An Integrated Approach for Image Fusion using PCA and DCT

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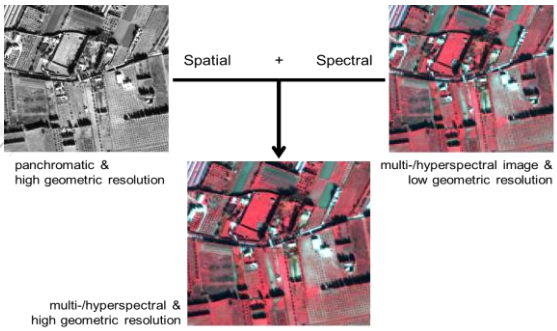
Abstract

Image fusion amalgamates the information from several images of one scene to obtain an enlightening image which is more appropriate for human visual perception or additional vision processing. Image quality is a closely related to image focus. In some images it is not possible to obtain a clear focus in all regions simultaneously, so image fusion is used to combine pictures with different focus into one with all the best-focused regions. The objective of this paper is to propose a new integrated technique for image fusion. The proposed approach combines PCA and DCT for image fusion.

Keywords: Image Fusion, Discrete Cosine Transformation, Wavelet Transformation, Principle Component Analysis.

1. Introduction

Image fusion is a method of merging pertinent information from several images into a single image. The fused image will be more useful for computer processing task than every input image. Image fusion takes information of concern in several images of same scene into one useful image; information of concern depends upon area consideration. The image fusion objective is to extract all the valuable information from input images without the addition of artifacts or discrepancies [6]. Image fusion is suitable method for integration of similar sensor and multi-sensor images to improve the information. The image fusion objective is to convey only the worthwhile information by uniting appropriate information from several images of the same scene [5]. The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving for real-time systems using standards of still image or video based on DCT [5]. A visual sensor network (VSN) is a network consists of several smart camera or sensor devices distributed spatially. They are capable of handling and fusing images of a scene from different viewpoints into a single and more useful image than the individual images. Visual sensors or cameras generate a great amount of data. This needs additional local processing to convey only the useful information in a concise and appropriate form. Visual sensor networks (VSNs) are suitable for area surveillance, tracking, and environmental monitoring applications. Image fusion is a process of finding the appropriate information from each of the several input images and combine to form



an image whose quality is superior to every input images [13].

Figure 1. Image fusion process [15]

Figure 1 is demonstrating the complete process of the image fusion with respect to resolution concept. It is clearly shown that the intensity of low resolution image is substituted with the intensity component of high resolution image. Image fusion is a suitable option for many applications which require high spatial and spectral resolution in a single image. The Image fusion techniques in medical images are suitable for the purpose of an accurate disease diagnosis [11]. Medical fusion image generally combine functional image and anatomical image to produce one image with plenty of information for an accurate diagnose of disease [3].

2. Image Fusion Methods

Image fusion techniques can be divided into three levels, namely: pixel level, feature level and decision level of representation depending on the level at which

fusion occur [10]. These fusion methods can be generally categorized into spatial domain and transform domain fusion. Brovey method, Principal Component analysis (PCA), IHS (intensity hue saturation) and High pass filtering methods fall in the spatial domain fusion techniques. Spatial image fusion work by combining the pixel values of the two or more images. The easiest method of image fusion is to take pixel by pixel average of the two images. But, this method yields reduced contrast as unwanted side-effects. The methods such as PCA, IHS Transform, and Brovey Transform have been generating good quality fused images but suffer from some limitations. The most significant problem is color distortion. Wavelet transform and Laplacian transform are some of the other fusion techniques [6]. In the transform domain method the multi-scale decomposition of the images is done and the composite image is constructed by using the fusion rule. Then inverse multi-scale transform is applied to achieve the fused image. These methods produce fusion results suffering from blocking effects problem. The wavelet transform has been used more extensively than other methods. The wavelet transform is having a restricted ability to handle curved structure images. To overcome this curve let image fusion is suggested [3]. These techniques display an improved performance in spatial and spectral quality of the output fused image than any other spatial fusion techniques.

2.1 Discrete Cosine Transform (DCT)

Discrete Cosine Transformation (DCT) is important to numerous applications in science, engineering and in image compression like MPEG etc [5]. For simplicity, Discrete Cosine Transformation (DCT) can convert the spatial domain image to frequency domain image [10]. Fig. 2 shows that frequency distribution of the image which is converted by Discrete Cosine Transformation (DCT).

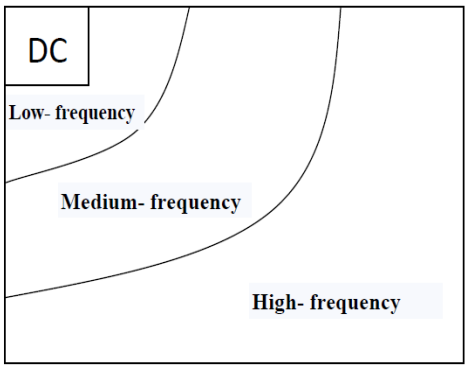


Figure 2. Frequency Distribution of DCT [4]

The figure 2 showed that images converted can be distributed by 3 parts, the coefficient on the left-top named DC value, others are named AC values. The DC value represents the average illumination and the AC values are coefficients of high frequency. Large DCT coefficients are concentrated in the low frequency regions [13]. Then it is useful to observe the distribution of AC values by standard deviation. The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension [16]. The definition of the two-dimensional DCT for an input image A and output image B is

$$B_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

Where

$$\alpha_p = \begin{cases} \frac{1}{\sqrt{M}}, & p = 0 \\ \sqrt{\frac{2}{M}}, & 1 \le p \le M-1 \end{cases}$$

and

$$\alpha_q = \begin{cases} \frac{1}{\sqrt{N}}, & q = 0 \\ \sqrt{\frac{2}{N}}, & 1 \le q \le N-1 \end{cases}$$

M and N are the row and column size of A, respectively [16]. If you apply the DCT to real data, the result is also real. The DCT tends to concentrate information, making it useful for image processing applications. There are several circumstances in image processing where high spatial and high spectral resolution in one image is required. The main application of image fusion is merging the grey level high resolution panchromatic image and the coloured low resolution multispectral image**.** The image fusion techniques permit the integration of different information sources [2]. Both spatial and spectral resolution characteristics can be present in a fused image.

2.2 Principal Component Analysis (PCA)

Principal component analysis (PCA) is a valuable statistical tool from linear algebra. PCA is used amply in

all forms of analysis - from neuroscience to computer graphics - because it is a simple, non-parametric method of extracting relevant information from mystifying data sets. For images, it creates an uncorrelated feature space which can be used for further analysis instead of the original multispectral feature space. This technique is applied to the multispectral bands. The PCA converts inter correlated MS bands into a new set of uncorrelated components. The first component is replaced by a high-resolution PAN for the fusion. The reverse PCA transform is performed to bring fused dataset back into the original multispectral feature space. The number of bands is not restricted in PCA fusion like IHS or Brovey fusions. Patil et al. proposed the image fusion algorithm using hierarchical PCA [10]. The PCA has the characteristics such as dimensionality reduction. PCA changes the features from the original domain to a PCA domain where the features are arranged in the order of their variance. Image fusion is performed by keeping only features containing a majority of information. The PCA determines as few components that contribute towards much of the total variation in the data.

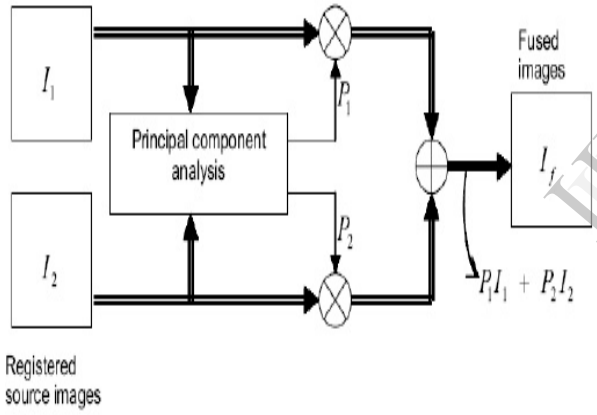


Figure 3. Image fusion using PCA [13]

Steps involved in PCA Fusion are:

a) First the data should be organized into column vector. Let R is the resulting column vector of dimension 2*N.
b) After dividing the data into columns, empirical mean along each column. The dimension of Empirical mean is 1*2.
c) Subtract Mean from each column of R. The resulting matrix X has dimension 2*N.
d) Find covariance matrix C of matrix X.
e) Consider first column of Eigen vector which correspond to larger Eigen value to compute normalized component P1 and P2.

3. Proposed Algorithm

The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving in real-time systems. An efficient method for multi-focus images fusion is proposed. The proposed algorithm will integrate PCA and DCT to achieve the fusion process. In order to enhance the results histogram equalization on the output image is used. The overall objective is to improve the visibility of fused images. The following figure shows the flowchart of proposed algorithm.

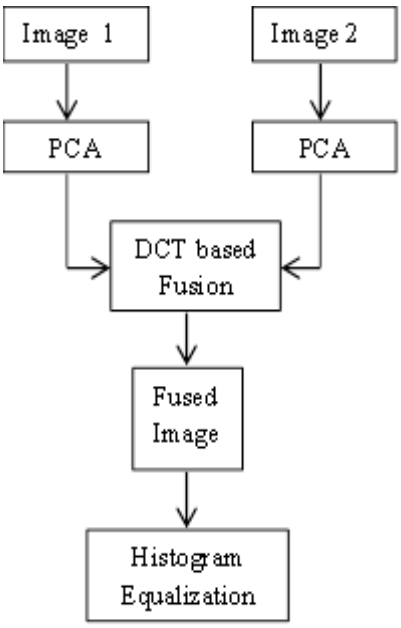


Figure 4. Flowchart of proposed algorithm

The proposed algorithm includes the following steps:

1. First of all two images which are partially blurred are passed to the system.
2. Apply RGB2PCA to convert given image in PCA plane.
3. Now differentiate PCA of image1 and image2 into their 3 planes as image is assumed to be in RGB.
4. For PCA(:,:,1) of image 1 and image 2 will be passed for fusion using DCT and PCA(:.:.2) & PCA(:.:.3) of image 1 and image 2 will determine new components by taking their averages respectively.
5. Now concatenation of each output of step 4 will be done.
6. Now PCA2RGB will be applied to get original fused image.
7. Now Histogram equalization will be applied to get clearer image.

4. Discussion

The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving in real-time systems using still image or video standards based on DCT. But it is found that most of the existing researchers have neglected some of the popular issues of vision processing like image de-noising, image enhancement, and image restoration. So to overcome these problems a new algorithm is proposed in this paper.

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