

A Survey of Various Digital Images Enhancement Methods Using Piecewise-Linear Transformation

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Abstract: This paper presents a survey of various digital images enhancement methods using piecewise-linear transformation. Images enhancement is process that the output images more suitable than the original. Images enhancement has very applications, for example medical images, images captured in remote sensing, images from satellite etc. The primary condition for image enhancement is that the information you want to restore must exist in the original image. Piecewise linear transformation would divide the image into triangular regions. Each triangular region in the target image would be mapped to its corresponding triangular region in the reference image using a linear transformation.

Keywords: Images enhancement, piecewise-linear transformation, digital image processing, Contrasts stretching and intensity level.

مسح لطرق تحسين الصور الرقمية المختلفة باستخدام التحويل الخطي المتقطع

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المستخلص

تقدم هذه الورقة مسحا لطرق تحسين الصور الرقمية المختلفة باستخدام التحويل الخطي المتقطع. تحسين الصور هو عملية تكون فيها الصور الناتجة أكثر ملاءمة من الصورة الأصلية. تحسين الصورة له تطبيقات كثيرة ، على سبيل المثال الصور الطبية ، الصور الملتقطة في الإستشعار عن بعد ، الصور من الأقمار الصناعية وما إلى ذلك. الشرط الأساسي لتحسين الصورة هو أن المعلومات التي تريد إستعادتها يجب أن تكون موجودة في الصورة الأصلية. التحويل الخطي المتقطع يقسم الصورة إلى مناطق مثلثة ، سيتم تعيين كل منطقة مثلثة في الصورة المستهدفة إلى منطقتها المثلثية المقابلة في الصورة المرجعية باستخدام تحويل خطي.

الكلمات المفتاحية: تحسين الصور ، التحويل الخطي المتقطع ، معالجة الصور الرقمية ، تمدد التباين ومستوي الكثافة.

1. Introduction

The image enhancement is an important stage in the image processing domain [15].

Image enhancement is one of the classic problems in image processing and pattern recognition [17]. Many images like medical images, satellite images, aerial images and also real life photographs suffer from poor and bad contrast and noise [6]. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in medical images detection and analysis is image enhancement techniques. It improves the clarity of images for human viewing, removing blurring and noise, increasing contrast, and revealing details [6]. The digital images will be considered as a set of pixels [13]. There are a large number of applications of image processing in diverse spectrum of human activities, from remotely sensed scene interpretation to biomedical image interpretation [18]. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images [7] and [10]. The main aim of image enhancement is to enhance the quality and visual appearance of an image or to provide a better transform representation for future automated image processing [6] and [14]. The Purposes of digital image processing is an area characterized by the need for extensive experimental work to establish the viability of proposed solutions to a given problem [11]. The digital image processing has multiple purposes [19]:

- To improve the quality of an image in a subjective way, usually by increasing its contrast. This is *called image enhancement*.
- To use as few bits as possible to represent the image, with minimum deterioration in its quality. This is called *image compression*.
- To improve an image in an objective way, for example by reducing its noise or blurring. This is called *image restoration*.
- To make explicit certain characteristics of the image this can be used to identify the contents of the image. This is called *feature extraction*.

Image enhancement is a very important process used for enhancing the quality of an image [2]. Spatial domain refers to the two-dimensional image plane in terms of pixel intensities [19] and [21].

Perform image processing by using image transformation. Image transformation is performed using operators. An operator takes as input an image and produces another image. Image enhancement is the process of editing an image in order to make it better for a human viewer for a particular application. This involves smoothing or sharpening image contents [16]. Image enhancement used to improve the picture or vision of information in images for observer and to provide better input for other image technique or method as Piecewise-Linear Transformation [3].

2. Image enhancement techniques

Image enhancement refers to the process of highlighting certain information of an image, as well as weakening or removing any unnecessary information according to specific needs. Image enhancement techniques can be divided into two broad categories:

2.1 Image enhancement in spatial domain

The term spatial domain refers to the image plane itself, and methods in this category are based on direct manipulation of pixels in an image [4], [9] and [11]. Spatial domain method, directly process image pixels for the enhancement [1].

$$g(x, y) = T[f(x, y)] \quad (1)$$

Where $f(x, y)$ is the input image, $g(x, y)$ is the output image and T is an operator on f defined over a neighborhood of point (x, y) [11]. The operator can apply to a single image or a set of images. The process that figure 1, illustrates consists of moving the origin of the neighborhood from pixel to pixel and applying the operator T to the pixels in the neighborhood to yield the output at that location [20].

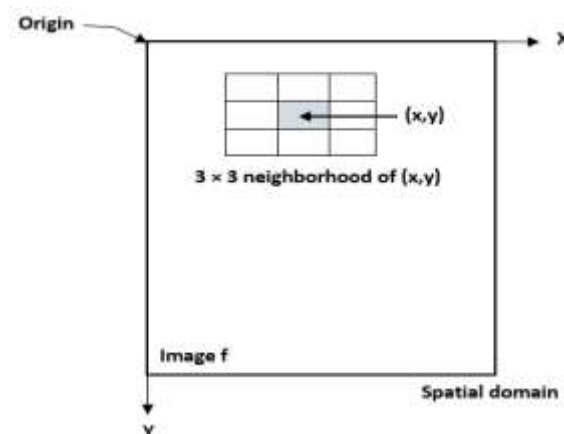


Figure 1. A 3x3 neighborhood about point (x,y)

2.2 Image enhancement in frequency domain

Image enhancement in the frequency domain is straightforward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter (rather than convolve in the spatial domain), and take the inverse transform to produce the enhanced image [8].

3. Piecewise-Linear Transformation Methods

Piecewise-linear transformation is type of gray level transformation that is used for image enhancement. It is method to divides images into regions by triangulation. Using a set of corresponding control points from two images, the control points in reference image are triangulated by Delaunay triangulation. Delaunay triangulation is a set of lines connecting each point from a set of given points to its natural neighbors [5]. Piecewise-linear transformation is gray level transformation, those non-linear transformation which are applied to input image pixels based on some criteria. It is a spatial domain method. It is used for manipulation of an image so that the result is more suitable than the original image for specific application. For the same image pixels, the transformation applied can be different. There are various piecewise linear image transformation some are [12] and [16]:

3.1 Contrast Stretching

A contrast stretching is simple image enhancement methods that improve the contrast in an image by ‘stretching’ the range of intensity values it contain to span a desired range of values; it uses linear scaling function [12]. Low contrast image occur often due to improper illumination or non-linearly or small dynamic range of an imaging sensor. Contrast is difference between the highest gray level and lowest gray level of image. Low contrast images can result from poor illuminations, lack of dynamic range in the imaging sensor, or even the wrong setting of a lens aperture during image acquisition. Contrast stretching is a process that expands the range of intensity levels in an image so that it spans the full intensity range of the recording medium or display device [12]. T becomes an intensity transformation function (gray level or mapping function of the form.

$$S = T(r) \tag{2}$$

Where: $r = \text{gray level of } f(x,y)$ and $S = \text{gray level of } g(x,y)$.

Contrast stretching transform is given by:

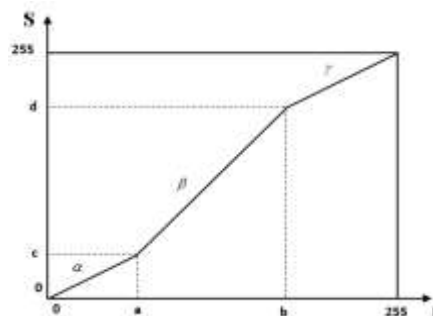


Figure 2. Piecewise Linear Transformation Function.

$$s = \left(\frac{S_{\max} - S_{\min}}{r_{\max} - r_{\min}} \right) * (r - r_{\min}) + S_{\min} \tag{3}$$

- $c = a$ and $d = b$ (Identity transformation, no change in image).
- $a = b, c = 0,$ and $d = 255$ (Thresholding function-image converted to black and white).
- Intermediate value of (a,c) and (b,d) produced various degree of spread in the intensity level of the output image.

$$\alpha = \frac{c - 0}{a - 0}, \quad \beta = \frac{d - c}{b - a} \quad \text{and} \quad \gamma = \frac{255 - d}{255 - b} \tag{4}$$

A formulation is given below:

$$S = \begin{cases} \alpha * r & 0 \leq r < a \\ \beta * (r - a) + c & a \leq r < b \\ \gamma * (r - b) + d & b \leq r < 255 \end{cases} \tag{5}$$

Where: α, β and γ are slopes.

Clipping: A special case of contrast stretching is clipping. It is used for noise reduction when the input signal is known. It puts all gray levels below ‘a’ to black (0) and above ‘b’ to white (1).

$$S = (0.5) * (r - 0) + 0 \tag{5.1}$$

Thresholding: Another special case of contrast stretching. It is also used for noise reduction. Produce a two-level (binary image, a mapping of the form called Thresholding function.

$$S = (2) * (r - LT) + (0.5 * LT) \tag{5.2}$$

Gray level slicing: Highlighting a specific range of gray level in an image.

- Case-I:
 - To display a high value for all gray levels in the range of interest.
 - To display a low value for all gray levels.
- Case-II:
 - Brighten the desired range of gray level.
 - Preserve the background quality in the range.

$$S = (0.5) * (r - UT) + (0.5 * LT) + 2 * (UT - LT) \tag{5.3}$$

See in figure 3, piecewise linear transformation function.

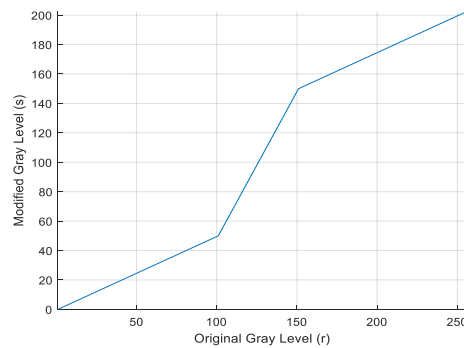


Figure 3. Transformation Function of Contrast Stretching.

The contrast stretching image for the transformation functions above as shown in figure 4, below.

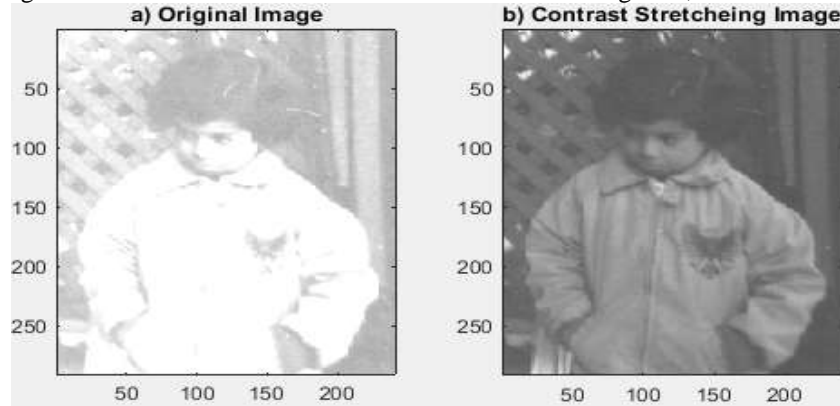


Figure 4. Contrast Stretching Image.

3.2 Intensity Level Slicing

The goal is to highlight the contribution made to the image's appearance by specific bits. Highlighting a specific range of intensities in an image often is of interest. This transformation shown in figure 5, it can implement two approaches [12]:

1. Highlighting the intensities in a defined range $[A, B]$ and reducing all other intensities to a lower level.
2. Highlighting the intensities in a defined range $[A, B]$ and preserving all other intensities.

a) Reducing Intensities to a Lower Levels. b) Preserves All Other Intensity Levels.

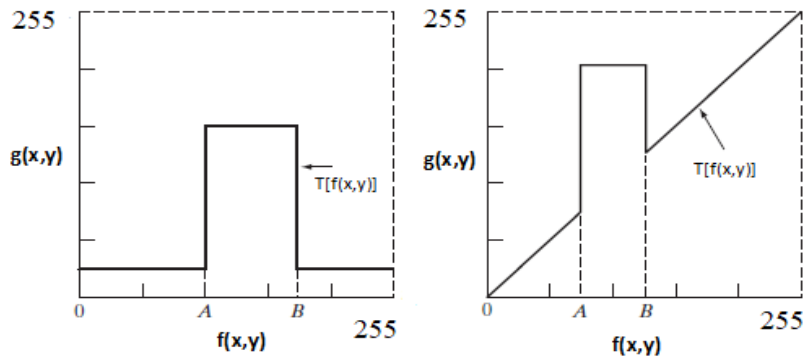


Figure 5. Highlights Intensity Range [A, B].

One approach is to display a high value for all gray levels in the range of interest and a low value for all other gray levels. As shown in figure 7.

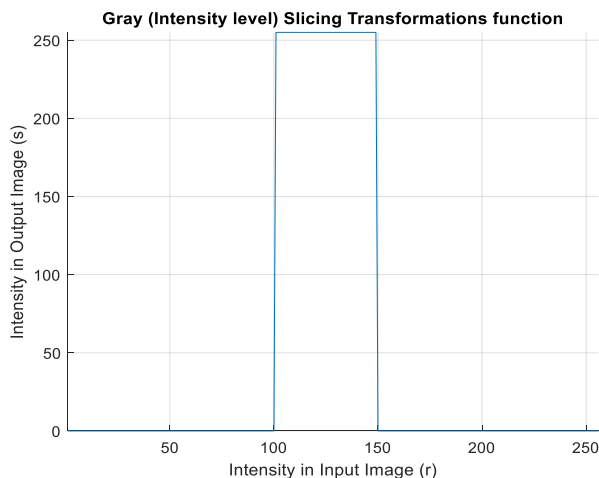


Figure 6. Transformation Function (Case-I).



Figure 7. Intensity Level Slicing (Case-I).

The second approach, based on the transformation brightens the desired range of gray levels but preserves gray levels unchanged. As shown in figure 9.

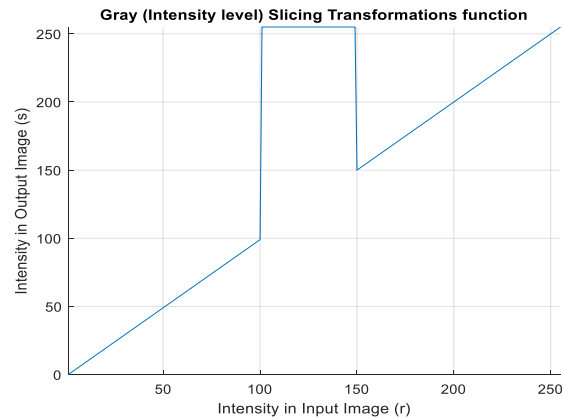


Figure 8. Transformation Function (Case-II).

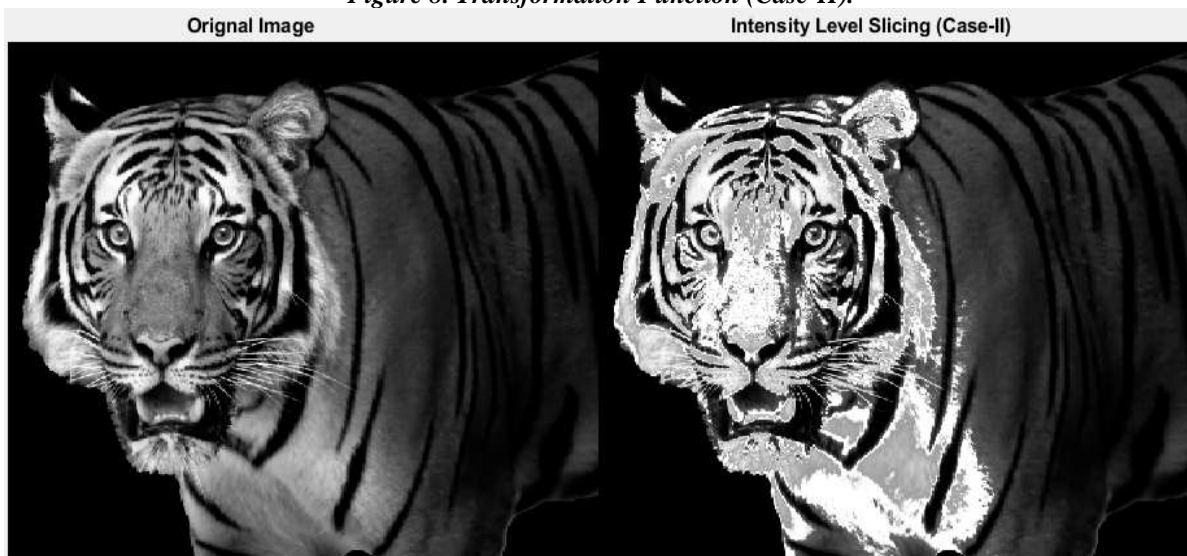


Figure 9. Intensity Level Slicing (Case-II).

3.3 Bit-plane slicing

Bit plane slicing is a method of representing an image with one or more bits of the byte used for each pixel. One can use only MSB to represent the pixel, which reduces the original gray level to a binary image. The main goal of bit plane slicing is to converting a gray level image to a binary image. This technique is useful for image compression and steganography.

The gray level of each pixel in a digital image is stored as one or more bytes in a computer. Pixels are digital numbers composed of bits. 256 gray scale image is composed of 8 bit. Instead of highlighting intensity level range we could highlight the contribution made to total image appearance by specific bits. 8 bit image may be considered as being composed of eight 1 bit plane, with plane 1 containing the lowest order bit of all pixels in the image and plane 8 all the highest-order bits. The result as shown in figure 11.

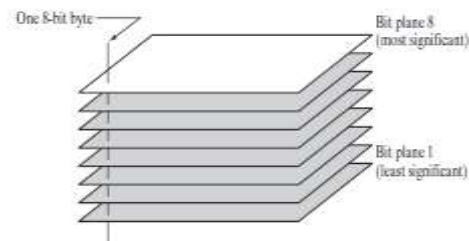


Figure 10. Bit-plane representation of an 8-bit image.

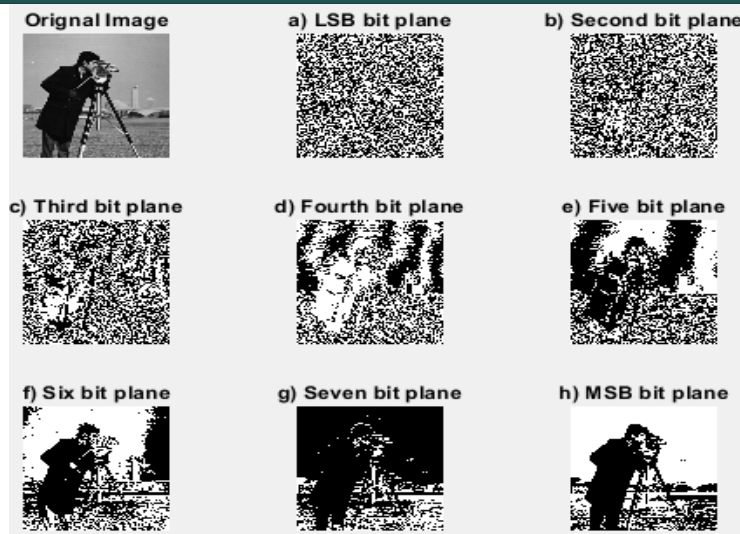


Figure 11. Bit-plane slicing.

4. Results and Discussion

In this paper digital image enhancement using piecewise-linear transformation method discussed.

In figure 4, shows a typical transformation used for contrast stretching. The locations of points (r_0, s_0) , (r_1, s_1) , (r_2, s_2) and (r_3, s_3) control the shape of the transformation function. If $r_1 = s_1$ and $r_2 = s_2$ the transformation is a linear function that produces no changes in intensity levels. If $r_1 = r_2$, $s_1 = 0$ and $s_2 = 255$, the transformation becomes a thresholding function that creates a binary image. In general $r_1 \leq r_2$ and $s_1 \leq s_2$ is assumed so that the function is single valued and monotonically increasing. This condition preserves the order of intensity levels, thus preventing the creation of intensity artifacts in the processed image. In figure 7, apply intensity level slicing in MATLAB to read tiger image, then if the pixel intensity in the old image is between (100–150) convert it in the new image into 255 (white). Otherwise convert it to 0 (black). And figure 9 shows apply intensity level slicing in MATLAB to read tiger image, then if the pixel intensity in the old image is between (100–150) convert it in the new image into 255 (white). Otherwise it leaves it the same. In figure (11), shows the bit planes of an 8-bit gray-scale image of ascending from the least significant bit to the most significant bit. It is apparent that the two or three least significant bits do not encode much useful visual information (it is, in fact, mostly noise). Figure 11(a), shows LSB bit plane gray-scale image, figure 11(b), second bit plane, figure 11(c), third bit plane, figure 11(d), fourth bit plane, figure 11(e), fifth bit plane, figure 11(f), sixth bit plane, figure 11(g), seventh bit plane, figure 11(h), MSB bit plane.

5. Conclusion

This paper has discussed results various digital images enhancement of piecewise-linear transformation methods, to improve the graphical appearance and image features. Piecewise-linear transformation which is applied to input image pixels based on some criteria. The output of each method showed that improving the contrast of gray level image with higher intensity value. Image enhancement techniques include sharpening, smoothing, highlighting features or normalizing illumination for display or analysis. Enhancement method are either used as a preprocessing step to other imaging tasks or post-processing to create a more visually describe image.

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