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A Novel Approach for Contrast Enhancement of Gray Scale Images using Multiscale Morphology

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***Abstract*—*Generally image enhancement techniques are applied for improvement of gray scale images as well as on medical and scientific images like x-ray images, MRI images, ultrasound images and satellite images etc. The present work is based on the enhancement of gray scale images using multiscale morphological techniques with different structuring elements at different scales. The structuring elements like disk, line, square, diamond are selected to calculate top-hat transformation, bot-hat transformation respectively on different scales.*

The proposed algorithm is used to extract the white and black region of an image and then calculate their sum of extracted regions. Subsequently, black and white regions are calculated at the neighboring scales also with their calculated sum. The summation of the results reveals the enhanced image. From the enhanced image, again black and white regions are extracted and the sum is obtained. The results of the white and black regions and at its neighboring scales are combined with the first enhanced image to obtain the final image. The results are compared with the other conventional techniques like un-sharp masking, contrast stretching, with the help of Background variance (BV), Detail Variance (DV) and Entropy as performance metrics. Thus the final enhanced image shows better results both quantitatively and qualitatively.

***Keywords*—** *Enhancement, Multiscale Morphology, Structuring element, Detail Variance, Background Variance, Top-hat transformation, Bot-hat transformation.*

I. INTRODUCTION

Gray scale images are defined as in which the colors in RGB (red, green, blue) space are having different shades of gray. The different colors in gray level pattern have equal intensities, due to which only a single intensity value needs to be specified for each pixel as compared as to different intensities needed for defining full colored images. An image can be defined as the intensity of any pixel located at x and y coordinates in the x-y plane is called gray level image (I) at that point mathematically expressed by (1):

$$I = f(x, y) \quad (1)$$

The aim of image enhancement is to obtain meaningful information from the perception/scene. The main aim of enhancement of images is contrast manipulation, reduction of noise from the image, edges sharpening, filtering, background removal, etc. The technique is quite helpful to extract details from the images. Enhancement can be done by using multiscale morphological approach to get the more enhanced results. Some of the traditional techniques like un-sharp masking, contrast stretching, etc. have some limitations. In the current study, the contrast enhancement of image is done by applying morphological operations like erosion, dilation, opening and closing and further on which top-hat and bot-hat transformations are done with the help of different structuring elemnets like disk, line square, diamond. The erosion operation of structuring element of A by B is the set of all points z such that B, translated by z, is contained in A. B is assumed to be a structuring element. Erosion shrinks foreground, enlarges Background as defined by (2).

$$A\Theta B = \left\{ z \middle| (B)_z \subseteq A \right\} \quad (2)$$

The dilation operation of structuring element of A by B then is the set of all displacements, z, such that B^ and A overlap by at least one element as defined by (3).

$$A \oplus B = \left\{ z \middle| \left(B^{\wedge}\right)_z \cap A \neq \varnothing \right\} \quad (3)$$

Opening operation of structuring element is used to smooth the contour of an object and eliminates thin protrusions as defined in (4).

$$A^{\circ}B = (A\Theta B) \oplus B \quad (4)$$

Closing operation of structuring element tends to smooth section of contours but as opposed to opening, it generally fuses narrow breaks and long thin gulfs, eliminates small holes, fill gaps in the contour as defined in (5).

$$A \bullet B = (A \oplus B)\Theta B \quad (5)$$

There asre two classes of mathematical mporphology as tophat transformation and bottom-hat transformations. The tophat transformation of a gray-scale image f is defined as f minus its opening as defined in (6).

$$T_{hat}(f) = f - (f^{\circ}b) \quad (6)$$

The bottom-hat transformation of f is defined as the closing of f minus f defined in (7).

$$B_{hat}(f) = (f \bullet b) - f \quad (7)$$

The top hat transform is used for light objects on a dark background, and the bottom-hat transform is used for the converse. The final image F_e of good quality is obtained by following method (or) formula as defined in (8).

$$F_e = f_o + T_h - B_h \quad (8)$$

Next, the white and black regions are being extracted at each scale as well as at neighbouring scales thereby computing the sum of white regions and black regions at each scale and at neighbouring scales. Therefore an enhanced image is obtained by adding the input image to the computed sum of white and black regions at each scale and neighbouring scales. Similarly extract the white and black regions at each scale and neighbouring scales of the enhanced image also. Thereby, computed the sum of white regions and black regions at each scale and at neighbouring scales of the enhanced image. The final enhanced image is obtained by adding the input image to the computed sum of white and black regions at each scale and at neighbouring scale of the enhanced image The proposed algorithm has been compared with other conventional techniques like un-sharp masking, ritika et.al. (2012) and Bai and Zhou (2010), and it is evident that the more enhanced results are achieved in case of proposed algorithm both quantitatively and qualitatively.

II. Related Works

Hassanpour et al. [4] has proposed the technique of morphological transforms for quality enhancement of medical images. A structuring element of disc shaped have a size of the input image is taken for morphological operations. It proposes filters from top-hat transforms in a multistep process (depending on CIR) increasing the size of mask at each step.

Ritika [14] has proposed an algorithm for the extraction of bright and dark image at different levels of the structuring component of the images being extracted. Results so obtained have been correlated with the base image for restructuring the outpuht image. A comparison with those of the already existing techniques exhibits better visualization.

Bai and Zhou [1] presented an algorithm is proposed in which firstly white and dark areas have been obtained by applying structuring components, subsequently two different features having light and black areas at each scale which are used to obtain the final light and dark areas an image. Then enhancement is done by enlarging the contrast between different regions of the image.

Stojic and Reljin [16] proposed two methods for enhancing the micro-calcifications in mammograms. One method is based on multifractal approach (MF) and the other on mathematical morphology (MM). In MM approach, the contrast is enhanced using the top hat transforms. The base image is gained as to the difference between the top-hat alteration as well as bottom hat altered images. This procedure can be iteratively repeated to obtain an output.

Oh and Hwang et.al. [11] proposed an algorithm based on feature extraction of the images, a novel morphological based homomorphic separation which has been suggested for enhancement. This technique is based on the decomposition of an image into different sub-bands of morphology followed by homomorphic filtering and then algorithm based on differential evolution is used to determine best gain and structuring components for each sub-band.

Mahmoud and Marshall [10] develop a new filter using edge-detection has been proposed. The positions of the edges are detected first using gradient based operators, then morphological filtering is applied.

Sun and Sang [18] presented a method for enhancing the contour of images as enhancement of coronary artery based multiscale dissections. Gabor wavelet is used for the detection of the diameter of the vessel on each and every pixel in an image. Then, a group of morphological opening operations are applied on the image based on the estimated scales. Finally, this estimated background is subtracted from the original angiogram.

Hassan and Akamatsu [4] proposed methods consisting of two steps: technique called un-sharp masking is used to enhance the boundaries and edges of the images. In contrast enhancement step, a 3×3 image portion is used values that go over the threshold remain unchanged whereas other pixels are remapped. The results from applying this approach on gray scale scale; color and medical images show that the technique is robust and able to recover even too dark images from blurring and darkness.

Kale et al. [6] proposed an algorithm to improve the ridge and valley structure for genuine feature extraction. Morphological dilation and erosion operations are applied on gray scale images and morphological top-hat transformation is used for enhancing details. The experimental results showed that the algorithm can effectively increase the contrast, reduce the noise and fills the gaps between the broken bridges.

Ruberto et al. [13] introduced a morphological approach for segmentation of cell images to diagnose the deadbeats using the studies of a colored pixel of stained malarial blood from a microscopic for calculation of the number of deadbeats in number of red blood corpusels and then the opening and the closing operation is used to diminishes or smoothens required areas.

Khriji et al. [7] introduced a new method for contrast enhancement in noisy environmentin which detail variance and background variance as the parameters for comparison of various methods.

Kaur et al. [9] compared different enhancement techniques to remove the blurred images. The main focus is on the comparison of multi-scale morphology technique with other enhancement techniques. By reviews of different papers this has been concluded that in the gray scale images the enhancement is done perfectly. Edges and other fine details of images are also not preserved properly.

III. Proposed Work

Consider an original image and apply morphological operations by selecting different shape structuring elements like line, disk, diamond, square at different scales. Multi-scale top-hat transformation and bot-hat transformation are obtained by different SE at all scales like 3×3, 5×5, 7×7, 9×9, 11x11, 15x15 pixels. From the top hat and bot hat transformation images extract the white and black regions and calculate their sum. Similarly, calculate the white and black regions at neighboring scales and obtain their sum. The final enhanced image is obtained by adding input image to the sum of both exhibiting white and black details in the image and also the sum of the extracted white and black regions at the neighboring scales. The process is repeated as the white and black pixels are calculated at each scale and at neighboring scales of the enhanced images. The final results are being compared by adding first enhanced image and the second enhanced image. The final result obtained is the more enhanced image. The results of the algorithm in flow chart are compared with un-sharp masking, Bai and Zhou and ritika et.al using BV, DV and Entropy as performance evaluation metrics as shown in figure 1.

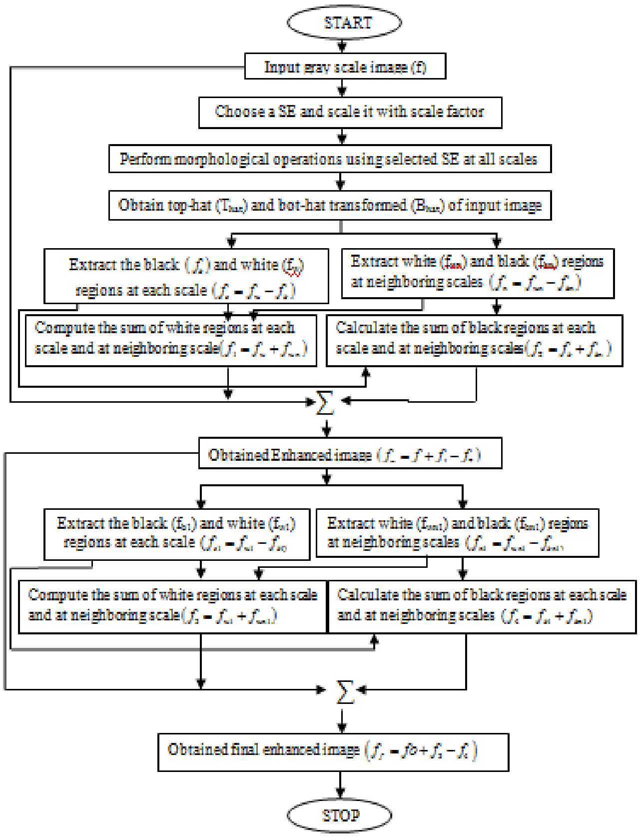

Fig. 1. Flow chart of present work.

IV. Results and Discussion

The present algorithm is applied on a set of images to evaluate the results both visual as well as quantitatively. The proposed work has used multi-scale morphology for enhancement of contrast in the images. The multi-scale morphology preserves the edges as well as the important details of an image. The results are compared qualitatively and quantitatively using DV, BV, Entropy as quality metrics with different structuring elements at different scales the results are better when compared with Ritika et.al and Bai and Zhou in which the work is based on extracting only the black and white regions and then calculating it also at neighboring scales, but the limitations of Ritika et.al. and Bai and Zhou get improved in the proposed algorithm. In un-sharp masking, the boundaries and edges of the objects in the image are get more prominent and even the lines of the affected area become more fine and crisp, whereas the results in the present algorithm are more clear and enhanced as the boundaries of the objects in an image get prominent. The Bai and Zhou also improves the contrast of the image by exhibiting more light and brightness but in current work the image gets brighter and enhanced.

The values of performance evaluation metrics for the Proposed Algorithm and existing techniques are evident in table I. From the table, it is revealed that the values of BV and Entropy is less in proposed algorithm and the value of DV is more in proposed algorithm, than the values of other traditional enhancement techniques and the work of other papers also.

TABLE I. Comparison of enhancement techniques using 'diamond' as structuring element

	Method	Quality Metrics		
		BV	DV	ENTROPY
Image =	'moon.jpg'			
	Original	0.072	76.128	2.615
Diamond (d=4)	Un-sharp	0.104	78.51	2.603
	Bai and Zhou. (2010)	0.258	106.285	2.47
	Ritika et al. (2012)	0.118	99.954	3.476
	Proposed Algorithm	**0.024**	**106.604**	**1.865**
Image =	'numbers.jpg'			
	Original	0.218	88.051	3.147
Diamond (d=4)	Un-sharp	0.706	69.141	5.345
	Bai and Zhou. (2010)	0.073	106.921	3.496
	Ritika et al. (2012)	1.413	89.401	6.847
	Proposed Algorithm	**0.055**	**112.313**	**2.92**
Image =	'charlie.jpg'			
	Original	0.187	88.833	2.553
Diamond (d=4)	Un-sharp	1.886	64.842	4.9
	Bai and Zhou. (2010)	0.073	99.094	2.304
	Ritika et al. (2012)	1.476	87.6	6.723
	Proposed Algorithm	**0.074**	**100.244**	**1.803**
Image =	'butterfly.jpg'			
	Original	0.294	90.7034	3.461
Diamond (d=4)	Un-sharp	0.773	66.385	4.331
	Bai and Zhou. (2010)	0.097	99.364	3.62
	Ritika et al. (2012)	1.434	88.172	6.299
	Proposed Algorithm	**0.049**	**105.832**	**3.178**

It is evident that the proposed algorithm gives the more enhanced results.

V. Conclusion and Future Scope

In the present work the image enhancement algorithm has been developed using multi-scale morphological approaches with the use of different multiscale structuring elements.

And further the results are evaluated clearly by using some performance metrics, so that the results of the output image is being more enhanced and clear; the output achieved is more accurate and clear as the techniques used for the comparison are: Un-sharp masking, Bai and Zhou (2010), ritika et.al. (2012) and compared with the proposed algorithm. Three quality metrics are also used for each of techniques and they are: Background Variance, Detail Variance and Entropy. Experimental results showed that the new method shows well than the different techniques in terms of contrast enhancement. The proposed method also gave good quantitative results in comparison to the other techniques.

The present work can be applied to other scientific images, MRI images, x-ray images etc. as shown in fig. 2. For future work, the enhancement can be extracted with the use of nonflat structuring components. These structuring elements are three dimensional, through their uses, further the algorithm will be able to identify the spherical objects from the image to get faster execution.

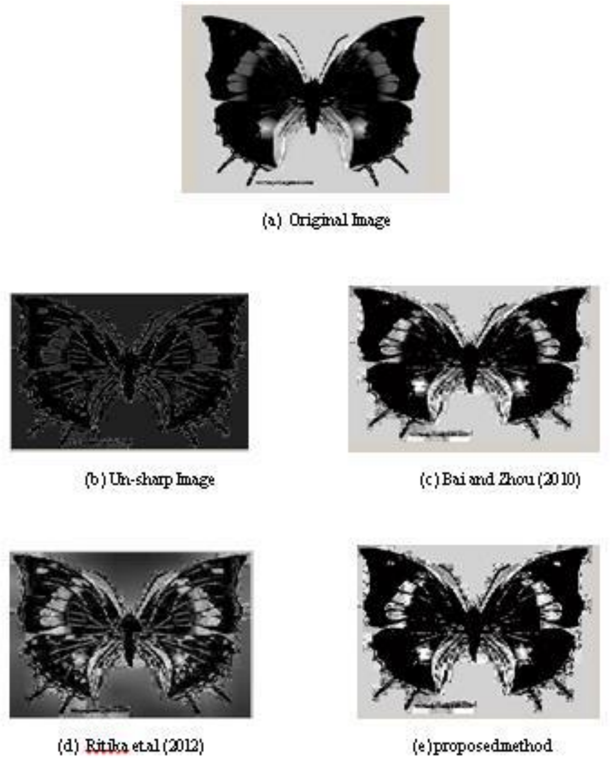

Fig. 2. Shows the results of enhancement algorithms for diamond as structuring element with radius d=4.

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