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Fusion of Multi-Focus and Multi-Exposure Images by Enhance the YCbCr Channel Information in Gradient Domain

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Abstract: Image fusion is one of the important aspects in the field of computer vision. Image fusion is the process of combining several images into a single image. Due to image fusion process the fused image has more information than individual images. There are several state-of-art techniques are available for image fusion in that gradient based guided filter is one of the most prominent technique. In this paper, initially the image converts from RGB to YCbCr after that performs the gradient operations on Y (Luminance) Channel and Chrominance channel (CbCr) separately. Reconstruct the Luminance channel from gradient domain using Wavelets with Poisson Solver refinement at each resolution. On the other hand chrominance fusion obtained as a weighted mean of the chrominance channels. Finally fuse the enhanced luminance channel based on guided filter and chrominance channels.

Keywords: Image Fusion, Luminance Channel, Chrominance Channel, Wavelets, Guided Filter.

I. INTRODUCTION

Optical lenses, particularly those with long focal lengths, suffer from the problem of limited depth of field. Due to that, the image obtained by the lenses will not be in focus everywhere, i.e., if one object in the scene is in focus, another one will be out of focus. A possible way to overcome this problem is by image fusion, in which several pictures with different focus points are combined to form a single image. This fused image will contain all relevant objects in focus. The term fusion means in general an approach to extraction of information acquired in several domains. In computer vision, image fusion is the process of combining the relevant information from two or more images into a single image. The resulting image will have more information than the input images. Image fusion has been used in many application areas like remote sensing, astronomy, medical imaging (Evaluation of CT, MRI, and/or PET images), military, security, and surveillance areas etc. There are several image fusion [1-3] approaches are present in that fusion in the gradient domain has been recently studied by some researchers. Socolinsky and Wolf [4] proposed an image fusion approach which integrates information from a multi-spectral image dataset to produce a one band visualization of the image. They generalize image contrast, which is closely related to image gradients, by defining it for multi-spectral images in terms of differential geometry. They use this contrast information to reconstruct the optimal gradient vector field, to produce the fused image. Later, Wang et al [5] fused the images in gradient domain using weights dependent on local variations in intensity of the input images. At each pixel position, they construct an importance-weighted contrast matrix. The square root of the largest eigenvalue of this matrix yields the fused gradient magnitude, and the corresponding eigenvector gives the direction of the fused gradient. In this paper, a gradient-based image fusion algorithm is proposed. The algorithm proposed here works for the fusion of both color as well as grayscale images.

II. ALGORITHM IMPLEMENTATION

In this section, a new image fusion algorithm is proposed. The proposed algorithm can be applied to fuse together a sequence of either color or grayscale images (minimum two images). A flowchart of the algorithm in its most general case (i.e., fusion of multiple color images) is illustrated in Figure1. The proposed algorithm operates in the YCbCr color space. The luminance (Y) channel represents the image brightness information and it is in this channel where variations and details are most visible, since the human visual system is more sensitive to luminance (Y) than to chrominance (Cb, Cr). This important observation has two main consequences for the proposed fusion algorithm. Firstly, it indicates that the fusion of the luminance and chrominance channels should be done in a different manner, and that it is in the luminance channel where the most advanced part of the fusion is to be performed. Secondly, it reveals that the same procedure used for the luminance channels fusion can be used to fuse single channel images (i.e., images in grayscale representation). In what follows, the proposed luminance fusion technique is described, followed by chrominance fusion.

III. LUMINANCE FUSION

The luminance fusion can be carried out on grayscale images, or on color images that are in the YCbCr color coordinate system. If the input images are in RGB representation, conversion to YCbCr should be performed first. Luminance fusion is performed in the gradient domain. This domain choice is motivated by the fact that the image gradient depicts information on detail content, to which the human visual system is more sensitive under certain illumination conditions. For example, a blurred, over- or under-exposed region in an image will have a much lower gradient magnitude of the luminance channel than the same region in an image with better focus or exposure. This observation implies that taking the gradients with the maximal magnitude at each pixel position will lead to an image which has much more detail than any other image in the stack.

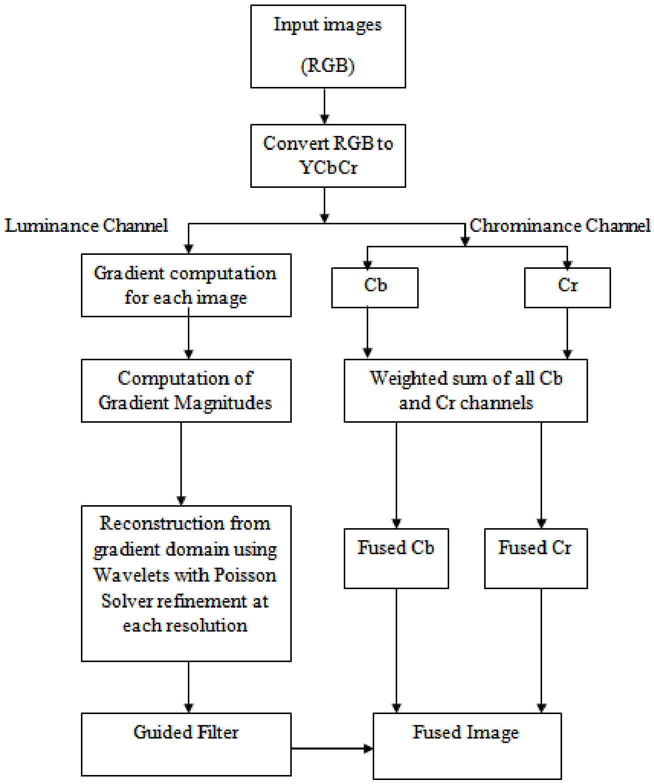

Fig1.Flowchart of Proposed Method.

Let the luminance channels of a stack of N input images be I = {I_1, I_2....I_N}, where N ≥2. According to a commonly employed discretization model, the gradient of the luminance channel of the nth image in the stack may be defined as:

$$\emptyset_n^x(x,y) = I_n(x+1,y) - I_n(x,y) \quad (1)$$

$$\emptyset_n^y(x,y) = I_n(x,y+1) - I_n(x,y) \quad (2)$$

Where $\emptyset_n^x$ and $\emptyset_n^y$ are the gradient components in the x- and y-directions. The magnitude of the gradient may be defined as

$$H_n(x,y) = \sqrt{\emptyset_n^x(x,y)^2 + \emptyset_n^y(x,y)^2} \quad (3)$$

Let the image number having the maximum gradient magnitude at the pixel location (x, y) be p(x, y). It may be mathematically represented as

$$p(x,y) = \max_{1\le n\le N} H_n(x,y) \quad (4)$$

Using (4), the fused luminance gradient may be represented as

$$\emptyset^x(x,y) = \emptyset_{p(x,y)}^x(x,y) \quad (5)$$

$$\emptyset^y(x,y) = \emptyset_{p(x,y)}^y(x,y) \quad (6)$$

Where $\emptyset_{p(x,y)}^x(x,y)$ and $\emptyset_{p(x,y)}^y(x,y)$ denote the values of the x and y gradient components of the image with index p(x, y), at pixel position (x, y). So, the fused luminance gradient is $\emptyset = [\emptyset^x, \emptyset^y]^T$. It may be noted that the fused luminance gradient has details from all the luminance channels from the stack and in order to get the fused luminance channel, reconstruction is required from the gradient domain.

Further enhancement of luminance channel is obtained by guided filter [6]. The guided filter follows following steps

1. Read the image says I(gray scale image), it acts as a guidance image.
2. Make p=I, where p acts as our filtering image (gray scale image).
3. Enter the values assumed for r and ε, where r is the local window radius and ε is the regularization parameter.
4. Compute the mean of I, p, I*p.
5. The compute the covariance of (I,p) using the formula:-
   cov_Ip=mean_Ip -mean_I.*mean_p;
6. Then compute the mean of (I*I) and use it to compute the variance using the formula:-
   var_I= mean_II - mean_I .* mean_I
7. Then compute the value of a, b. where a, b are the linear coefficients.
8. Then compute mean of both a and b.
9. Finally obtain the filtered output image q by using the mean of a and b in the formula
   q = mean_a .* I + mean_b;

IV. CHROMINANCE FUSION

Chrominance fusion is to be carried out for the fusion of the input chrominance channels of color images in YCbCr representation (i.e., grayscale images). If the input images are in RGB representation, conversion to YCbCr should be performed first, to obtain the luminance (Y) and chrominance (Cb, Cr) channels representation. If the input images are in single channel (e.g., grayscale representation), this step does not apply. Inherently different than luminance fusion, chrominance fusion operates directly on chrominance values, as opposed to their gradients. Specifically, the chrominance fusion is done by taking a weighted sum of the input chrominance channels. The values in the chrominance channels have a range from 16/240 and carry information about color. These channels are such that when both Cb and Cr are equal to 128, the image is visually similar to a grayscale image, and thus carries the least amount of color information.

V. RESULTS AND DISCUSSIONS

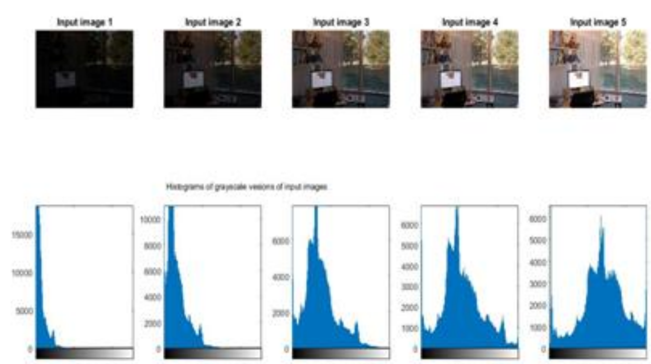

Fig2. Fusion Set of “office.jpg” image and its Histograms.

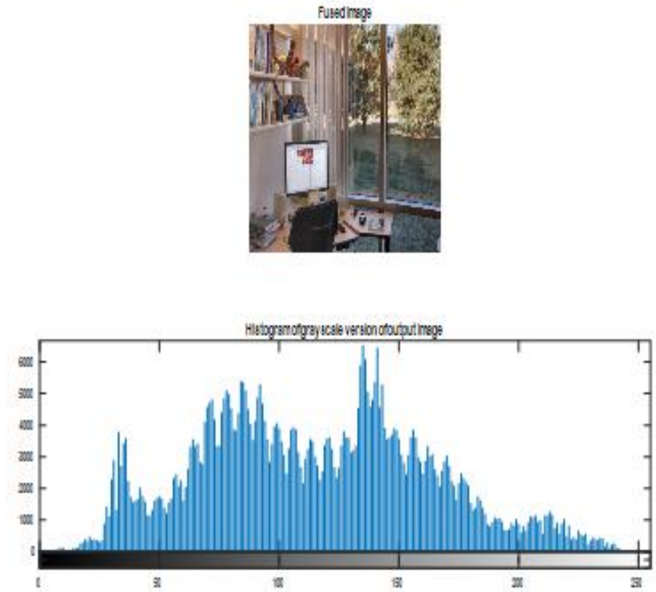

Fig3. Fused image of “office.jpg” and its Histogram.

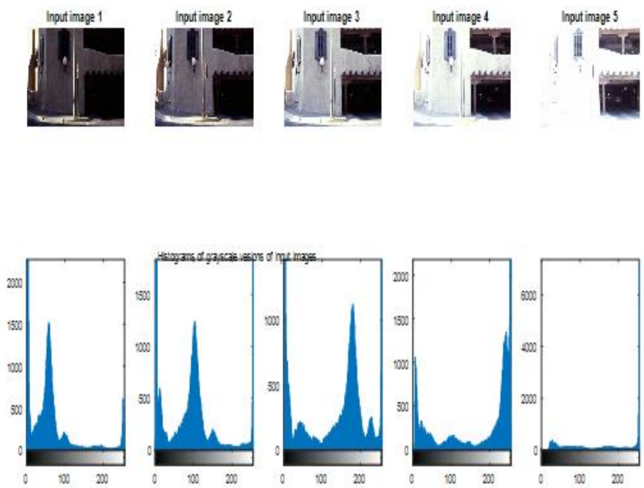

Fig4. Fusion Set of “garage.jpg” image and its Histograms.

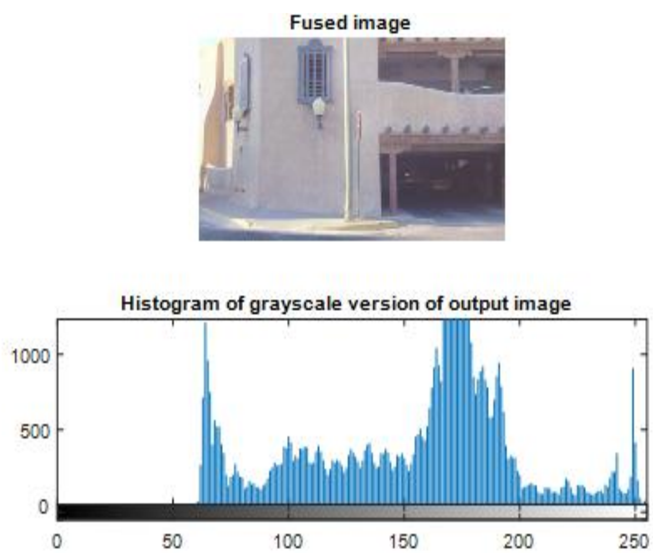

Fig5. Fused image of “garage.jpg” and its Histogram.

Table1. Location of Histogram of various source images

Image	Histogram					
	image 1	image 2	image 3	image 4	image 5	Fused image
Office	Towards Low Intensity Levels	Towards Low Intensity Levels	Towards Low Intensity Levels	Towards Middle Intensity Levels	Entire Intensity Levels	Entire Intensity Levels
Garage	Towards Low Intensity	Towards Low Intensity	Entire Intensity Levels	Entire Intensity Levels	Towards High Intensity Levels	Towards Medium-High Intensity Levels

From figure 2, the first image the details within the office are not visible but as contrast incremented the details within the office images are visible. Therefore From figure 2 and table 1, it may be observed as contrast incremented the location of histogram moves toward the higher intensity levels and also information within the images is also increases. The proposed algorithm fuses all input images properly and then obtain fused image which is shown figure 3.

VI. CONCLUSION

In this paper, a new method is proposed to fuse the multi-focus and multi-exposure images by maximizing the chrominance and luminance channel information in gradient domain. Here fusion of luminance channel and chrominance channel are done separately. The fusion of the luminance channel is done in the gradient domain and is obtained based on wavelet-based gradient integration algorithm. The fusion of the chrominance channels is obtained by weighted sum of the chrominance channels of the source images. Finally fuse the enhanced luminance channel based on guided filter and chrominance channels.

VII. REFERENCES

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