RESEARCH ARTICLE OPEN ACCESS

Weighted Technique Using Image Fusion Techniques for Enhanced Visual Quality

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ABSTRACT
Image fusion is a process by which complimentary details from multiple input images are integrated into a single image, where the output fused image provide more information and more suitable for the purpose of human visual perception. Various enhancement schemes are used for enhancing an image which includes gray scale manipulation, filtering and Histogram Equalization (HE). Histogram equalization is one of the well-known image enhancement technique. In this study, an image fusion based techniques, called weighted technique, is proposed for image enhancement. First compute the conventional histogram then calculate magnitude gradient and weight function.
Keywords:- Weighted Technique, Histogram Equalization, Image Fusion, Gradient, Weight Function

I. INTRODUCTION

Image Enhancement is to bring out detail that is hidden in an image or to increase contrast in a low contrast image. Whenever an image is converted from one form to other such as digitizing the image some form of degradation occurs at output. A post-processing procedure using an image enhancement method is needed in order to produce an image having better quality. Many software or image enhancement methods were developed to cope with these problems. In general, image enhancement methods can be classified into four categories: histogram-based methods, transform based methods, exposure-based methods and image fusion based methods. Histogram equalization (HE) is the most well-known technique for image enhancement**.** HE uses a non-linear mapping function to produce an enhanced image with its histogram approximating a uniform distribution. However, HE fails to produce pleasing pictures owing to three common drawbacks: 1) false contour; 2) amplified noises; 3) washed out appearance. Pizer et al. proposed a local HE method called adaptive histogram equalization. First, an image is divided into several non-overlapping blocks. Then, HE is applied on each block independently. Finally, the enhanced blocks are fused together using bilinear interpolation in order to reduce blocking artifacts. Some brightness preservation HE methods tried to preserve the original brightness to some extent, which is essential for consumer electronic products. These methods first divide the histogram into two or more sub-histograms and then apply HE on each sub-histogram independently. The main drawback of brightness preservation methods is that sometimes they may produce unnatural artifacts because some regions may be enhanced excessively.

The paper is organized as follow. Section 2 illustrates the related works followed, in Section 3 presents the Proposed weighted techniques of image enhancement. Section 4 presents the experimental results. Section 5 represents conclusion, Section 6 represents the Future scope. Section 7 represents **References.**

II. RELATED WORK

X. Fang et al. [1] proposed a method to improve the enhancement result with image fusion method with evaluation on sharpness. Image enhancement can improve the perception of information

C. Wang and Z. Ye [2] proposed a novel extension of histogram equalization, actually histogram specification, to overcome such drawback as HE (HISTOGRAM EQUALIZATION). To maximize the entropy is the essential idea of HE to make the histogram as flat as possible

Mary Kim and Min Gyo Chung[3]Recursively separated and weighted histogram equalization for brightness preservation and contrast enhancement

Chen Hee Ooi, Nicholas Sia Pik Kong, and Haidi Ibrahim[4]Bi-Histogram Equalization with a Plateau Limit for Digital Image Enhancement

Pei-Chen Wu, Fan-Chieh Cheng, and Yu-Kumg Chen[5]A Weighting Mean-Separated Sub-Histogram Equalization for Contrast Enhancement

S. D. Chen and A. Ramli [6-7] proposed a generalization of BBHE referred to as Recursive Mean-Separate Histogram Equalization (RMSHE) to provide not only better but also scalable brightness preservation

Y. Wang, Q. Chen [8] presented a novel histogram equalization technique equal area dualistic sub image histogram equalization, is put forward in this paper. First, the image is decomposed into two equal area sub images based on its original probability density function

Y. T. Kim [9] proposed a novel extension of histogram equalization to overcome such drawback of the histogram equalization

D. Rajan and S. Chaudhuri [10] presented two new techniques of using data fusion, based on the modality of the data generation process, to generate a super resolved image from a sequence of low resolution image intensity data

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III. PROPOSED WEIGHTED TECNIQUE FOR IMAGE ENHANCEMENT

In this study, an image fusion based approach, called weighted technique, will be proposed for image enhancement. Image fusion have been widely developed for producing high quality images in applications such as remote sensing, medical imaging, high dynamic range imaging ,multi-focus imaging.

The proposed weighted technique approach works on pixel value, Image fusion algorithm could be applied on greyscale images or colour images.

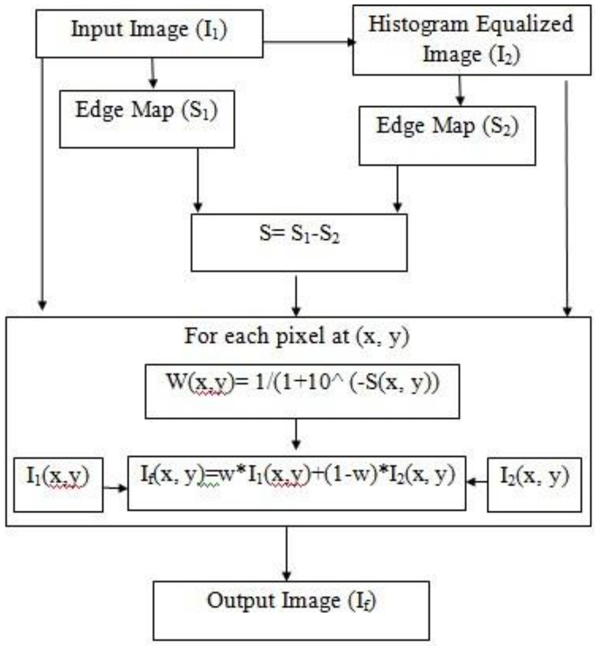
Flowchart of Image Fusion:-

Image fusion algorithm could be applied on greyscale images or colour images. The fusion algorithms for both greyscale as well as color images are described below:

Greyscale Images:-

The outline of the fusion algorithm for greyscale images is as follows:

1. Let the input image is I1.
2. Compute the conventional histogram equalized image I2 from I1.
3. Calculate magnitude gradient of I1 using Sobel operator to get the edge map S1.
4. Calculate magnitude gradient of I2 using Sobel operator to get the edge map S2.
5. Calculate S = S1 – S2.
6. Calculate the absolute maximum value of matrix S.
7. Normalize the matrix S with the absolute maximum value.
8. For each pixel located at position (x, y) repeat the following steps:
9. Calculate $w = \frac{1}{1+10^{-S(x,y)}}$. This function is used for weighting each pixel based on the strength of edges of I1 and I2. If S1(x, y) > S2(x, y), then I1(x, y) is given the higher weight age and I2(x, y) the lower weight age. But if S2(x, y) > S1(x, y), then I2(x, y) is given the higher weight age and so on.
10. Use the value of w to find the fused image If(x, y).



Colour Images

1. For colour images the process is outlined below:
2. Let the input image is I1.
3. Compute the conventional histogram equalized image I2 from I1. For this step histogram equalization is carried out for each of the channels i.e. R, G and B channels are equalized independently and finally combined.
4. Calculate the gradient of I1 using to get the edge map S1.
5. Calculate the gradient of I2 using to get the edge map S2.
6. Calculate S = S1 – S2.

7. Calculate the absolute maximum value of matrix S.
8. Normalize the matrix S with the absolute maximum value.
9. For each pixel located at position (x, y) repeat the following steps:
10. Calculate $w = \frac{1}{1+10^{-S(x,y)}}$.
11. Use the value of w to find the fused image If(x, y). This step is repeated for each R, G and B channel.
12. Finally combine the R, G and B channels to get the output fused image. The flowchart for color image fusion is same except the fusion is carried out on the three channels simultaneously.

Gradients

For a function f(x, y), the gradient of f at (x, y) is defined as the two dimensional column vector

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad (3.1)$$

The magnitude of this vector is given by

$$|\nabla f| = \left[\left(\frac{\partial f}{\partial x} \right)^2 + \left(\frac{\partial f}{\partial y} \right)^2 \right]^{1/2} \quad (3.2)$$

The first order derivative of a one dimensional function f(x) is the difference

$$\frac{\partial f}{\partial x} = f(x+1) - f(x) \quad (3.3)$$

The simplest approximations [1] to the first order derivative are

$$G_x = (z_8 - z_5) and G_y = (z_6 - z_5) \quad (3.4)$$

Masks of even size are awkward to implement. The smallest filter mask is of size 3 × 3. An approximation using absolute values still at point z5 but using 3 × 3 mask is

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3) \quad (3.5)$$

$$G_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7) \quad (3.6)$$

The difference between the first and third rows of the 3 × 3 image region approximates the derivative in the x-direction, and the difference between the transition in gray level. In practice optics, sampling and other image acquisition imperfections yield edges that are blurred, with the degree of blurring being determined by factors such as the quality of the image acquisition system, the sampling rate, and illumination conditions under which the image is acquired. Instead an edge point now is any point contained in the ramp, and an edge would then be a set of such points that are connected. The thickness of the edge is determined by the length of the ramp, as its transition from an initial to a final grey level.

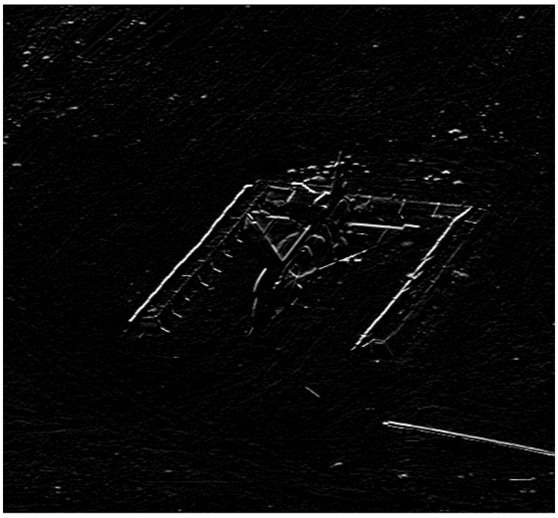
Z1	Z2	Z3
Z4	Z5	Z6
Z7	Z8	Z9

Figure 3.1: Filter Mask [1].

The slope can be calculated using derivatives and therefore the magnitude of the first derivative can be used to detect the presence of an edge point in an image. The magnitude of the gradient gives the maximum rate of increase of f(x, y) per unit distance in the direction of gradient. Edges are calculated as the difference between the pixel values. Greater is the difference between the pixels greater is the strength of the edge. Since gradient gives the maximum rate of change between the pixel values it can be used to calculate the strength of the edges. Therefore the masks which are used to calculate the gradients can also be used to calculate the strength of edges.

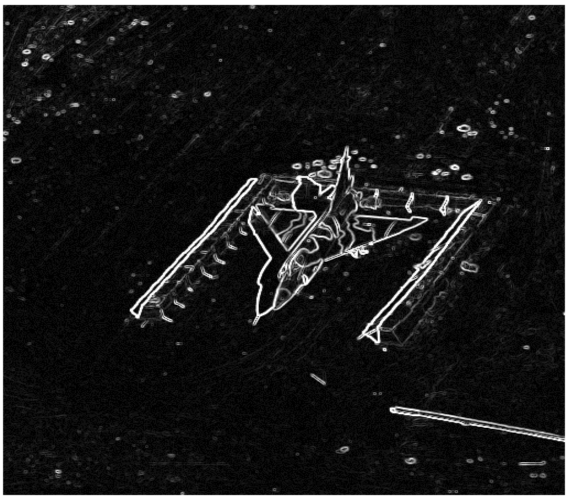
third and first columns approximates the derivatives in the y-direction. These masks shown in equation are called Sobel operators. A general pattern of the mask is also shown in figure 3.1. Weight value of 2 is used to achieve some smoothing by giving more importance to the centre point. An edge is a set of connected pixels each of which is located at an orthogonal step

(a) Original image



(b) Image after applying x-direction Sobel mask

(c) Image after applying y-direction Sobel mask



(d) Image after calculating gradient

Figure 3.2: Edge detection

The slope can be calculated using derivatives and therefore the magnitude of the first derivative can be used to detect the presence of an edge point in an image. The magnitude of the gradient gives the maximum rate of increase of f(x, y) per unit distance in the direction of gradient. Edges are calculated as the difference between the pixel values. Greater is the difference between the pixels greater is the strength of the edge. Figure 3.2 shows an airplane image and its gradient to detect the edges. Hence gradient of an image is an important parameter for analyzing the image. In case of colour images to calculate the gradient the direct approach is to calculate the gradient of each R, G and B channels independently and combine them, but this direct approach given misleading results. For color images following equations are used [1] for calculating the gradient and hence the edges of the image:

$$g_{xx} = \left(\frac{\partial R}{dx}\right)^2 + \left(\frac{\partial G}{dx}\right)^2 + \left(\frac{\partial B}{dx}\right)^2 \quad (3.7)$$

$$g_{yy} = \left(\frac{\partial R}{dy}\right)^2 + \left(\frac{\partial G}{dy}\right)^2 + \left(\frac{\partial B}{dy}\right)^2 \quad (3.8)$$

$$g_{xy} = \frac{\partial R}{dx}\frac{\partial R}{dy} + \frac{\partial G}{dx}\frac{\partial G}{dy} + \frac{\partial B}{dx}\frac{\partial B}{dy} \quad (3.9)$$

$$\theta = \frac{1}{2}\tan^{-1}\left[\frac{2g_{xy}}{g_{xx} - g_{yy}}\right] \quad (3.10)$$

$$F(\theta)=\left\{\frac{1}{2}\left[\left(g_{xx}+g_{yy}\right)+\left(g_{xx}-g_{yy}\right)\cos 2\theta+2g_{xy}\sin 2\theta\right]\right\}^{1/2} \quad (3.11)$$

Here gxx, gyy, gxy are the gradients in x, y and x-y directions respectively and θ is the direction of maximum gradient. F (θ) represents the gradient of the colour image.

Design of Weight Function

As shown for fusing the two images weight w is used. The value of w can lie in the range [0, 1]. Detail aware contrast enhancement method assigns weights manually. In order to automate the process of image fusion the calculation of this weight value needs to be automated. For pixel-by-pixel fusion of the two images this weight value must be calculated for each possible pixel location in the images. Based on the strength of edges in the two source images two cases are possible

1. If S1(x, y) > S2(x, y) i.e. edge at location (x, y) in image I1 is greater than the edge at location (x, y) in I2.
   In this case the pixel in image I1 i.e. I1(x, y) must be given the higher weight age and I2(x, y) the lower weight age.
2. If S2(x, y) > S1(x, y) i.e. edge at location (x, y) in image I2 is greater than the edge at location (x, y)in I1.
   In this case the pixel in image I2 i.e. I2(x, y) must be given the higher weightage and I1(x, y) the lower weightage

For implementing the above two cases we use equation of the form $w=\frac{1}{1+\alpha^{-x}}$ where $x\in[-1,1]$ and $\alpha>1$. The variation of w with value of α = {2, e = 2.7183, 10} in the interval $x\in[-1,1]$ is shown in Fig 1.

From Figure 3.3 it is clear that α = 10 cover the maximum range of values in the interval $w\in[0,1]$ so we will use 10 as the value of α. Although higher values of α can be used but α = 10 seems to cover almost the entire range of w so we will be using it in the fusion algorithm. The minimum and maximum values for the three values of α are shown in the table .

A	Minimum	Maximum
2	0.3333	0.6667
e = 2.7183	0.2689	0.7311
10	0.0909	0.9091

Table 3.1: Minimum and maximum values of w for various values of α.

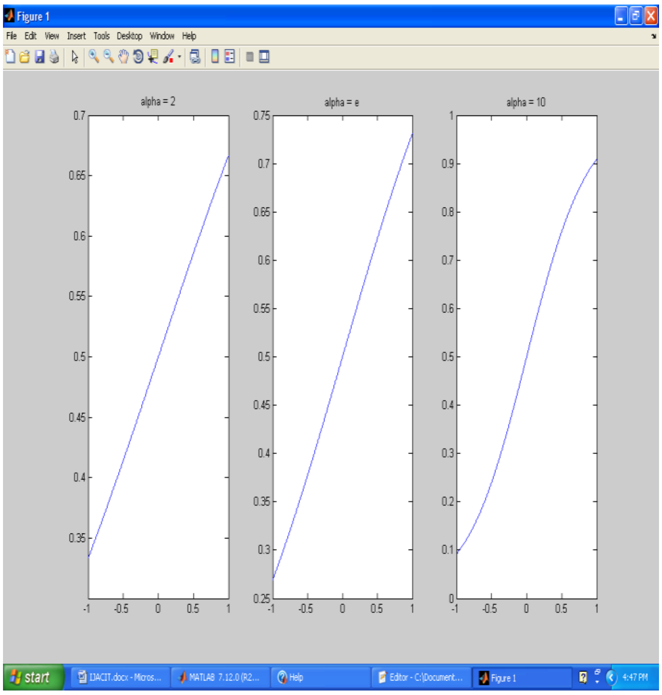


Figure 3.3: Variation of w with α= 2, α = e = 2.7183, α = 10.

IV. EXPERIMENTAL RESULTS

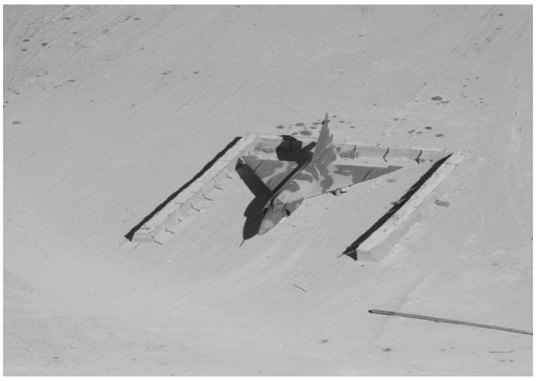
For Greyscale Images

In this section we apply the fusion algorithm described above on a set of images. The analysis of the simulation is based on subjective and objective analysis. The information in the output fused image is the weighted sum of information in the original source image and histogram equalized image. We can subjectively analyze from the fused airplane image that it contains information of both the source images. In subjective analysis human ingenuity is used to verify the results.

Objective methods used for the measurement of image fusion performance are statistical in nature. Here we used the standard deviation, average gradient and entropy for comparing the original image and the fused image. Standard deviation is the deviation about mean. It represents the dynamic range of values present in an image about the mean. Average gradient is used for measuring the clarity of the image. Entropy is the measure of randomness or amount of information present in the image. More is the entropy more is information present in the image.

In the first airplane image, the track become clear after histogram equalization but key information is lost then final fused image obtained consist of both the key information and visibility of the track. In the second image of road map, road become clear after histogram equalized image but some information is lost, then final fused image comprise both key information of the original image and visibility as that of histogram equalized image. Third image comprised a view of the bridge which shows better results after applying the algorithm as compare to original and histogram equalized image. Last image comprised a crowd view in which many people are sitting, the image become clear after histogram equalization but key information is lost then final fused image obtained consist of both the key information and visibility of the crowd.

The simulation results of these images are shown below. We are interested in relative changes between source and fused images.



(a) Original Image

(b) Histogram Equalized Image

(c) Final Fused Image

Figure 4.1: Greyscale Image Fusion [2].

It is clear from the figure 4.1 that visibility of final fused image is greater than the original image or it can be said that final fused image contain more information than original image.

Performance Parameter	Original Image	Fused Image
Standard Deviation	0.0867	0.1867
Average Gradient	0.1055	0.2857
Entropy	4.0045	6.3641

Table 4.1: Comparison between original and fused images using Statistical Parameter.

It can easily find out that the output fused image has greater standard deviation, average gradient and entropy as compared the original image. This means that the output fused image has greater contrast, better clarity and more information as compared to the original image.

(a) Original Image

(b) Histogram Equalized Image

(c) Final Fused Image

Figure 4.2: Greyscale Image Fusion.

It is clear from the figure 4.2 that visibility of final fused image is greater than the original image or it can be said that final fused image contain more information than original image.

Performance Parameter	Original Image	Fused Image
Standard Deviation	0.0911	0.2004
Average Gradient	0.1683	0.3091
Entropy	6.1502	7.1729

Table 4.2: Comparison between original and fused images using Statistical Parameter.

It can easily find out that the output fused image has greater standard deviation, average gradient and entropy as compared the original image. This means that the output fused image has greater contrast, better clarity and more information as compared to the original image.

For Colour Images

For colour images the results of subjective analysis is shown in figure below. As shown in the figure the result of fused image tends to enhance the details of the original image. The colour histogram equalized image is produced by equalizing each of the three R, G and B channels. The histogram equalized images over enhances the original colour image and hence may involve significant colour changes. The fusion of the original image with the histogram equalized image tends to reduce these significant changes in the colour levels. A small amount of variation in colour is fruitful as it gives some insightful information about the original image. This is depicted in the fusion of Fig. 4.2(c). Image fusion of the original and equalized images tends to reduce the large amount of changes in the colour.

(a) Original Image

(b)Histogram Equalized Image

(b) Final Fused Image

It is clear from the figure 4.1 that visibility of final fused image is greater than the original image or it can be said that final fused image contain more information than original image.

(a)Original Image

(b)Histogram Equalized Image

(c) Final Fused Image

Figure 4.6: Colour Image Fusion.

It is clear from the figure 4.6 that visibility of final fused image is greater than the original image or it can be said that final fused image contain more information than original image. The result of fused image tends to enhance the details of the original image. The color histogram equalized image is produced by equalizing each of the three R, G and B channels. The histogram equalized images over enhances the original color image and hence may involve significant color changes. The fusion of the original image with the histogram equalized image tends to reduce these significant changes in the color levels.

V. CONCLUSION

We implemented the image fusion algorithm for both grayscale and color images. we simulated the fusion algorithm on a set of grayscale and color images. Now we analyze the results obtained during the simulation of the fusion algorithm.

For grayscale images consider the airplane image. When we histogram equalize it using the conventional histogram equalization the details which were not clear in the original image gets exposed here. Consider the track that gets visible after the histogram equalization. This happens because histogram equalization enhances the contrast of the original image. But the disadvantage of using histogram equalization is that it over enhances the original image. Because of this the key information that was present in the original image gets lost in the histogram equalized image. In other words, original image and histogram equalized image contains complementary information. This is clear from the original airplane and histogram equalized airplane image. We can utilize this complementary relation between the two images by using the fusion algorithm described to produce output fused image. The information in the output fused image is the weighted sum of information in the original source image and histogram equalized image. We can subjectively analyze from the fused airplane image that it contains information of both the source images.

Our claim that the fused image is the enhanced version of the original image is supported by the objective analysis of original image and the fused image. This can be easily found that the output fused image has greater standard deviation, average gradient and entropy as compared the original image. This means that the output fused image has greater contrast, better clarity and more information as compared to the original image.

Similar arguments can be given for the enhancement of colour images. one can easily say that output fused image is the enhanced version of the input image merely on the basis of subjective analysis. The enhancement in case of colour images involves variation in colour information and it is this variation in colour information which is responsible of input image enhancement. It is to be noted that fusion of the histogram equalized image with the original image keeps the colour change within limits.

VI. FUTURE SCOPE

While designing image enhancement techniques the speed of execution of the program is also an important factor. Therefore, the fusion algorithm can be optimized for speed in future research. Also future research can also be done to compare the performance of fusion algorithm on colour images objectively.

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