

Dynamic histogram equalization, PCA & MAX-DCT based multi-focus image fusion

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Abstract: The idea of image fusion in multi-focus cameras to combine data from various images of the similar landscape in order to bring the multi focused image. Discrete cosine transform is an image fusion method which is extra appropriate and acceptable in real-time systems using discrete cosine transform based standards of motionless image or video. This review paper shows an arranged approach for fusion of multi-focus images which is based on variance calculated in discrete cosine transform domain. In this paper a new technique is proposed which will combine the PCA, Max-DCT and dynamic histogram equalization to raise the outcome. The proposed algorithm is calculated and implemented in MATLAB using image processing toolbox. The experiments have shown that the proposed algorithm outperforms over the available techniques.

Index Terms: Image fusion, Multi-focus, Visual Sensor, DCT, and PCA.

1. Introduction

Visual sensor network [2] is a network of spatially distributed smart camera appliance able of processing and fusing images of a landscape from a variety of perspective into several forms further helpful than the single images. A visual sensor network may be a kind of wireless sensor system. The network usually consists of the cameras themselves, which have several local image processing, transmission and storage space potential, and perhaps additional central computers, where image information from many cameras is more fused. Visual sensor networks too offer a number of advanced services to the client so that the huge quantity of information can be refined into information of interest using specific queries.

The main dissimilarity between visual sensor networks and other kinds of sensor networks is the environment and quantity of data the single sensors obtain: mainly sensors, cameras are directional in their field of view, and they catch a huge quantity of visual information which might be partially processed separately of data from other cameras in the network.

Image fusion [4] is a procedure of combining the related information from multiple images into a single image where the fused image will be more useful and accomplish than some

of the input images. Image fusion means the combining of multiple images into a sole image that has the utmost information content without producing facts that are missing in a given image. It is now probable to get information from multi-origin images to create a high class fused image with spatial and spectral information. The outcome of image fusion is a fresh image that keeps the most attractive information and characteristics of input image. Some conditions in image processing want high spatial and high spectral motion in a single image. In remote sensing, multi sensor fusion is used to attain high spatial and spectral motion by merging images from multiple sensors. The fused image can have balancing spatial and spectral resolution characters.

2. Adaptive Histogram Equalization

Adaptive histogram equalization is a computer image processing technique used to recover contrast in images. Adaptive histogram equalization is an excellent contrast enhancement for both natural images and medical images and other initially non visual images It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute lightness value of the image. In image fusion process, fusion process may degrade the sharpness of the fused image so to overcome this problem of poor brightness adaptive histogram equalization will be used to enhance the results further. We

can say that adaptive histogram equalization will come in action to preserve the brightness of the fused image.

Need of adaptive histogram equalization: Convert the reference image to cosine transform. Then inverse cosine transform is applied to reference image. When inverse cosine transform is applied then noise is occurred in fused image then adaptive histogram is applied to remove noise and color artifacts which will introduced due to transform domain method i.e. DCT

3. Image Fusion Technique



Fig 1(a) Right blurred image [1]

Fig 1(a) is showing the right blurred image and fig 1(b) is showing the left blurred image. The objective is to unite important information from various images into a single image that is more informative for both visual perception and computer processing



Fig 1 (b) Left blurred image [1]

A. Discrete wavelet transform

The discrete wavelet transform of image signals produce a non-redundant image representation; it can provide better spatial and spectral localization of image information as compared to other multi resolution representations. Therefore, the DWT based method has been popular widely used for image fusion. The basic idea of image fusion based on DWT is to perform multi resolution decomposition on each source image; the coefficients are then performed with a certain fusion rule. After that, the fused image is obtained by performing the inverse DWT (IDWT) for the corresponding combined wavelet coefficient.

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-a}{a}\right), (a, b \in \mathbb{R}), a > 0$$



Fig 2 DWT based image fusion [1]

B. Discrete cosine transform

The technique uses a contrast measure as selection criterion to combine the several blurred images in a single good quality image. This contrast measure is based on the transformation of the image from the spatial domain to the frequency domain through the computation of the DCT. The DCT technique is a algorithm that work on the frequency domain. This technique divide the image in fixed size blocks in order to decide which source image should be selected to constitute the final resulting image. DCT is an important transformation used in digital image processing. DCT based image fusion are more suitable and time saving in real time system using DCT based standard of still image or video. DCT based fusion is one of the best applications of the DCT based algorithms.

DCT are important to application in engineering, science and image compress. For simplicity, DCT can convert the spatial domain image to frequency domain image. Contrast can be defined as the variation in luminance and/or colors between the pixels in an image, which makes scene objects more distinguishable. Strictly speaking, contrast is not directly related focus but it has a strong relationship with good quality in images. The technique uses a contrast measure as selection criterion to combine the several blurred images in a single good quality image. This contrast measure is based on the transformation of the image from the spatial domain to the frequency domain through the computation of the DCT.

Two dimensional DCT transform of an $N \times N$ image block $f(x, y)$ [8] is given as

$$F(u,v) = \frac{2}{N} c(u)c(v) \sum_{y=0}^{N-1} \sum_{x=0}^{N-1} f(x,y) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \times \cos\left[\frac{(2y+1)v\pi}{2N}\right]$$

Where $u,v=0,1,\dots,N-1$ and

The inverse transform is defined as

$$f(x,y) = \frac{2}{N} c(u)c(v) \sum_{v=0}^{N-1} \sum_{u=0}^{N-1} c(u)c(v) f(u,v) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \times \cos\left[\frac{(2y+1)v\pi}{2N}\right]$$



Fig 3 DCT based Image fusion [1]



Fig 5 Final proposed image [1]

C. Principal component analysis

PCA is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is used extensively in image classification and image compression. The PCA involves a mathematical formula that transforms a number of correlated variables into a number of uncorrelated variables called principal components. It computes a compact and optimal description of the data set. The first principal component accounts for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. Within this Subspace, this component points the direction of maximum variance. The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on



Fig 4 PCA based image fusion [1]

Output image taken by the DCT and PCA based image fusion with nonlinear enhancement. The image has contained the balanced color and brightness as the original images to be fused. The quality of output image is fairly superior with our proposed method with respect to all the techniques discussed.

4. Gaps in Literature Survey

The related work on image fusion algorithms has shown that the existing algorithms are time consuming in nature and also degrades the brightness of the fused images. The main reason behind this is that the most of researchers have neglected one of the following or both:

1. No appropriate image enhancement technique is used to overcome the poor brightness of the fused image.
2. No transform domain method is used to speed up the fusion algorithms.
3. No method is considered for complex background images so it becomes difficult to fused images with complex background.

5. Problem definition

The main objective of image fusion is to combine information from multiple images of the same scene in order to deliver only the useful information. The discrete cosine transforms (DCT) based methods of image fusion are more suitable and time-saving in real-time systems using DCT based standards of still images. In this dissertation an efficient approach for fusion of multi-focus images based on variance calculated in DCT domain is presented. This research work propose a new technique which will integrate the higher valued Alternating Current (AC) coefficients calculated in Discrete Cosine Transform (DCT) domain based fusion with principle component analysis (PCA) and adaptive histogram equalization to reduce the color artifacts which will be introduced due to the transform domain method i.e. DCT. The fusion process may degrade the sharpness of the fused images so to overcome this problem adaptive histogram equalization will be used to enhance the results further. The use of PCA is for increasing the speed of the AC-DCT based fusion method; because in color images AC-DCT will be applied on each color separately which is time consuming in nature.

To do the performance analysis different metrics will be considered in this dissertation. The performance of image fusion is usually evaluated in terms of accuracy, PSNR and speed etc.

6. Research methodology

To attain the objective, step-by-step methodology is used in this dissertation. Subsequent are the different steps which are used to accomplish this work. Following are the various steps used to accomplish the objectives of the dissertation.

The steps are as follows:

Proposed algorithm

Step 1: Input images: Input 2 images image 1 and image 2 in which image1 is left blurred and image 2 is right blurred.

Step 2: RGB2PCA: Now RGB to PCA conversion will be done based upon the certain vector values. Also division of each PCA image will also be done into PCA1, PCA2 and PCA3.

Step3: Apply AC-DCT based fusion: The next step is to apply AC-DCT based fusion on first PCA as highest variations found on the first PCA plane. And chrominance fusion will come in action for other PCA planes i.e. PCA2 and PCA3.

Step4: Concatenation: Now concatenate the result of each plane and get the fused image.

Step5: Dynamic histogram equalization: Now dynamic histogram equalization will come in action to preserve the brightness of the fused image.

7. Experimental set-up

In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. In order to do cross validation we have also implemented the enhanced DCT based image fusion using nonlinear enhancement. The developed approach is compared against some well-known image fusion techniques available in literature. After these comparisons, we are comparing proposed approach against DCT using some performance metrics. Result shows that our proposed approach gives better results than the existing techniques.

7.1 Experimental results

Figure 6(a) has shown the input images for experimental analysis. Fig. 6(a) is showing the left blurred image and fig. 6 (b) is showing the right blurred image. The main objective of image fusion is to combine useful information from various images into a single image which is extra informative and fit for both visual perception and further computer processing.



Fig 6(a) Left blurred image



Fig 6(b) Right blurred image



Fig 7 Max-DCT based image fusion

Figure 7 has shown the output image taken by Max-DCT. The output image has contained too much brightness and color imbalance as compare to original blurred images to be fused.

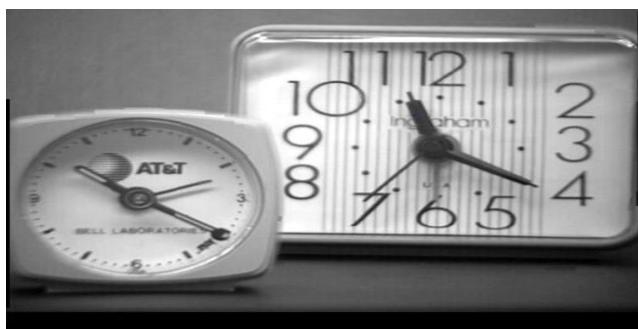


Fig 8 Final proposed image

Figure 8 has shown the output image taken by the proposed image fusion with dynamic histogram stretching. The image has contained the balanced color and brightness as the original images to be fused. The superiority of output image is fairly

good with our proposed method with respect to all the techniques discussed.

8. Performance analysis

This section hold the cross validation between existing and proposed techniques. This section shows some familiar image performance parameters for digital images which have been chosen to show that the performance of the proposed algorithm is quite superior to the existing methods.

8.1 Mean Square Error Evaluation

Table 1 is showing the quantized analysis of the mean square error. When mean square error is reduced then the proposed algorithm is showing the better result than the available methods as mean square error is less in every case.

Table 1 Mean Square Error Evaluation

Images	Max-DCT	Proposed
Image1	40	4
Image2	11	8
Image3	1	0.987
Image4	2	2
Image5	3	1
Image6	11	4
Image7	1	0.764
Image8	8	0.758
Image9	8	1
Image10	65	6

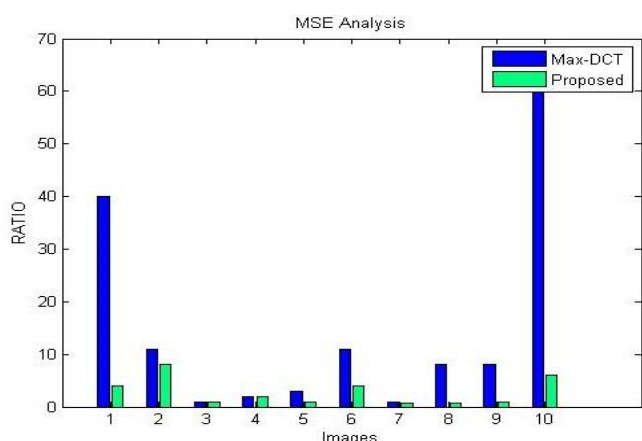


Fig 9 MSE of MAX-DCT & Proposed Approach for different images

Figure 9 has shown the quantized analysis of the mean square error of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color). It is very clear from the plot that there is decrease in MSE value of images with the use of proposed

method over other methods. This decrease represents enhancement in the objective quality of the image.

8.2 Peak Signal to Noise Ratio Evaluation

Table 2 Peak Signal to Noise Ratio Evaluation

Images	Max-DCT	Proposed
Image1	64.0309	82.4717
Image2	75.2049	77.3510
Image3	93.0782	98.0330
Image4	46.9695	89.6805
Image5	85.3504	90.7525
Image6	54.9511	82.9654
Image7	93.3311	98.5240
Image8	78.1538	98.2394
Image9	77.4619	92.7624
Image10	39.9786	80.4440

Table 2 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Table 2 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods

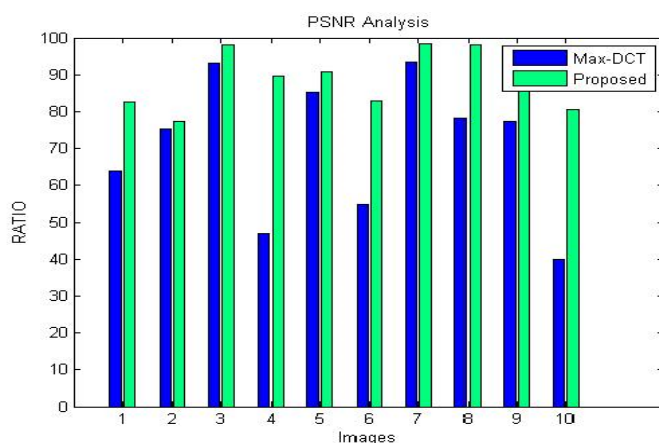


Fig 10 PSNR of MAX-DCT & Proposed Approach for different images

Figure 10 has shown the quantized analysis of the peak signal to noise ratio of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color). It is very clear from the plot that there is increase in PSNR value of images with the use of proposed method over other methods. This increase represents improvement in the objective quality of the image.

9. Conclusion

The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving

in real-time systems using motionless image or video standards based on DCT. But it is found that the majority of the existing researchers have ignored some of the well-liked issues of vision processing like image de-noising, image enhancement, and image restoration. So to control these troubles a new algorithm is proposed in this paper. The proposed work integrates dynamic histogram equalization with consistency verification based Max-DCT based fusion technique to give improved results than the older techniques. The integrated technique has effectively reduced the limitations of the existing fusion technique. Comparative analysis has shown the significant improvement of the proposed algorithm over the existing algorithms. In near future we will extend this work to use decision based median filters to improve the proposed max-DCT base fusion in well-organized manner. To take the complete benefits of the proposed algorithm we will extend this work to use it in smart cameras by using the embedded systems. Maximum difference of error has not shown significant results so will modify the proposed algorithm further for enhancing this parameter.

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