Various Image Enhancement Techniques- A Survey

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Abstract

The main goal of image enhancement is to process an image so that result is more suitable than original image for specific application. It improves the visual appearance of an image and provides a better transform representation for future automated image processing. Many images like medical images, satellite images, aerial images and even real life photographs suffer from poor contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in all kind of images detection and analysis is Image Enhancement techniques which improves the clarity of images for human viewing, remove blur and noise, increase contrast, and reveal many details. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. This paper will provide an overview of underlying concepts, along with algorithms commonly used for image enhancement. The paper focuses on spatial domain techniques for image enhancement, with particular reference to point processing methods and histogram processing.

Keywords: *Image enhancement; Spatial domain enhancement; Gray scale manipulation; Digital image processing.*

1. Introduction

Digital image processing is a broad subject and often involves procedures which can be mathematically complex, but central idea behind digital image processing is quite simple. The ultimate aim of image processing is to use data contained in the image to enable the system to understand, recognize and interpret the processed information available from the image pattern [1]. Image enhancement techniques improve the quality of an image as perceived by human. Generally image enhancement techniques are used to get detail that is obscured, or to highlight certain features of interest in image. In image enhancement process one or more attributes of image are modified. Image enhancement can be applied to different areas of science and engineering. Except for illumination conditions, quality of images is also affected by external noises and environmental disturbances such as ambient pressure and temperature fluctuations. Thus, image enhancement is necessary. The survey of available techniques is based on the existing techniques of image enhancement, which can be classified into two broad categories:

1. Spatial domain image enhancement
2. Frequency domain image enhancement.

In this paper, we will focus on only spatial domain image enhancement techniques. In spatial domain techniques [2], we directly deal with the image pixels. To get the desired results the pixel values are manipulated. In frequency domain techniques, the image is first transferred in to frequency 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 enhanced 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 of the output image will be modified according to the transformation function applied on the input values.

2. Spatial domain methods

Basically in spatial domain the value of pixel intensity are manipulated directly as

$$G(x, y) = T [f(x, y)]$$

Where f (x,y) is input image, G(x, y) is output image and T is an operator on f, defined over some neighborhood of f(x, y).

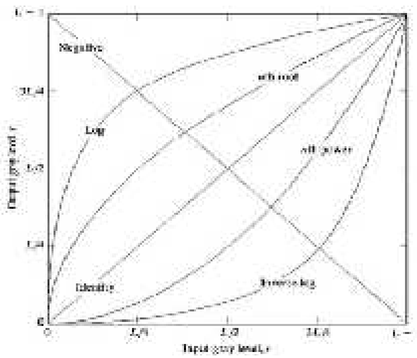


Fig 1. Basic grey level Transformations

The idea of blurring an image by reducing its high frequency components or sharpening an image by increasing the magnitude of its high frequency components is intuitively easy to understand. However, computationally, it is often more efficient to implement these operations as convolutions by small spatial filters in the spatial domain. The paper focuses on spatial domain techniques for image enhancement, with particular reference to point processing methods, histogram processing.

2.1 Point processing operations: The Point processing approaches can be classified into four categories as:

2.1.1 Image Negative: In this 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 $0 \le x < M$ and $0 \le x < N$.

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.

Original Image **Image Negative**

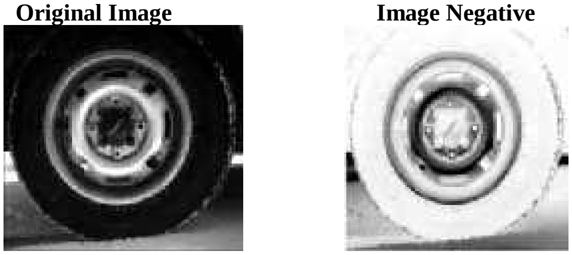


Fig. 2. Original image and its negative image

2.1.2 Image thresholding: 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) is also named as binary image. Thresholding transformations [3] are particularly useful for segmentation in which we want to isolate an object of interest from a background as shown in figure below:

Original image Thresholded image

Fig 3. Showing effect of thresholding transformation for isolating object of interest

2.1.3 Logarithmic Transformations

The general form of the log transformation is

$s = c * \log(1 + r)$

The log transformation maps [4] a narrow range of low input grey level values into a wider range of output values. The inverse log transformation performs the opposite transformation. Log functions are particularly useful when the input grey level values may have an extremely large range of values. Logarithmic image of a cameraman reveal more detail as shown in Fig.4.

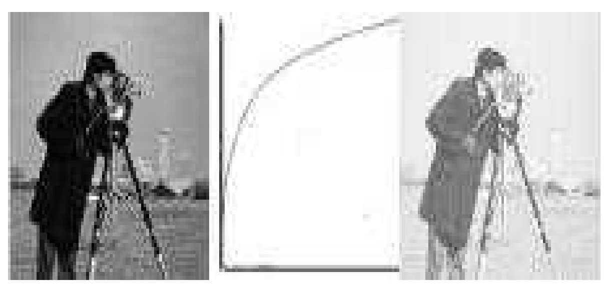


Fig. 4 DFT of image and its logarithmic

2.1.4 Powers-Law Transformations

In Power Law (Gamma) transformation the relation between pixel values of f(x, y) and g(x, y) in this transformation is given by

$s = cr^{\gamma}$

where c and γ are positive constants. If $\gamma < 1$ 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.5.

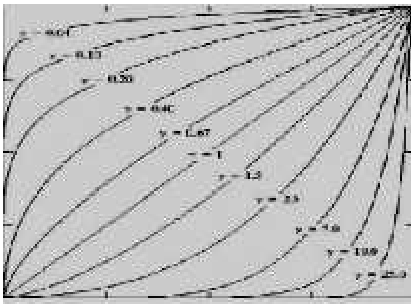


Fig 5. γth power and γth root curves for c=1.

2.2 Piecewise Linear Transformations

2.2.1 Contrast Stretching

It 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.

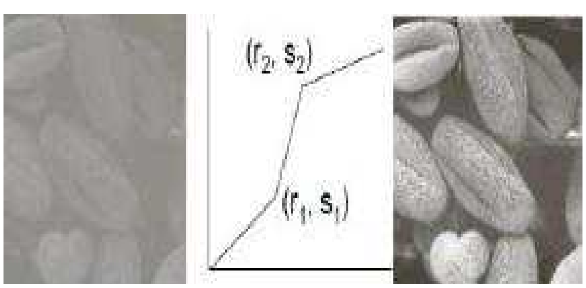


Fig. 6 Original image and its stretched image

2.2.2 Grey Level Slicing

Grey level slicing [5] is the spatial domain equivalent to band-pass filtering. A grey level slicing function can either emphasize a group of intensities and diminish all others or it can emphasize a group of grey levels and leave the rest alone. Example is shown in the following figure

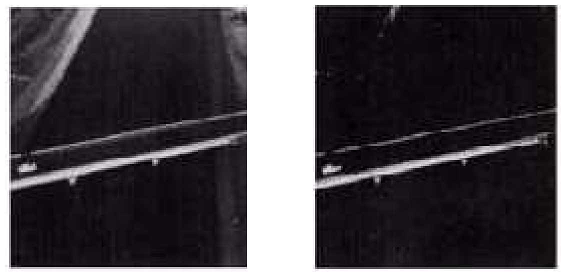


Fig 7. Showing example of Grey level slicing

2.2.3 Bit plane slicing

Instead of highlightning grey level ranges, highlightning the contribution made to total image appearance by specific bits might be desired. Suppose that each pixel in an image is represented by eight bits. Imagine that the image is composed of eight one bit planes, ranging from bit plane zero for the least significant bit to bit plane 7 for the most significant bit. In terms of eight bit bytes, plane zero contain all the lowest order bits in the bytes comprising the pixel in the image and plane 7 contains all the high order bits.

3. Histogram Processing

Histogram processing is used in image enhancement the information inherent in histogram can also used in other image processing application such as image segmentation and image compression. A histogram simply plots the frequency at which each grey-level occurs from 0 (black) to 255 (white). Histogram processing should be the initial step in preprocessing. To produce a much better image histogram equalization and histogram specification (matching) are two methods widely used to modify the histogram of an image. The histogram is a discrete function that represents the frequency of occurrence of all gray-level in the image, that means it tell us how the values of individual pixel in an image are distributed. Histogram is given as-

$$h(r_k) = n_k / N$$

Where r_k and n_k are intensity level and number of pixels in image with intensity r_k respectively.

3.1 Histogram Equalization

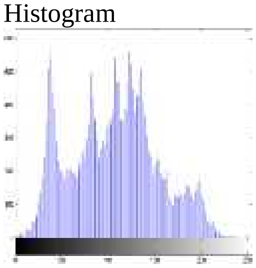
Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer. Histogram equalization involves finding a grey scale transformation function that creates an output image with a uniform histogram (or nearly so). How do we determine this grey scale transformation function? Assume our grey levels are continuous and have been normalized to lie between 0 and 1. We must find a transformation T that maps grey values r in the input image F to grey values s = T(r) in the transformed image ^ F. It is assumed that

- T is single valued and monotonically increasing, and
- 0 <= T(r) <=1 for 0 <= r <= 1.

Original image

Equalized image

Histogram



Equalized histogram

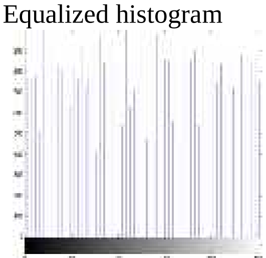


Fig 8. The original image and its histogram and the equalized versions.

3.2 Histogram Matching

Histogram equalization [7] automatically determines a transformation function seeking to produce an output image with a uniform histogram. Another method is to generate an image having a specified histogram is histogram matching.

1. Find the histogram *pr*(*r*) of the input image and determine its equalization transformation

$$s = T(R) = (L-1)\int_0^r p_r(w)dw$$

2. Use the specified pdf $p_z(r)$ of the output image to obtain the transformation function:

$$G(z)=(L-1)\int_0^z p_z(t)dt = s$$

3. Find the inverse transformation *z* = *G-1*(*s*) – the mapping from *s* to *z:*

$$Z= G^{-1}[T(r)]=G^{-1}(s)$$

4. Obtain the output image by equalizing the input image first; then for each pixel in the equalized image, perform the inverse mapping to obtain the corresponding pixel of the output image.

3.3 Local Enhancement

Previous methods of histogram equalizations and histogram matching are global. So, local enhancement [6] is used. Define square or rectangular neighborhood (mask) and move the center from pixel to pixel. For each neighborhood, calculate histogram of the points in the neighborhood. Obtain histogram equalization/specification function. Map gray level of pixel centered in neighborhood. It can use new pixel values and previous histogram to calculate next histogram.

5. 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 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 in spatial domain only. 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. Despite the effectiveness of each of these algorithms when applied separately, in practice one has to devise a combination of such methods to achieve more effective image enhancement.

6. References

accomplished and is one of the most important and

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