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Enhancement of Low Contrast Medical Images Using Adaptive Sigmoid Function, Histogram Transformation and Swarm Optimization

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ABSTRACT: In this paper, we have proposed an approach for the contrast enhancement of medical images. The contrast of any image is a very important characteristic which decides the quality of image. Low contrast images occur often due to poor or non-uniform lighting conditions and sometimes due to the non-linearity or small dynamic range of the imaging system. Enhancing the contrast of medical images is of importance since it is difficult to analyse the information with a poor-quality image. Though several methods are proposed for grey scale images, but some are complicated while others are not generating efficient results. In this paper, we have enhanced the contrast of images by applying three techniques which are modified sigmoid function, Histogram equalization & Particle swarm optimization. The generated image has an improved entropy.

KEYWORDS: Particle Swarm Optimization, Histogram Equalization, Modified Sigmoid Function.

I.INTRODUCTION

Image enhancement, one of the important image processing techniques, can be treated as transforming one image to another to improve the interpretability or perception of information for human viewers, or to provide better input for other automated image processing techniques. Image enhancement techniques can be divided into four main categories: point operation, spatial operation, transformation, and pseudo coloring. Image enhancement techniques are used to improve an image, where "improve" is sometimes defined objectively (e.g., increase the signal-to-noise ratio), and sometimes subjectively (e.g., make certain features easier to see by modifying the colors or intensities). Intensity adjustment is an image enhancement technique that maps an image's intensity values to a new range.

Imaging has become an essential component in many fields of bio-medical research and clinical practice. Biologists study cells and generate 3D confocal microscopy data sets, virologists generate 3D reconstructions of viruses from micrographs, radiologists identify and quantify tumours from MRI and CT scans, and neuroscientists detect regional metabolic brain activity from PET and functional MRI scans. Analysis of these diverse types of images requires sophisticated computerized quantification and visualization tools

Histogram transformation is considered as one of the fundamental processes for contrast enhancement of gray level images, which facilitates subsequent higher level operations such as detection and identification. Linear contrast stretching employs a linear transformation that maps the gray-levels in a given image to fill the full range of values. Pseudo coloring is an enhancement technique that artificially" color" the grayscale image based on a color mapping, with the extensive interactive trials required to determine an acceptable mapping. Color images can be enhanced by separating the image into the chromaticity and intensity components. Majority of the image enhancement work usually manipulates the image histogram by some transformation function to obtain the required contrast enhancement. Consequently, this operation also delivers the maximum information contained in the image.

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II. RELATED WORK / LITERATURE REVIEW

AnImage Enhancement covers a variety of theoretical and practical approaches that deals with living today and in the future. There are several ways or methodologies to Enhance image contrast and Entropy. Some of them are as follows:-

(a) ApurbaGorai and Ashish Ghosh[1],proposed a PSO based automatic Image enhancement technique for gray level images. Results of the proposed technique are compared with some other image enhancement techniques, like linear contrast stretching, Histogram equalization and genetic algorithm based image enhancement. Most of the times it is observed that our technique is giving better result compared to other techniques mentioned above. In PSO, the most important property is that, it can produce better result with proper tuning of parameters.

(b) Saruchi[2], has proposed the adaptive sigmoid approach for enhancement of all types of low contrast photography, from snapshots to medical images. The approach has been fused with HE, which is producing better results. On comparing the proposed methodology with the existing popular approaches of enhancement, it has been concluded that the proposed technique is giving much better results than the existing ones.

(c) Gourav Garg and Poonam Sharma[3],proposed new & quite simple brightness contrast method that uses the activation function for calculating the mask; this mask is applied on original image in order to improve the overall dynamic appearance of an image.

(d) Shyam Lal And Mahesh Chandra [4], This Paper highlighted contrast enhancement of natural gray scale images. A new contrast enhancement algorithm was proposed for image enhancement purpose for various applications. This algorithm was tested on different gray scale natural images. The qualitative and subjective enhancement performance of proposed ACEBSF algorithm was evaluated and compared to other state-of-art contrast enhancement techniques for different gray scale natural images.

(e) Harish Kumar Verma and Sandeep Pal [5], In this Paper the consistency obtained in result for several runs established robustness of the proposed algorithm. This paper proposes algorithm which is based on optimizing contrast factor c for low contrast image. This method improves the visual effect obviously, moreover holds the details simultaneously.

III.HISTOGRAM EQUALISATION

One of the most popular image enhancement methods is Histogram Equalization (HE) [7]. HE becomes a popular technique for contrast enhancement because this method is simple and effective. HE technique can be applied in many fields such as in medical image processing, radar image processing, and sonar image processing. The basic idea of HE method is to re-map the gray levels of an image based on the image's gray levels cumulative density function. HE flattens and stretches the dynamic range of the resultant image histogram and as a consequence, it enhances the contrast of the image and gives an overall contrast improvement. However, HE is rarely employed in consumer electronic applications such as video surveillance, digital camera, and television since HE tends to introduce some annoying artifacts and unnatural enhancement, including intensity saturation effect. One of the reasons to this problem is because HEnormally changes the brightness of the image significantly, and thus makes the output image becomes saturated with very bright or dark intensity values. Hence, brightness preserving is an important characteristic needed to be considered in order to enhance the image for consumer electronic products

IV.SIGMOID FUNCTION

The sigmoid function is the continuous non-linear mathematical function. The name sigmoid is derives from the fact that the function is alphabet letter "S" shaped [2]. This function is also called as logistic function.

$$f(x) = \frac{1}{1 + e^{-\frac{(x-\alpha)}{\beta}}}$$

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This function maps the entire range of x to the domain [0, 1] of y. The parameters α and determines the center and width of the sigmoid function respectively. The graphical illustration of sigmoid function is shown in Figure 1, it goes up smoothly and kindly.

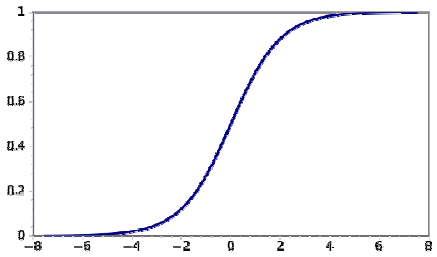

Figure1. Sigmoid function.

V.MODIFIED SIGMOID FUNCTION

The modified sigmoid function defined in equation 2. This mathematical formula operates upon the original image on pixel by pixel in the spatial domain. The following formula demonstrates the pixel value of the first step output image:

$$o(i,j) = f(i,j) + K_1 * \frac{f(i,j)}{1 - \exp(K_1 * (K_2 + f(i,j))}$$

Where K_1 is control parameter which controls the actual contrast of input image. If the value of K_1 is selected 5 then its effect on the input image is little change in the contrast, if the value of K_1 is selected 1 then its reduces contrast to about 20% of original and if the value of K_1 is selected 10 then its increase contrast about to 2.5 times the input image. Therefore, a reasonable range of values of $K_1$is to be selected in the experiments. For effective contrast enhancement of input images the value of K_1 should be lies between 10 to 25.

$K_2$is another control parameter which represents the normalized gray value about which contrast is increased or decreased. The initial value of $K_2$is selected 0.5 (i.e., the midpoint of the gray scale) but different images may require different points of the gray scale to be enhanced. Therefore, a reasonable range of values of $K_2$is to be selected in the experiments. For effective contrast enhancement of input images the value of K_2should be lies between 0 to 1. The typical value of $K_2$is used in the experiment is 0.5

VI.PARTICLE SWARM OPTIMIZATION

PSO is an optimization algorithm proposed by J. Kennedy and R. C. Eberhart in 1995 [11]. This optimization algorithm is a multiagent based search strategymodeled on the social behavior of organisms such as bird flocking and fish schooling. PSO as an optimization tool, provides a population based search procedure in which individuals called particles change their position with time. In a PSO system, particles fly around in a multidimensional search space. During flight, eachparticle adjusts its position according to its own experience, and the experience of its neighboring particles, making use of the best position encountered by itself and its neighbors. Thus, as in modern GAs and memetic algorithms, a PSOsystem combines local search with global search, attempting to balance exploration and exploitation.

VII.PERFORMANCE EVALUATION

Contrast - Contrast is the difference in luminance or color that makes an object (or its representation in an image or display) distinguishable. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. The human visual system is more sensitive to contrast than absolute luminance, we can perceive the world similarly regardless of the huge changes in illumination over the day or from place to place. The maximum contrast of an image is the contrast ratio or dynamic range.

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Entropy-Image entropy is a quantity which is used to describe the `business' of an image, i.e. the amount of information which must be coded for by a compression algorithm. Low entropy images, such as those containing a lot of black sky, have very little contrast and large runs of pixels with the same or similar DN values. An image that is perfectly flat will have an entropy of zero. Consequently, they can be compressed to a relatively small size. On the other hand, high entropy images such as an image of heavily cratered areas on the moon have a great deal of contrast from one pixel to the next and consequently cannot be compressed as much as low entropy images.

$$\text{Entropy} = -\sum_{i} P_i \, \text{Log}_2 P_i$$

In the above expression, P_i is the probability that the difference between 2 adjacent pixels is equal to i, and Log_2 is the base 2 logarithm.

PSNR-Assume that *N is* the total number of pixels in the input or output image, MSE (Mean Squared Error) is calculated through (12). Based on MSE, we calculate PSNR then it is defined below. According to the definition of PSNR the output image quality is better if those images has maximum PSNR.

$$\text{MSE} = \frac{\sum_I \sum_J (x_{i,j} - y_{i,j})^2}{N}$$

$$\text{PSNR} = 10\log_{10} \frac{255^2}{\text{MSE}}$$

VIII. PROPOSED TECHNIQUE

The Present work uses Modified Sigmoid Function as a transformation function based on the contrast of the images that is high contrast or low contrast, which take intensity value of each pixel from the input image and generate a new intensity level of corresponding pixel so that image looks better. The Proposed method introduces a novel hybrid image enhancement approach by taking both the local and global information of an image. In the present work, sigmoid function is being modified on the basis of contrast of the images. The gray image enhancement problem is treated as nonlinear optimization problem with several constraints and solved by particle swarm optimization.

The entropy and edge information is included in the objective function as quality measure of an image. The effectiveness of modified sigmoid function based enhancement over conventional methods namely linear contrast stretching, histogram equalization, and adaptive histogram equalization are better revealed by the enhanced images and further validated by statistical analysis of these images. Here we have processed the image using MSF & HE individually then we have combined both the results and the image obtained is efficient. Here we have taken the optimum values of k1 & k2 by using particle swarm optimization. This method generates pbest&gbset values from their neighbourhood and then uses these values for getting best results.

Implementation Steps Involved in the Proposed Algorithm

Step 1: Read the input image.
Step 2: Convert input image into gray scale image if it is color image.
Step 3: Calculatethe control parameter *K1* and *K2 by* using PSO.
Step 4: Calculate output of modified sigmoid function.
Step 5: Output image of modified sigmoid function (i.e., o) is further passes through histogramequalization.
Step 6: Perform above steps for entire image.

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Fig 2: Block diagram of Proposed Algorithm.

IX. RESULT AND DISCUSSION

The test images have been enhanced using proposed algorithm & Sigmoid fused with HE. These mentioned enhancement techniques produced following results for the below considered images:
In visual analysis, it is observed that contrast has been enhanced to various levels by all the algorithms but the proposed algorithm is enhancing the image more precisely in comparison to HE and Sigmoid fused with HE. The human visualization is not considered as benchmark for image quality, so to evaluate the performance of above mentioned algorithms quality metrics have been calculated for the output images. Values for SNR, Entropy and Contrast have been calculated for the resultant images in comparison to the original image.

Image	Parameters	Original Value	HE with Sigmoid	By proposed PSObased Method
Chest X ray	Entropy	7.43	7.86	7.93
	Contrast	0.68	0.80	0.73
	SNR	3.15	9.94	4.72
Collar bone (Male)	Entropy	7.22	7.45	7.72
	Contrast	0.81	0.91	0.83
	SNR	4.02	4.75	5.17
Collar bone (Female)	Entropy	7.23	7.63	7.69
	Contrast	0.57	0.78	0.82
	SNR	2.82	3.44	4.74

Fig 3: Chest X-Ray (A) Original Image (B) HE withSigmoid (C) By Proposed PSO Algorithm

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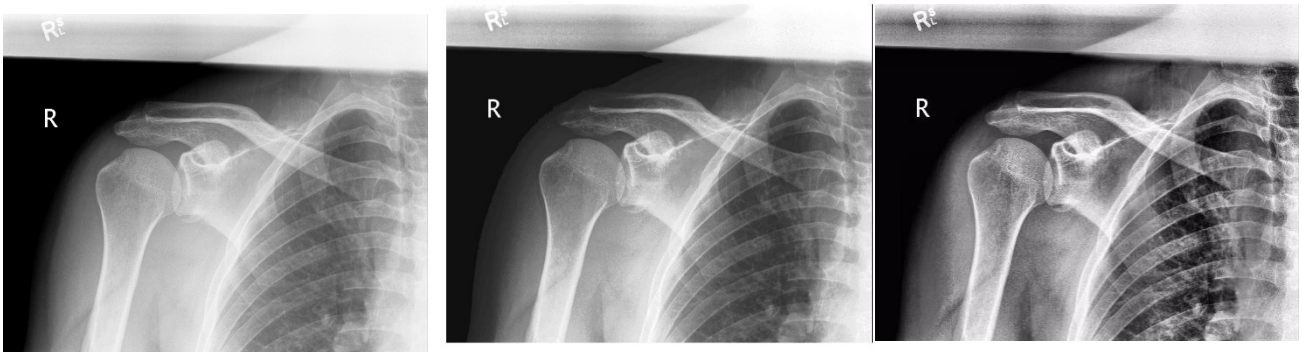

Fig 4: Collar Bone (Male) (A) Original Image (B) HE withSigmoid (C) By Proposed PSO Algorithm

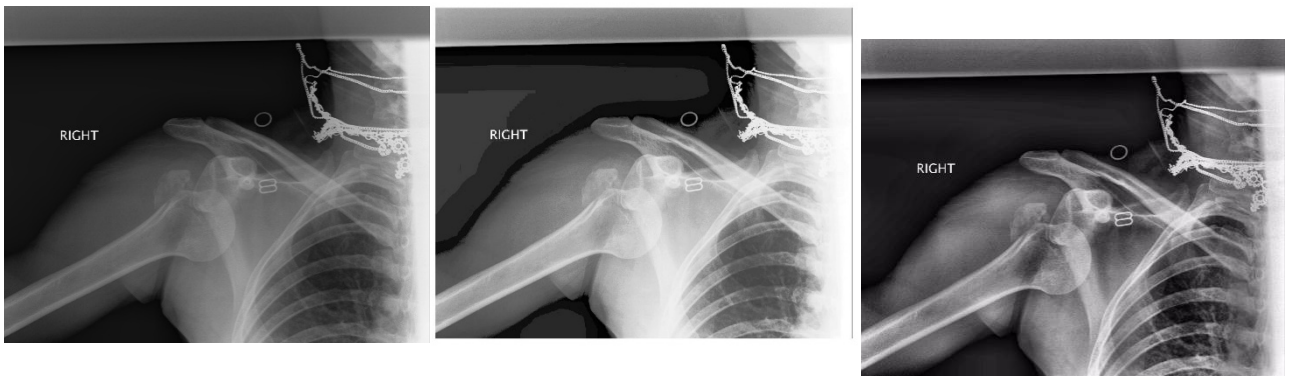

Fig 5: Collar Bone (Female) (A) Original Image (B) HE withSigmoid (C) By Proposed PSO Algorithm

X.CONCLUSION& FURTHER RECOMMENDATIONS

This paper is representing the Modified sigmoid and Particle Swarm Optimization approach for enhancement of all types contrast medical images. The approach has been fused with HE, which is producing better results. On comparing the proposed methodology with the existing popular approaches of enhancement, it has been concluded that the proposed technique is giving much better results than the existing ones. From the results of applying proposed technique on real images we can clearly see that the image quality was improved. Many more details become visible the resultingimages after applying the new proposed contrast enhancer on both dark, grey scale images were satisfactory

The proposed method can be extended to colored images in future and new parameters can be included to test performances of algorithm. As contrast enhancement techniques also enhance noise, some denoising technique may also be included in the algorithm to improve the high noise images.

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