Comparison of Contrast Enhancement Technique with Partitioned Iterated Function System

K.Nithya, Mr.K.Karthik, Dr.K.Ramasamy

Abstract— Contrast enhancement is essential in cases where substandard quality images are acquired.In many research fields such as remote sensing, medical image analysis etc., the acquisition of digital image with sufficient contrast and detail is a strong requirement.The ultimate aim of image enhancement is to improve the interpretability and perception of information in image for human viewers.The most popular methods for contrast enhancement includes histogram adjustment, unsharp-masking, homomorphic processing and adaptive modification of the local contrast and local luminance mean. Histogram adjustment and unsharp masking are conceptually and computationally simple technique, which can often provide significant improvement in image quality to the human observer. However these methods also enhance noise that is present within the image. On the other hand unsharp masking enhances strong edges of the image resulting in overshoot artifacts on the output image. Several approaches have been proposed for coping with aforementioned problems, including adaptive histogram equalization, adaptive unsharp masking, nonlinear unsharp masking, adaptive nonlinear filters etc.This project introduces a novel method for contrast enhancement based on the theory of partitioned iterated function systems. The objective of proposed algorithm is to provide strong contrast enhancement by increasing the mean contrast measurement of the enhanced image, and the obtained results are compared with four other contrast enhancement methods namely linear unsharp masking(Linear UM), histogram equalization(HE), contrast stretching(CS), and contrast limited adaptive histogram equalization(CLAHE).

Index Terms—Contrast enhancement, Contrast stetching, Contrast limited adaptive histogram equalization, Histogram equalization Linear unsharp masking, Mean contrast measurement, Overshoot artifacts, Partitioned Iterated Function System.

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1 INTRODUCTION

CONTRAST is the difference in visual properties that makes an object distinguishable from other objects and the background. For human perception, contrast is determined by the difference in the colour and brightness of the object and other objects within the same field of view. Contrast enhancement are especially used for medical image, low contrast image are widely used in variety of medical images like radiography, computed tomography (CT), magnetic resonance(MR), mammography, ultrasound, angiography and nuclear medicine[1]. Obtaining high contrast in most of the images give high cost in examination time.

Image enhancement is to improve the interpretability and perception of information in images for human viewers. It is divided into two broad categories: spatial domain methods and frequency domain methods. Spatial domain methods operate directly on the pixels of the input image, while frequency domain methods operate on the fourier transform of the image. Linear contrast stretching and histogram equalization are two widely used methods for global image enhancement. Linear contrast stretching, linearly adjusts an image's dynamic range, and uses the input-to-output mapping relation obtained from the image histogram. These methods are not used in local enhancement but it is used in global histogram equalization(GHE)[2][6].Fractal based Image compression using iterated function system(IFS), it is used to determine the set of con-

tractive affine transformations, once it is obtained then the rest is an iterative sequence to produce attractor, here the main problem is to find appropriate attractor for that purpose image compression is enough to store the relevant parameters of the said transformations instead of the whole image[3]. This technique is known as partitioned iterated function system (PIFS)

In block based transformation[4][7], image transformations used are not fixed-size square block-based transformations but region-based transformations, where the regions can be large and irregularly shaped segments of the image here it uses Heuristic algorithm.

2 EXISTING METHOD

The existing method has four commonly used contrast enhancement methods such as linear unsharp masking, histogram equalization, contrast stretching, and contrast limited adaptive histogram equalization. All these methods are compared with proposed method.

2.1 Linear Unsharp Masking

Linear unsharp mask filtering enhances diagnostic information by subtracting it from the original image, the linear blur was formed in the direction of the linear tomographic movement. Unsharp masking (USM) is an image sharpening technique. It uses unsharp positive image to create a mask of the original image, then this unsharped mask image is then combined with the negative image, creating an image that is less blurry than the original. The resulting image produce may be clearer, may be a less accurate representation of the image. The total amount of blurring can be controlled by changing the softness or hardness of the light source used for the initial input image. The strength of the effect can be

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- *K.Nithya is currently pursuing masters degree program in computer and communication engineering in P.S.R.Rengasamy college of engineering for women, Sivakasi, E-mail: puraniengr@gmail.com*
- *K.Karthik is currently working as a assistant professor in P.S.R.Rengasamy college of engineering for women,Sivakasi,E-mail: karthik1312g@gmail.com*
- *K.Ramasamy is currently working as a principal in P.S.R.Rengasamy college of engineering for women,Sivakasi,E-mail: ramasamy@psrr.edu.in*

controlled by changing the contrast and density of the unsharp mask.

Linear filters consist of a matrix with values and a gain factor when considering a linear filter of size 3x3, the 9 matrix values are multiplied with 9 pixel values in the input raster map, and this is summed and then multiplied with the gain factor. Linear means that the output for the obtained for the images separately this procedure is known as linear filtering. The disadvantage of this method, it gives less contrast and image appears overshoot artifacts.

2.2 Histogram Equalization

The Histogram equalization enhances the contrast of images by transforming the values in an intensity image so that the histogram of the output image approximately matches a specified histogram. It is a method that improves the contrast in an image, in order to stretch out the intensity range. Equalization means mapping one distribution (the given histogram) to another distribution (a wider and more uniform distribution of intensity values) so the intensity values are spread over the whole range.

Histogram equalization is one of the common tools for improving contrast in digital photography, remote sensing, medical imaging, and scientific visualization. It is a process for recovering lost contrast in an image by remapping the brightness values in such a way that equalizes or more evenly distributes its brightness values. HE often falls short to maintain the image quality after enhancement due to quantum jump in the cumulative distribution function (CDF) in the histogram. Moreover some detail parts appear to be wasted out after enhancement. HE, which enhance the image details parts separately and combine it with the enhanced image using weighted function. The disadvantages of this method is output is sometimes over enhanced and some information is lost in some area where there is a quantum jump occurs in the CDF.

2.3 Contrast Limited Adaptive Histogram Equalization

It operates on small regions in the image, called as tiles, rather than the entire image. Each tiles of the image are enhanced, so that the histogram of the output region approximately matches the histogram specified by the distribution parameter. The neighbouring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited to avoid amplifying any noise that might be present in the image. It partitions the images into contextual regions and applies the histogram equalization to each one of the histogram image to get contrast enhanced image.

CLAHE an improved version of AHE, or Adaptive Histogram Equalization, both overcome the limitations of standard histogram equalization. Noise can be reduced while maintaining the high spatial frequency content of the image by applying a combination of CLAHE, median filtration and edge sharpening. The advantage of CLAHE is to prevent the over amplification of noise, it is able to increase contrast. The disadvantages of this method is operates only on small region, quite complex and expensive.

2.4 Contrast Stretching

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by stretching the range of intensity values. It differs from other histogram equalization in that it can only apply a linear scaling function to the image pixel values. As a result the enhancement is less harsh. (Most implementations accept a gray level image as input and produce another gray level image as output.). Before the stretching can be performed it is necessary to specify the upper and lower pixel value limits over which the image is to be normalized. Often these limits will just be the minimum and maximum pixel values that the image type allows.

One of the simplest piecewise linear function is a contrast stretching transformation.Low contrast images can result from poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed. The disadvantage of this method is, if the original range covers the full possible set of values straightforward contrast stretching will achieve nothing, but even then sometimes most of the image data is contained within a restricted range; this restricted range can be stretched linearly, with original values which lie outside the range being set to the appropriate limit of the extended output range.

3 PROPOSED METHOD

3.1 Fundamental concept of PIFS

This paper introduces PIFS algorithm to find parts of an image that are properly transformed to provide strong contrast enhancement, by means of increasing the mean contrast measurement of the enhanced image, without affecting the information stored in the original image. PIFS consists of contractive transformation, each transformation has spatial and intensity components. The transformation of the gray levels is determined by two parameters which adjust the brightness and contrast of the transformed block.

Partitioned Iterated Function System (PIFS) is used to create a low pass version of the original image. It is to represent a gray-level image using a series of contractive transforms. Each transform has a spatial component and an intensity component and affects a region (usually a square block) of the image.In first, the original image is partitioned into small blocks usually of square size called range block. A second, the original image is partitioned into larger blocks usually of double size called domain blocks. To define contractive block transformation, each transformation shuffles the positions of the pixels in a domain block and alters the gray levels of the pixels in the block. An image is contractive if and only if it brings every pair of pixels in a block both closer spatially and in value. For each range block, a domain block and a transformation are found then after transformed domain block best matches the range block, under the least squares sense.

The parameters of each transform are obtained by minimization process. Minimization process refers to block classification techniques or nearest neighbor techniques, this is used to reduce the large search space in the transformed domain

block. Then, the gray-level values of each range block are calculated by properly transforming the gray-level values of the pixels in the corresponding domain block.

The contrast-enhanced image is obtained by adding the difference of the original image with its low pass version, to the original image. It uses constant value for the contrast parameter for adjusting the brightness of the image, and it is calculated using k-dimensional trees. The low pass version of the original image is obtained by applying the PIFS on the original image repeatedly while keeping the contrast parameter that is lower than the previous one. The performance of the PIFS has been compared with four other methods of contrast enhancement such as linear unsharp masking, histogram equalization, contrast stretching, and contrast limited adaptive histogram equalization. PIFS gives quality]]ative and quantitative comparative results show advantageous performance than the other.

3.2 Enhancement Algorithm

• Im(x, y) denote original gray-level image.

- • *Size=$M_x \times M_y$.*

- • *S = [(0, M_x) × (0, M_y)].*

- •*M_x, M_y are intensity value of the input image.*

• Original gray level image is partitioned into two blocks:-

- • Non overlapping range blocks:-

  - • *$A_{i,j}=[x_i, x_i + v_x) \times [y_j, y_j+v_y)$*

  - • *Size=$v_x \times v_y$ pixel.*

  - • *$X_i = iv_x$ (i=0, 1,….., M_x/v_x-1).*

  - • *$Y_j = jv_y$ (j=0, 1,….., M_y/v_y-1).*

  - • *P=$U_{i,j}$ $B_{i,j}$-Pixel value vector*   (1)

- •Overlapping domain blocks:-

  - • *$B_{k,l}=[u_k, u_k + 2v_x) \times [w_l, w_l+ 2v_y)$*

  - • *Size=$2v_x \times 2v_y$ pixel.*

  - • *$U_k = kh_x$ (k=0,1,…..).*

  - • *$W_l = lh_y$ (j=0,1,…..).*   (2)

  - • *h_x, h_y are horizontal and vertical distance between neighbouring domain blocks.*

• Each domain block is down sampled by a factor of two.

- • Average pixel values of each distinct is 2×2 sub blocks.

- •Squared Euclidean distance:

  $S(k,l;i,j)=\| \beta_{k,l} (b_{k,l} - \mu_{Bk,l}) -(a_{k,l} - \mu_{Ai,j}) \|^2$

  (3)

$\mu_{Ai,j}$ - Mean pixel value for range block.
$\mu_{Bk,l}$ - Mean pixel value for sub sampled domain block.

•Using a predefined constant value for a contrast parameter:

$$\beta_{k,l} (\beta_{k,l} = \beta)$$

$$S(k,l;i,j)=\| \beta(b_{k,l} - \mu_{Bk,l}) -(a_{k,l} - \mu_{Ai,j}) \|^2$$

This minimization function gives large search space for selecting proper domain block.

• The search space is significantly reduced by KD Tree:-

• KD tree is a space partitioning data structure for organizing points in kd space.

• The sub sampled domain blocks are arranged properly as tree's nodes.

• The best match for range block is then allocated by searching the tree using the nearest neighbour algorithm.

– Parameter for each block transformation is obtained.

• Global contractive transformation:-

It is defined by:

$$K(I)(x,y)= \sum_{i,j} [\beta(Im(2(x-x_i)+u_{k(i,j)},2(y-y_j)+w_{l(i,j)})-Bk(i,j),l(i,j))+$$

$$\mu_{Ai,j} Q_{i,j}(x,y) \qquad (4)$$

$$Q_{i,j}(x,y) =\{1,(x,y) \in A_{i,j}$$

$$\{0,(x,y) \notin A_{i,j} \text{ and } (k(i,j),l(i,j))=argmin\{S(k,l;i,j)\}$$

• To achieve contrast gain:-

• Image is coded with high value parameter Eq(4) β=0.8.

• Decoded image is created by reapplying Eq(4) with lower value β=0.1.

• The resulting image is low pass version of original image

• The high pass image is obtained by:

$$I_{HP}(x, y) = Im(x, y) - I_{LP}(x, y) \qquad (5)$$

• The enhanced image is obtained by:

$$Im_{enh}(x, y) = Im(x, y) + \alpha I_{HP}(x, y) \qquad (6)$$
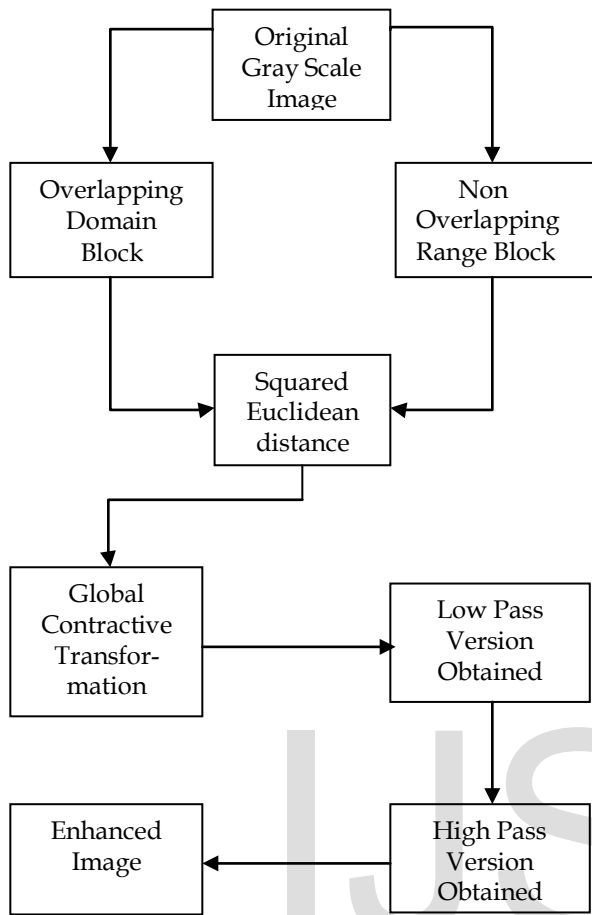
The parameter α adjusts the contrast gain.

Linear Unsharp Masking

Contrast Stretching

Histogram Equalization

CLAHE

Proposed Technique

(a)

Linear Unsharp Masking
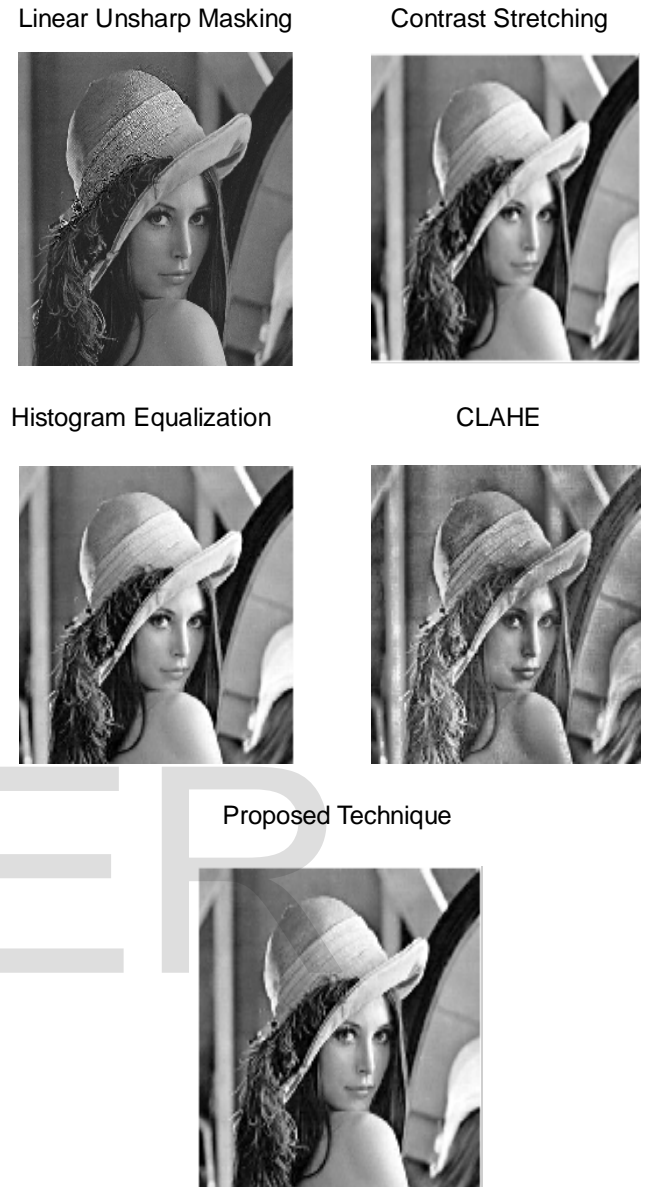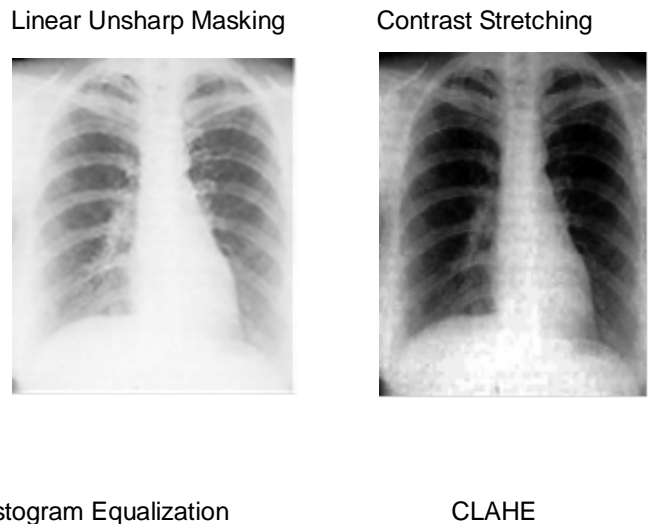
Contrast Stretching

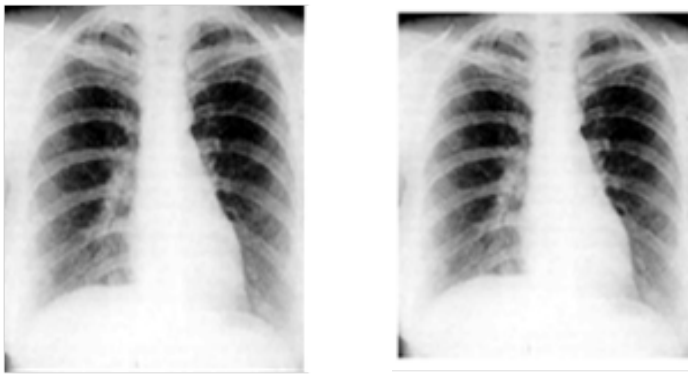Histogram Equalization

CLAHE

FIG 1: BLOCK DIAGRAM FOR PIFS

4 RESULTS AND DISCUSSION

The below diagrams show the result for five contrast enhancement method for different images such as (a)lena image, (b)chest image,(c)and mammography image. linear unsharph masking uses filter to reduce noise but the contrast of image is minimized, contrast stretching uses stretching mechanism to stretch the range of intensity values to span a desired range of values but it must have the desired maximum and minimum pixel value, histogram equalization uses the entire image to enhances the contrast of images by means of transforming the values in an intensity image so that the dynamic range of the histogram of an image is increased compare to previously used method histogram equalization method gives better result but the noise induced in these method are not completely reduced and also it gives less accurate representation of the image, and contrast limited adaptive histogram equalization use only small region of image rather than entire image it operates on small regions in the image, called tiles, compare to all the above method this method produce less noise but output image appears over enhanced.
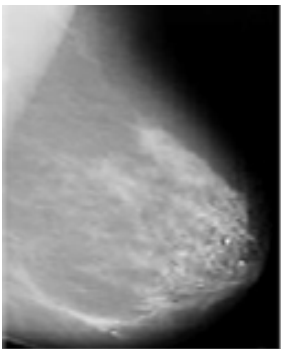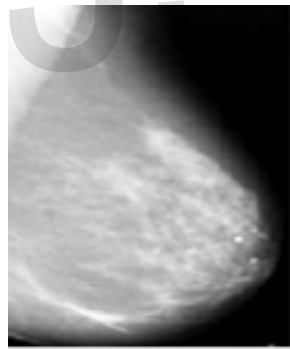
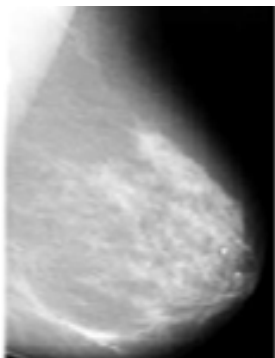Proposed Technique

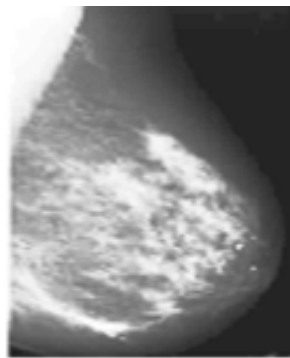(b)

Linear Unsharp Masking   Contrast Stretching
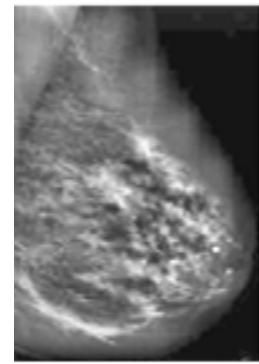
Histogram Equalization   CLAHE

Proposed Technique

(c)

FIG 2: (A) LENA (B) CHEST (C) MAMMOGRAPH IMAGE

The proposed method (PIFS) is better than all the other method, the contrast enhancement approach was quantitatively evaluated by examining the mean contrast difference between the original and the enhanced image. This method gives the high contrast gain by varying the parameter of enhanced image. Higher the contrast gain gives high contrast image with reduced noise. The above all enhanced method has some disadvantages like blurring, amplified noise, overshoot artifacts, and over enhancement .Here PIFS gives reasonable enhanced image with less amplified noise, reduced overshoot artifacts and also with high PSNR value .In general, the lower the PSNR, the more unwanted noise is amplified during contrast enhancement, PIFS has high PSNR value so that it does not amplify unwanted noise. This algorithm improves the interpretability and perception of information in image for human viewers. It gives high perception in all type of images.

TABLE 1

PERFORMANCE ANALYSIS

Performance of the five contrast enhancement methods on a variety of test images, in terms of the PSNR (dB).

PSNR(dB)				
Enhancement Method	Lena Image	Chest Image	Radiograph Image	Mammograph Image
PIFS Algorithm	31.33	31.08	32.40	30.29
CLAHE Method	30.95	28.32	31.80	29.67
Histogram Equalization	28.24	25.94	26.32	28.16
Linear U.M	17.30	17.66	14.84	14.33
Contrast Stretching	14.00	13.04	12.97	14.01

The above table shows the PSNR value for different images, compare to all other images PIFS algorithm gives highest

PSNR value than other enhancement method, because it reduces the ringing artifact effect, reduces the noise and it gives better visibility. For linear unsharp masking the PSNR value is low because it uses filter to reduce noise present in the image, for contrast stretching the value is very low because it depends upon the intensity of the pixel region, for histogram equalization the value appears moderate because it approximately matches a specified histogram, and for CLAHE the value appears nearer to the PIFS algorithm value because it uses limited intensity range from maximum to minimum but CLAHE gives result with over contrast enhancement. In general, the lower the PSNR, the more unwanted noise is amplified during contrast enhancement. The PIFS-based algorithm achieves higher PSNR values for all levels of noise enhances strong edges of the image resulting in reduced overshoot artifacts (ringing effect) on the output image and gives reasonable enhanced image.

5 CONCLUSION AND FUTURE WORK

This paper presented a novel approach for contrast enhancement based on the theory of the Partitioned Iterated Function Systems (PIFS). When compared to four widely used contrast enhancement methods, the Linear Unsnap Masking, the contrast stretching, the histogram equalization, and the Contrast Limited Adaptive Histogram Enhancement (CLAHE), the PIFS produced superior quality enhanced images after both visual and quantitative assessment. Finally, the PIFS algorithm proved to be quite tolerant in the presence of noise, as it was capable to increase the contrast gain of the test images without amplifying the noise, in terms of PSNR, as much as the other four methods in comparison. The future work may be a modified PIFS algorithm, by partitioning an image into different blocks like as I divided into range block and domain block, and then finding KD tree, low pass version, high pass version and enhanced image.

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