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A Novel Image Enhancement Technique for Ancient Images using Optimal Histogram Equalization and Fuzzy Enhancement Technique

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Abstract:Ancient image enhancement algorithm based on Optimal Histogram Equalization and Fuzzy Enhancement techniques were discussed in this paper, in-order to overcome the problems of poor contrast and sharpness in low quality images. This proposed method consist of two stages :the first, the technique of image Smoothing, where we make use of optimal histogram equalization and fuzzy enhancement technique on the low quality image. Second, The obtained three images , where each of these images individually preserve the enhancement effects of either of these techniques. Where on which we are going to perform image fusion technique(where images where coupled/fused into single image) by doing so increases the contrast in the image without introducing much side effects like washed out appearance or undesired artifacts. The experimental results shows that the proposed algorithm integrates the advantages of optimal histogram equalization and fuzzy enhancement effectively and achieves a considerable efficiency in the enhancement of degraded images exhibiting both blurred details and low contrast. The qualitative performances of the proposed technique are compared with other techniques previously used for producing better quality resultant image.

Keywords: ***Image Fusion, Optimal Histogram equalization, Fuzzy enhancement.***

I INTRODUCTION:

Generally image enhancement was one of the most widely used in image processing domain, which was very fundamental step that which has to be performed at very early stages of the image preprocessing to improve the appearance of the image. In general, unprocessed ancient images have a relatively narrow range of brightness values; hence, contrast enhancement is frequently used to enhance the image for better interpretation and visualization. Image enhancement can be broadly divided into two groups namely frequency domain and spatial domain methods. frequency domain works on the principle of modifying the frequency transform of the image which takes more time, which was not applicable for real time applications. And the other is spatial domain, which works upon the pixels of the image.

Image fusion is the process of multiplex many images and to form a new image by using a certain algorithm. The main objective of the image fusion exists in combining multiple source images into a fused image that exhibits more useful information than the individual source image. Here in our proposed system we obtain three images, one as an output of image Smoothing, one as the output of the optimal histogram equalization and the other as the output of the fuzzy enhancement algorithm. Where we are going to pass these three images as the input for the image fusion process to get a enhanced image with more information by using certain algorithm. The experimental results show how our proposed significantly improves the quality of degraded images. This paper was organized as follows section II presents Optimal histogram equalization, Section III presents image Smoothing technique, section IV represents Fuzzy Enhancement technique, section V represents experimental results and section VI represents Report conclusions.

II OPTIMAL HISTOGRAM EQUALIZATION

The Optimal histogram technique is an effective and efficient for contrast enhancement technique that takes control over the traditional Histogram Equalization so that it performs the enhancement of an image without making any loss of details in the original image. The Optimal Histogram Equalization was divided into three steps where in the first stage we are going to divide the entire histogram into multiple small histograms. This division goes until no domination of higher histogram was on lower histogram elements. This division of histograms as based on the local minima. It makes the partition by taking the portion that falls between the two minima. Mathematically if i_0, i_1, i_2…… i_n are *(n+1)* gray levels that correspond to *(n+1)* local minima, then the first sub-histogram will take the gray level range $[n_0, n_1]$, the second will take $[n_1+1, n_2]$ and so on. However if there was any domination of higher histogram on the lower histogram, we are going to split these histograms further based on the value of the mean(μ) and the standard deviation (σ) of the gray level frequencies of each histogram region. If the number of consecutive gray levels having frequency within the range from (μ- σ) to (μ+ σ) becomes more than 60.0 of the total frequency of all gray levels in a sub-histogram, then there is no dominating portion in the sub-histogram. If the percent is less than the 60.0 then there is a dominating portion where we have to perform splitting of current histogram into three sub-histogram regions gray levels between (μ-σ) to (μ+σ).

In the second stage, the gray level allocation is done based on the dynamic range of the gray levels in the input image. If the dynamic range is low, then based on the ratio of the span of gray levels that the input image sub-histograms will be distributed, Optimal Histogram Equalizer allocates a particular range of grey levels over which it may span in output histogram of an image.

$Span_i = n_i - n_{i-1}$

$range_i = \frac{span_i}{\Sigma span_i} * (L-1)$ ------ ii where

$span_i$ = dynamic grey used by sub-histogram i in the input image.

n_i = i^{th} local minima in the input image histogram.

$range_i$ =dynamic grey level range for sub-histogram i in output image.

If the dynamic range of gray levels in the input image is high ,then a obtained value of the mean frequency (Average frequency A_f) of the group of sub-histograms of an image is used to perform actively in the allocation process of gray ranges among the sub-histograms.

$factor_i = span_i * (\log cf_i)^x$

$range_i = \frac{factor_i}{\Sigma factor_i}$ -------------- iii

where

cf_i= sum of all the histograms values of i^{th} sub-histogram.

x= Amount of intensity at that frequency.

In the third stage, we are going to do the histogram equitation where all the span in the output image was allowed to be in the given gray level limit preferred to it. By doing so all the histograms in the original/input image will be equalized where we could eliminate the histogram domination.

III IMAGE SMOOTHING

Image smoothing is a process in which we are going to smoothen the image pixels to obtain more details of image in more efficient way by increasing the intensities of pixels where there were less intensity by averaging them with neighboring pixels and was aimed to produce less pixilated image. Here the reason behind doing image smoothing is because objects which where captured in ancient images were de-structured and lot of noise was added top the image. To reduce such noise we are going to use this smoothing technique. The pixels with high intensity where also handled using these filter.

Here we make use of 2D *Low-Pass filter*. Which was going to cut the intensity or the frequencies of the pixels which were outside the filter area? Here we are using the function

$$F(u,v) = \begin{cases} & \text{if } P(u,v) \le P_0 \\ 0 & \text{if } P(u,v) > P_0 \end{cases}$$

Where p0 is the constant and P(u,v) is the distance from the point (u,v) in the frequency domain and the frequency rectangle.

$$P(u,v)=\sqrt{\left(u-\frac{g}{2}\right)^2+\left(v-\frac{h}{2}\right)^2}$$

Where g and h are padded sizes

$g \ge 2M-1$

$h \ge 2N-1$

IV FUZZY ENHANCEMENT TECHNIQUE

Now we are going to enhance the image by using the fuzzy enhancement techniques for image by taking the entropy(E) and the index of fuzziness(IOF) into consideration. Where the size of the image is M x N had a intensity levels xi in the range(0,L-1) can be taken as fuzzy singleton in fuzzy set notation. The entropy of fuzzy set can be determined by using the formula

$$E(A) = \frac{1}{n1n2}\sum_i s(\mu_A(x_i)) \quad i=1,2,3\ldots\ldots\ldots\ldots n;$$

From Shannon function

$$s(\mu_A(x_i)) = -\mu_A(x_i)\ln[\mu_A(x_i)) - [1-\mu_A(x_i)]\ln[1-\mu_A(x_i)] \text{-----iv}$$

Here $\mu_A(X_i)$ representing the grade of belonging μ_A of X_i, X_i is an element in the set representing the gray scale intensity of the pixel. Now the index fuzziness is calculated as

$$\text{Index of fuzziness}(IOF) = \frac{2}{MN}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} \boldsymbol{min}(\boldsymbol{q_i}(\boldsymbol{1}-\boldsymbol{q_i}))$$

Where

$$q_i = sim\{\frac{\pi}{2}\times(1-\frac{\mu(m)}{\mu_{max}})\}$$

Where,$\mu(m)$ is a membership function. Here a,b,c were used by the membership function to maximize the image's information.

$$\mu(m) = \begin{cases} 0 & for\ m \le a \\ \frac{m-a}{(b-a)(c-a)} & for\ a < m \le b \\ 1-\frac{(m-c)^2}{(c-b)(c-a)} & for\ b < m \le c \\ 1 & for\ m \ge c \end{cases}$$

we obtain a,b,c from the equations

$a = \alpha E_{max}$

$b = \beta|IOF_{max} - E_{max}|$

$c = \gamma IOF_{max}$

Where

α , β, γ where the membership factors.

IOF_{max} was the maximum index of fuzziness.

E_{max} was the maximum entropy.

Now we are going to normalize the intensities of the image by converting it into fuzzy domain. Basically in the original image some of the area may be over exposed and some of them may be under exposed. So, the exposure was normalized by the factor of [0,1].When the value of expose is around .5 the image appears to be under exposed. so, we make use of the threshold so that it could divide the image into two parts. It was given by the equation Threshold (T) = θL(1-Exposure) Here θ was the exposure operator to obtain the optimal threshold, And T is from the range [0 L-1] which divides the grey level which were [0 T-1] for underexposed and [T L-1] for over exposed. The membership function could be modified to enhance the image.

$$\mu_{enh} = \begin{cases} \sqrt{\mu\boldsymbol{\pi}(\boldsymbol{m})} & \text{for } \mu(m) < T \\ [\mu(m)]^2 & \text{for } \mu(m) \ge T \end{cases}$$

All the gray levels of overexposed and underexposed were came near to the extreme boundaries of over or under exposed regions. How ever we are going to overcome the problem of over exposed and under exposed regions by changing the membership function.

Fusion Rules:

Image fusion rules where very important for image fusioning. Let us take W,R,Q images where W represents the sharpened image, R represents the optimal Histogram Equalizing image and Q represents the Fuzzy enhanced image.

Fusion image (F) is

$F(i,j)=p_1 * W(i,j) + p_2 * R(i,j) + P3 * Q(i,j)$.

$P_1+p_2+p_3=1$

Where p_1,p_2,p_3 were the weighted coefficients that can adjust the portion of the W,R,Q to control the brightness of the fused image. According to the experiments it was suggested to take $p_1=.2$ $p_2=.4$ and $p_3=.4$.

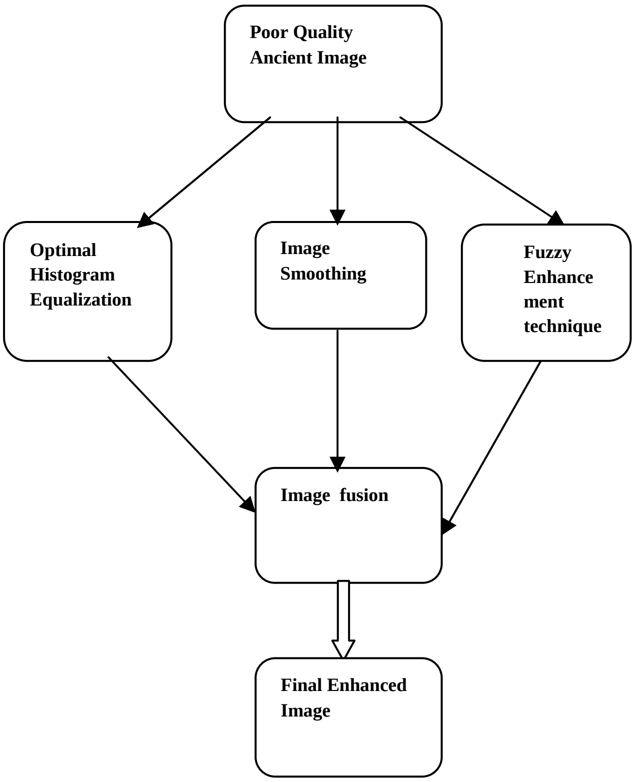

Figure 1: Block Diagram of the process

V EXPERIMENTAL RESULTS:

The experimental result for the proposed algorithm on two ancient images. The experimental result were shown in the below figures, figure2 and 3. Optimal Histogram equalization, Fuzzy Enhancement And Smoothing were applied to the same poor quality image to get three individual enhanced images. Here, now we were going to perform the image fusioning on the three images which we had obtained after performing image enhancement. Here all the three images were fused together to get a single enhanced image with more information when compared to that of the original image. Here fusion was performed on the three images which were obtained by enhancing the original image by smoothing, optimal Histogram equalization and the fuzzy enhancement. The larger the entropy the more will be the image information. The larger the average gradience and standard deviation values the more will be the grey levels and relatively good quality of image in terms resolution. Here the table 1 and table 2 shows the quantitative values

Table **1**: Quantitative Analysis for figure **2** using proposed Algorithm

Figure	**Standard Deviation**	**Average Gradient**	**Entropy**
Figure -2	53.131	6.129	2.759
Figure -2	62.109	9.015	3.245
Figure -2	68.591	12.961	4.615
Figure -2	74.627	23.988	5.608

Table **2**: Quantitative Analysis for figure **3** using proposed Algorithm

Figure	**Standard Deviation**	**Average Gradient**	**Entropy**
Figure-3	63.258	7.142	2.869
Figure-3	72.116	10.072	3.947
Figure-3	74.276	14.153	4.726
Figure-3	76.276	25.329	5.743

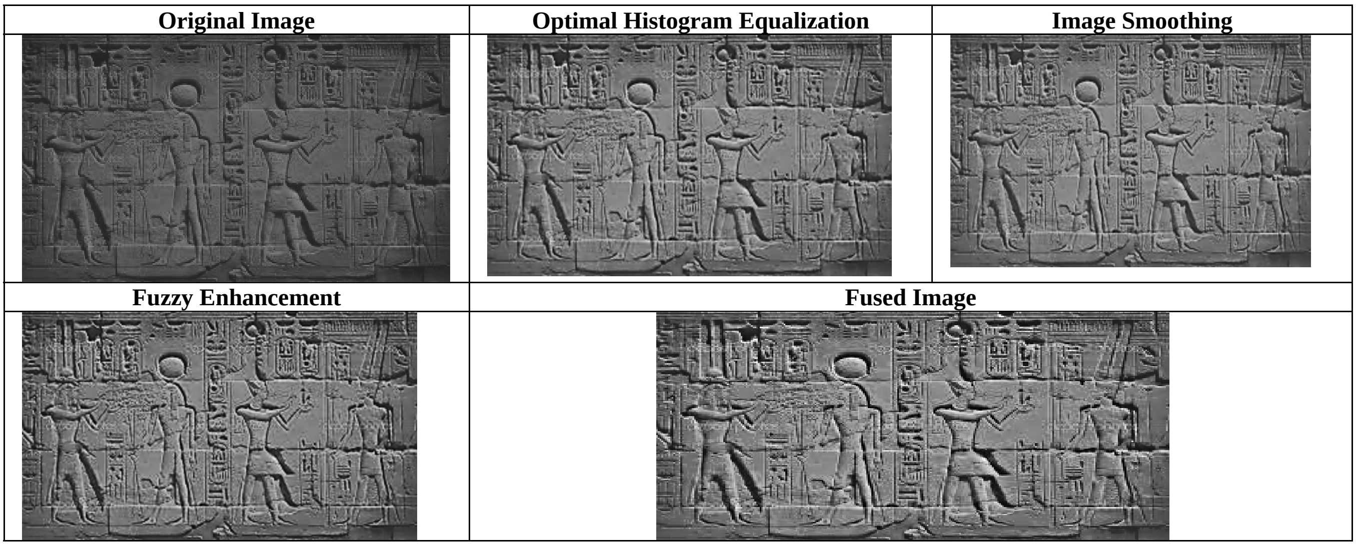

Figure 2:Resultant Images of the proposed Algorithm

Original Image	**Optimal Histogram Equalization**	**Image Smoothing**
		
Fuzzy Enhancement	**Fused Image**	
		

Figure 3: Resultant Images of the proposed Algorithm

VI CONCLUSION

Here in this paper I had enclosed the new algorithm Optimal Histogram Equalization Technique which was used to enhance the poor contrast and blurred images. Here we are going to perform Optimal Histogram Equalization, Image Smoothing and Fuzzy Enhancement respectively. And finally we are fusing the three resultant images of the algorithms to one single enhanced image with more information. Experimental results has proved the proposed algorithm has efficiently combined the merits of the all the three algorithms to form a high quality image which has improved the contrast and sharpness of the image.

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