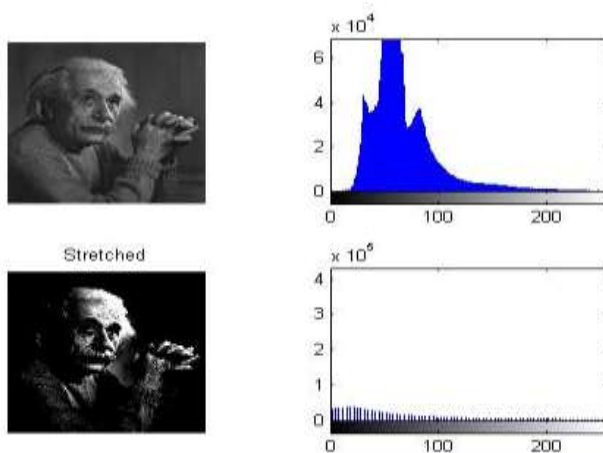


Fig.10. The example shows histogram stretching [1].

4. CONCLUSION

Image enhancement techniques offers various image enhancing methods in spatial as well as in the frequency domain. It is a subjective as it depends on the type of task, the contents of the input image, viewing conditions as well as viewers of the image. Different image enhancement techniques have successfully used for enhancing the poor quality images using different spatial and frequency domain methods. Image enhancement is subjective as it depends on the type of task, the contents of the input image, viewing conditions as well as viewers of the image. Image negatives are suitable for enhancing the images in which the information is hidden in the darker regions of the image and has application in the medical field. Log transformations are helpful for enhancing dark regions of the image by manipulation while power law transformations are used for contrast manipulation for different display devices. Thresholding transformation is helpful in segmentation as well as digital image conversion to binary image. Histogram equalization is a technique for contrast manipulation by redistributing the gray level values uniformly.

5. REFERENCES

- [1]. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", 3rd edition, by Pearson Education.
- [2] Anil.K.Jain, "Fundamentals of Digital Image Processing", by Prentice Hall, 2004.
- [3] Michael Ekstrom, "Digital Image Processing Techniques", 1st Edition, Academic Press.

- [4] Fari Muhammad Abubakar Department of Electronics Engineering Tianjin University of Technology and Education (TUTE) Tianjin, P.R. China , " Image Enhancement using Histogram Equalization and Spatial Filtering", by International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064.
- [5] Raman Maini and Himanshu Aggarwal, "A Comprehensive Review of Image Enhancement Techniques", by Journal of Computing, Volume 2, Issue 3, March 2010, ISSN 2151-9617.
- [6] Chahat Choudhary, Mehendra Kumar Patil, "Review of image enhancement Techniques using Histogram Equalization", by International Journal of Application or Innovation in Engineering & Management (IJAIEEM), Volume 2, Issue 5, May 2003. ISSN 2319-4847
- [7] Vijay A. Kotkar, Sanjay S. Gharde, "Review Of Various Image Contrast Enhancement Techniques", Vol. 2, Issue 7, July 2013.
- [8] Deepak K. Pandey, Prof. Rajesh Nema, "Selective Review on Various Images Enhancement Techniques", Vol. 2, Issue 6, June 2013.
- [9] Prof. Gayathri.R, Dr. Sabeenian.R.S, "Modern Techniques in Image Denoising: A Review", Volume 2, Issue 4, April 2013.
- [10] Kanika Gupta, S.K Gupta, "Image Denoising Techniques- A Review paper " Volume 2, Issue 4, March 2013.