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Comparative Study Of Image Enhancement In Spatial Domain

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Abstract :A comparative study of image enhancement in spatial domain is undertaken to access their usefulness. By applying the different transformations on certain images it was found that the usefulness of the particular transformation depends on the different type of image to be enhanced.

Keywords : **Comparison of point transformations, Image enhancement, Spatial domain.**

Introduction The word image has evolved from the Latin word 'imago'[1]. In information technology an image is a visual representation of an object which has been created or copied and stored in electronic form.
An image can be described in terms of two dimensional function f(x,y), where x and y are spatial(plane) coordinates and the value of the function f(x,y) represent the amplitude or intensity or gray level of the image at that point. If the coordinates (x,y) and the amplitude can be described in finite and discrete quantities, it can be called as a digital image.

The aim or objective of image pre processing or image enhancement is to improve the interpretability and quality of the image so that further analysis or work on the image becomes more reliable.

Image enhancement techniques can be divided into two broad categories

1. Spatial domain methods, and
2. Frequency domain methods,

Spatial domain refers to the aggregate of pixels comprising an image. Spatial Domain methods are those which operate directly on pixels to achieve desired enhancement. Spatial Domain

Processes are denoted by the expression

$g(x,y) = T [f (x,y)]$ where

f(x,y) is the input image

g(x,y) is the processed image and T is the transformation applied .
For Grey level transformation it can be simplified as

s = T (r) , where r is the grey level of the original image and s is the grey level of the processed image.

Frequency Domain methods operate on the Fourier transform of an image in frequency domain.

Image enhancement techniques in Spatial Domain

Some important image enhancement techniques in spatial domains for greyscale images are

1. Point Transformation Operation
2. Spatial Filter Operations
3. Histogram Processing operation

Point transformation Operation

Here work is done on a single pixel i.e T is a 1 X 1 operator. The new image obtained depends on transform function T and original image.

Point transformation can be subdivided broadly as follows:-

a) Linear Point Transformation
b) Non-linear point transformations
c) Piecewise Linear Transformation

Linear Point Transformation

In Linear Point Transformation the relationship between input variables and output variables is linear. Identity and Inversion are two basic type of Linear point Transformation.

Identity Transformation

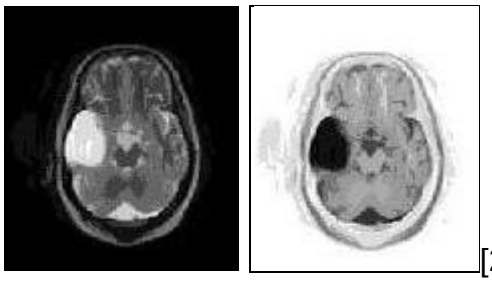
It does not modify the input image, the output intensities are identical to input intensities. Mathematically it can be written as

s = r

Inversion

This is one of the important linear point transformation, which performs a digital negative operation by inverting the grey level values. Mathematically it can be written as

s = L – 1 – r where the range of the image is from 0 to L-1



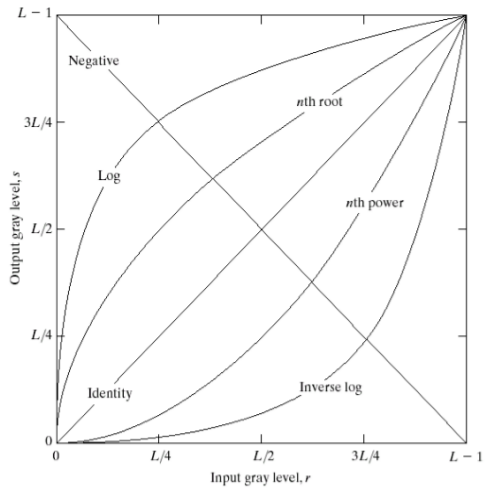
[2]

Fig 1 .(a) (b)
(a)Original image
(b) Inversion or negative image

Non-Linear point Transformation

In Non-Linear Point transformation the relationship between input variables and output variables is not linear The important Non-Linear point transform are

Logarithmic Function
Square Function
Exponential Function
Power Function

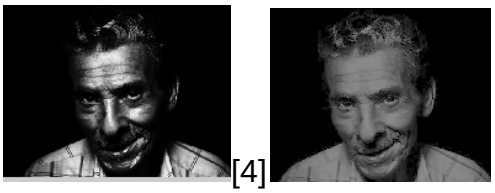


[3]

Fig 2. Some Basic Grey Level Transformation Function

Logarithmic Function or Log Transformation

The logarithmic function is given as
s = c log(1+ r), c is a constant and r>=0.
It increases the dynamic range of the dark region and reduces that of lighter region.



[4]

Fig 3 (a) (b)
(a) Original image
(b) Logarithmic image with c = .1

Square Function

To enhance the contrast of an image this function can be used..If the pixel values crosses the limit of the data type of the image the result is a whitened or saturated image.

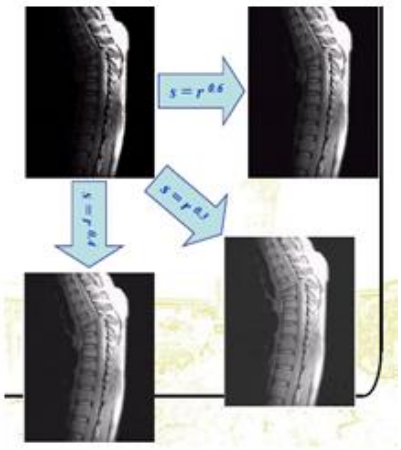
Fig 4 (a) (b)
(a) Original image
(b) Logarithmic image with c = .1

Exponential Function

This is the reverse of the logarithmic function. Here the dynamic range in the low value region is decreased and the details in high value regions is increased.

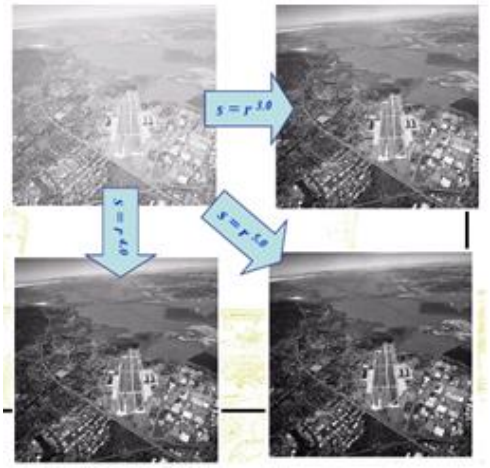
Power Law Transformations

This can be written as $s= cr^{\gamma}$ where c and γ are positive constants. Power Law Transformation are useful for general purpose contrast manipulation



[5]

Fig 5 MR image of a fractured of spine and the transformations with different values of Y(<1) to highlight the image.



[6]

Fig 6. Aerial images of a runway and the transformations with different values of ϒ(>1) to darken the image.

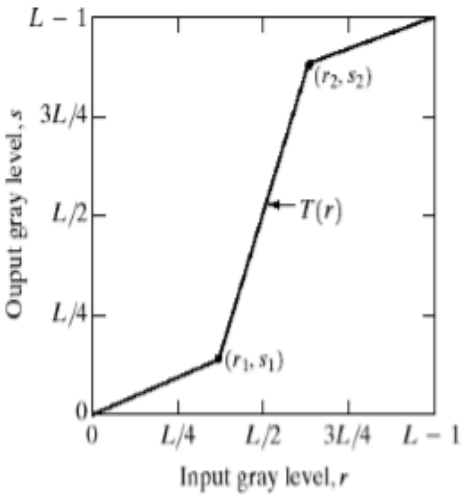
Piecewise Linear Transform

To manipulate the contrast of images this function is used. The advantage of this transformation is that it uses simple functions for representing complex function but it requires many input parameters from the user. Some of the important piecewise linear transform function are

Contrast Stretching
Intensity Slicing
Bit-plane Slicing

Contrast Stretching

Due to poor illumination or some problem with imaging sensor the resultant image is of low contrast. Contrast stretching increases the dynamic range of the image.



[7]

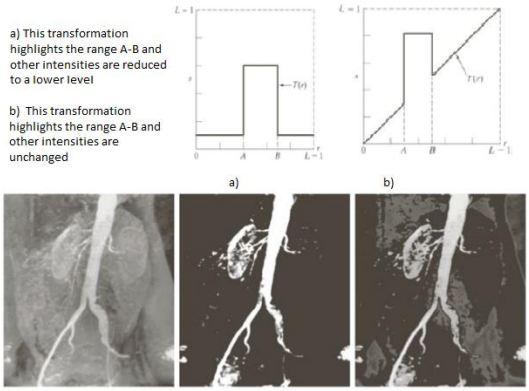
Fig 7. Different slopes of piecewise linear transformation

If slope >1, o/p grey level is stretched and for slope <1, grey level is compressed.

Fig 8 (a) (b)
(a) Low Contrast original Image
(b) Enhanced Image after contrast stretching

Intensity Slicing

Sometimes a particular frequency of the image is needed to be highlighted. The particular frequency is highlighted and reduces others to a constant level or others are kept unchanged.

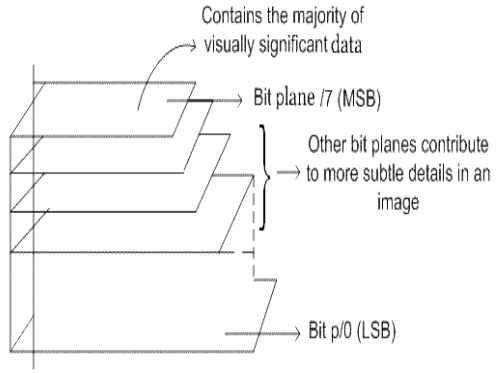


[8]

Fig 9: Aortic Angiogram and slicing transformation without and with the background preserved.

Bit-Plane Slicing

A digital image is expressed in pixels which is further represented in bits, In grey level image is pixel is represented by 8 bits. Sometimes highlighting the contribution made to the image by specific bits is also needed. The image can be imagined as composed of 8,1 bit planes ranging from Bit plane 0(LSB) to Bit plane 7(MSB). Separating a image into its bit planes is done for analysing the relative importance of each bit.



[9]

Fig 10. Bit planes showing importance of the individual bit planes.

TABLE I : Comparison of different nonlinear point transformation function

Logarithmic	Power Law	Square
Useful when low value pixels are to be enhanced. If most of the picture contains higher pixel value information is lost and not useful	Useful for contrast manipulation. In case of a dark image the expansion of grey levels is done with Ɣ value <1. In case of a washed out type of image compression of image is done with Ɣ>1	It is used to enhance the contrast of an image but sometimes this function results in whitening of the image

TABLE II : Comparison of different piecewise linear point transformation function

Contrast stretching	Intensity Slicing	Bit plane slicing
In contrast stretching by controlling the parameters of the function the dark region can be made darker and	To enhance the intensity of a particular region of an image Intensity slicing is used	A digital image is separated into it's bit planes. This is useful to find the relative importance of each bit of the image and helps in

the bright region brighter		image compression.

Conclusion :

In this work different transformation method have been compared to study their usefulness in image processing . It was observed that Inversion is useful for enhancing white or grey detail embedded in dark region. Logarithmic transformation can be used if majority of the image is dark. If the image has a washed-out appearance, Power Law Transformation can be used. Contrast stretching is useful if the image is of low contrast.

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