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RESEARCH ARTICLE

A Study of Various Multi-Focus Image Fusion Techniques

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ABSTRACT: This paper has presented a study of various image fusion techniques. The main objective of vision fusion is to merging information from multiple images of the same view in order to deliver only the useful information. The principal component averaging (PCA) based methods of vision fusion are more suitable and time-saving in real-time system using PCA based standards of still images. The overall objective of this paper is to evaluate the shortcoming is earlier image fusion technique.

KEYWORDS: IMAGE FUSION, PRINCIPAL COMPONENT ANALYSIS, IBPLCA.

1. INTRODUCTION

Image fusion is a technique of integrating all applicable and balancing information from images of similar source or various sources into a single merged image without any degradation. The main objective of medical image fusion is reliable integration of visual information observed from different input images into single image not including any degradation and loss of information. Where, the resulting image can give more creative information than any of the input images. These fused image information used in various applications such as Satellite imaging, Medical imaging, Robot vision, Multi-focus image fusion, Digital camera application etc. Three main fusion methods have been deal in the literature of image fusion – pixel level, feature level and decision level. Pixel-level is low level of image fusion, deals with pixels obtained at imaging sensor output. Feature-level fusion operation is performed on features extracted from source images. Decision-level deals with image descriptors.

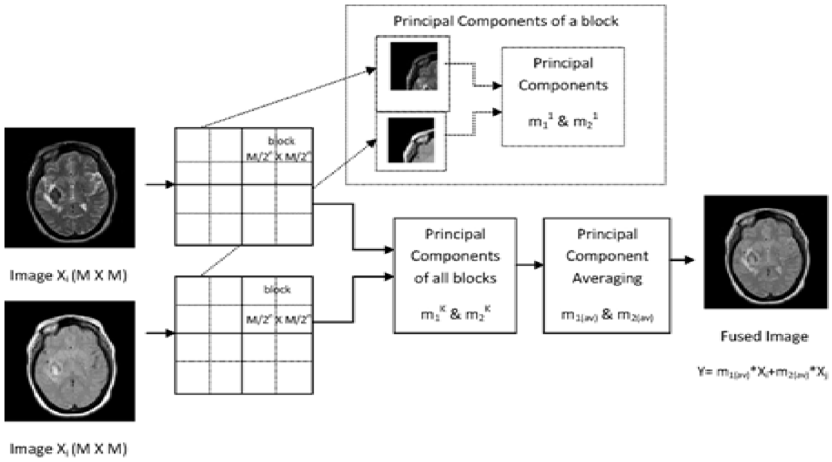

Figure 1: Block Diagram of Iterative Block Level Principal

Fusion process is categorized in two domains: spatial domain and frequency domain.

a. **SPATIAL DOMAIN**: In spatial domain, applicable pixel values of source images add to the pixel value in the fused image. Although spatial domain methods often guide to the non-existence of spectral information and introduce spatial distortions. Degradation in the type of poor perceptual feature is introduced by pixel level fusion methods such as averaging and weighted averaging.

b. **TRANSFORM DOMAIN**: In transform domain, multi-resolution approaches have been planned in the literature to defeat this difficulty. Algorithms based on pyramid approach and wavelets are quiet successful. Various pyramid fusion methods outcome in blocking result in significantly various regions of the image.

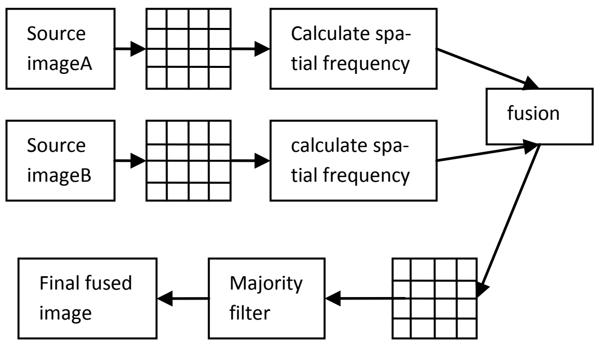

Figure 2: Block Diagram of image fusion process

Medical image fusion is the method of deriving necessary information from multimodality medical images. This derived information can be used for different purposes like, diagnosing diseases, detecting the tumor, surgery handling and so on. This kind of information cannot be obtained using particular modality image. Therefore, the drawbacks of particular modality medical image has smooth the way for the method of combining various modality images such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), and Single Photon Emission Computed Tomography (SPECT) into a single image.

2. **Methods of Image Fusion:** Image Fusion methods are:

2.1 DCT (DISCRETE COSINE TRANSFORM): The discrete cosine transform (DCT) helps divide the image into parts or spectral sub-bands of differing significance with respect to the image's optical feature. The DCT is same as the discrete Fourier transform. It transforms a signal or image from the spatial area to the frequency area. Discrete cosine transform (DCT) is an essential transform widely used in digital image processing. Large Discrete Cosine Transform (DCT) coefficients are determined in the low frequency area hence, it is known to have outstanding energy compression properties.

DCT splits the image/block into a sequence of waveforms, each with a exacting frequency. DCT coefficients are segregated into 2N-1 various frequency bands for image or block of size NxN. The mth group is collected of the coefficients with m=k1+k2. Image to be fused are separated into non-overlapping parts of size NxN. DCT coefficients are computed for each part and fusion policy are applied to get fused DCT coefficients. IDCT is then applied on the fused coefficients to generate the fused image/block. The process is repeated for each part. The 2D-DCT transformation equations :

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

Where u,v = 0,1.........................N-1 and

$$C(u)=\begin{cases}\frac{1}{\sqrt{2}}, if\ u=0\\ 1, if\ u\neq 0\end{cases}$$

The inverse transform is computed using the following equations:

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

where x,y = 0,1...............N-1

2.2 DWT (DISCRETE WAVELET TRANSFORM): The discrete wavelet transform (DWT) is a linear transformation that operates on a information vector whose length is an integer power of two, transforming it into a numerically various vector of the similar length. It is a device that decomposes data into various frequency components, and every component with resolution matched to its scale. DWT is computed with a cascade of filtering followed by a feature two sub-sampling. The registered input images are split into two sub-bands like low sub-bands and high sub-bands using wavelet transform. The low sub-bands and high sub-bands are fused using different fusion methods. Finally, the output of the fused image is obtained by applying inverse wavelet transform on the fused coefficients of low sub-bands and high sub-bands. An image can be splits into a series of various spatial resolution images using DWT. The DWT transformation equations:

$$F(u,v)=\frac{2c(u)c(v)}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(m,n)\cos\left(\frac{2m+1}{2N}u\pi\right))\cos\left(\frac{2n+1}{2N}v\pi\right)$$

u=0,1,2,………N−1 v=0,1,2…………N-1

where $c(k)=\frac{1}{\sqrt{2}}$ for k=0

=1, otherwise

2.3 PCA (PRINCIPAL COMPONENT ANALYSIS): Principal component analysis (PCA) is a capable technique for characteristics removal, dimensionality decrease and data representation. Number of algorithms has been planned for fusion based on PCA because of its calculation and understanding. PCA is well known de-correlation technique in statistical sense and preserves only the mainly important principal components, thus guide to reasonably good image fusion. Principal components are derived from the covariance matrix and its diagonalization by searching its eigen vectors and eigen values. Major Principal components are the linear illustration of mainly of the image details present in source images. These largest principal components parallel to the main eigen values of covariance matrix are the weights for the input images in the fusion rule. The Principal component Averaging (PCA) based methods of vision fusion are additional suitable and time-saving in real-time classification using PCA based principles of still images.

Let x_i and x_J are the two images to be fused and expressed as column vectors as given by

$$x_i=\begin{bmatrix}x_1\\x_2\\ \vdots\\x_N\end{bmatrix} \text{ and } x_j=\begin{bmatrix}x_1\\x_2\\ \vdots\\x_N\end{bmatrix}; \text{N is number of pixels}$$

The covariance matrix of between two source images is given by

$$\text{Cov}(x_i,x_j)=E\left[(x_i-\mu_i)(x_j-\mu_j)\right]$$

Mean of all pixels is

$$\mu_i=\left(\frac{1}{N}\right)\sum x_i \text{ and } \mu_j=\left(\frac{1}{N}\right)\sum x_{ij}$$

Diagonal matrix D of eigen values and full matrix V whose columns are the corresponding eigen vectors are computed. Eigen values and eigen vectors are arranged in descending order and first 2 × 2 values from V and D matrices are taken for fusion. The normalized components m1and m2are computed from V based on following conditions and should be less than one If D(1, 1) > D(2, 2)

$$m_1=\frac{V(1,1)}{V(1,1)+v(2,1)};\ m_2=\frac{V(2,1)}{V(1,1)+v(2,1)}$$

else

$$m_1=\frac{V(1,1)}{V(1,1)+v(2,1)};\ m_2=\frac{V^k(2,1)}{V(1,1)+v(2,1)}$$

m1and m2are the weights of input images in the fusion rule and the rule for PCA fusion is given by

$$y=m_1\times x_i + m_2 \times x_j$$

Weights for fusion rule, m1and m2, decide the amount of information fused from each source image.

2.4 ITERATIVE PCA (ITERATIVE PRINCIPAL COMPONENT ANALYSIS): Iterative block level principal component averaging fusion Source images are split into K number of blocks. PCA is implemented for the relevant blocks of source images. Principal components are evaluated for the all the blocks. Principal components for all K number of blocks are given as $m_1^K$and m_2^K. Average of all the principal components are given by

$$m_1(av)=\frac{1}{2^{2n}}\sum_{k=1}^{2^{2n}} m_1^k\ ;\ m_2(av)=\frac{1}{2^{2n}}\sum_{k=1}^{2^{2n}} m_2^k\ ;\quad n=1,2,3,4$$

n is subjective for different fusion input images. m1(av)and m2(av)constitute weights for fusion rule and the fused image is given by

$$y_{(IBLPCA)} = m_1(av) \times x_i + m_2(av) \times x_j$$

3. LITERATURE SURVEY

R. Vijayarajan et al. (2014) [1] has discussed that image fusion is a technique of integrating all applicable and balancing information from images of similar source or various sources into a single merged image without any degradation. A novel pixel level fusion called Iterative block level principal component averaging fusion is planned by separating source images into smaller blocks, thus principal components are calculated for applicable block of source images has been explored.

Qingping Li et al. (2013) [2] has discussed that in image fusion area, basic pixel-based image fusion methods are responsive to imperfections of source images, and it therefore has much power on the feature of the fusion results. Focusing on this trouble, a region-based multi-focus image fusion method is planned based on the local spatial frequency (LSF). compute LSF for each pixel of source images, and a s fragmentation of the average image is introduced to fragment the source images has been explored.

Huaxun Zhang et al. (2013) [3] has discussed that a method of medical image fusion based on wavelet theory is introduced. Medical image fusion have three steps, they are image processing, image list and image fusion. Image processing get across multi resolution features of wavelet to denoise, image list pass the wavelet analysis to achieve biggish transform point and obtain image edge to attain immediate, image fusion use dis-assumble image to various frequency sub-band to save all information to have a ideal fusion has been explored.

Rishu Garg et al. (2014) [4] has discussed that image fusion is a method of combining source images i.e. multi-modal, multi-focus etc. to achieve a novel more useful image. Multi-focus image fusion algorithm combines various images having various blocks in focus. Functions of image fusion contains secluded sensing, digital camera etc. Different multi-focus image fusion algorithms which use various focus determine such as spatial frequency, energy of image laplacian, morphological opening and closing etc. has been explored.

Wang Yang et al. (2013) [5] has discussed that medical image fusion is a type of latest equipment including medical image treatment and diagnosis. It can be practical to a wide mixture of medical fields such as clinic diagnosis and treatment, computer as instant diagnosis, long-distance medical treatment, radiation treatment and surgery arrangement plan, etc. Digital image fusion is a inclusive information of the multiple source images in order to achieve more exact, more inclusive and more consistent explanation for a exact region or objective, so that it can help the subsequent testing and accepting of the image. The purpose, substance, methods and arrangement of medical image fusion has been explored.

Mohammed Hossny et al. (2013) [6] has been discussed that image fusion procedure merges two images into a single more useful image. Objective image fusion presents metrics rely primarily on measuring the quantity of information transferred from every source image into the fused image. Objective image fusion metrics have evolved from image dealing distinction metrics. Additionally, researchers have developed many additions to image distinction metrics in order to improved value the local fusion worthy characteristics in source images. The development of objective image fusion presentation metrics and their individual and objective confirmation has been explored.

Mingjing Li et al. (2013) [7] has been discussed that image fusion can be performed at various levels: pixel, feature and decision-making levels. Pixel level image fusion refers to the dealing and synergistic mixture of information gathered by different imaging sources to offer a improved kind of a views. The pixel level image fusion is the direct fusion in the unique information layer, so the quantity of information reserved most. Almost all image fusion algorithms developed to date fall into pixel level. An overview of the most commonly used pixel-level image fusion algorithms and various explanation about their comparative powers and weaknesses has been explored.

Rong Fan et al. (2014) [8] has been discussed that in the method of image fusion, the spectral resolution of the antenna makes the information of image fusion be simple to misplace and so affects the feature of the image. Usual image fusion algorithm has great quantity of estimate and reduced real-time performance and does not carefully think the manipulation of fusion policies of low frequency component and the neighborhood features of high-frequency factor on the fusion at the similar time, so it cannot get the perfect fusion result. In order to explain this trouble the non-linear weighted multiband fusion algorithm which introduced the non-linear weighted value has been explored.

P. Devaki et al. (2014) [9] has been discussed that in the current past the images of different fields are being measured for processing for different purposes. An algorithm for protecting the secret image whose confidentiality requirements to be maintained, and also to validate the distributor who distributes that secret image to various users has been explored.

Om Prakash et al. (2013) [10] has been discussed that the purpose of image fusion is to merge applicable information from two or more images of the similar views into a particular merged image which is more informative and is more suitable for person and machine perception. In current past, various methods of image fusion have been planned in literature both in spatial domain and wavelet domain. Spatial domain based methods generate spatial distortions in the fused image. Spatial domain distortion can be well handled by the use of wavelet transform based image fusion methods. A pixel-level image fusion scheme using multi-resolution Biorthogonal wavelet transform (BWT) has been explored.

Lixin Liu et al. (2013) [11] has been discussed that usual techniques of multi-focus image fusion have high calculation and cause blocking outcome or artificial outcome easily. An efficient multi-focus image fusion technique based on the lifting method of wavelets has been explored.

K Sharmila et al. (2013) [12] has been discussed that medical image fusion is the techniques of deriving essential information from multi-modality medical images. This derived information can be used for different purposes like diagnosing diseases, detecting the tumor, surgery treatment. This kind of information cannot be obtained using particular modality image. Therefore, the drawbacks of particular modality medical image has smooth the technique for the process of combining various modality images such as computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), and Single Photon Emission Computed Tomography (SPECT) into a particular image. Hence, the above described method of combining multimodality images in to a particular fused image can be done using image fusion methods. A new image fusion method Discrete Wavelet Transform-Averaging-Entropy-Principle Component Analysis method [DWT-A-EN-PCA] and the results of planned system are compared with other existing fusion methods using quantitative metrics such as, Entropy (EN), Signal to Noise Ratio (SNR) and Fusion Symmetric (FS) for performance evaluation has been explored.

Gazal Malhotra et al. (2014) [13] has been discussed that image fusion extracts the information from different images of a particular view to achieve a final image which has more information for human optical perception and is more helpful in additional vision processing. The multi-focus image fusion has become one of the popular procedures in vision processing. Different digital image fusion algorithms have been developed in a number of functions. The AC-DCT based better fusion using edge preserving smoothing and DRSHE has been explored.

Ashwini Galande et al. (2013) [14] has been discussed that medical image fusion is the scheme to get better the image content by fusing images taken from various imaging equipment like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and single photon emission computed tomography (SPECT). The purpose of image fusion is to merge more useful information and eliminate redundant information from supply registered images. Image fusion methods are generally classified into two categories i.e Pixel level image fusion and transform based image fusion has been explored.

Radhika.V et al. (2014) [15] has been discussed that image fusion is the method of combining helpful information gathered from various optical sensors to present sub-stantial image information. The fused image contains improved information than any particular source image. The statistical method are used as feature measure to identify the significance of the image or sub image. Commonly most of the images are affected by Gaussian sound. Statistical measures like uniformity and softness recognize irregularity in the images in turn recognize the sub images having less noise. Hence, uniformity and softness in spatial domain for image fusion has been explored.

Vivek Kumar Gupta et al. (2013) [16] has been discussed that in remote sensing functions, the growing accessibility of space borne sensors gives a motivation for various image fusion algorithms. secluded sensing image fusion plans at integrating the information suggested by information obtained which cover various segments of the electromagnetic spectrum at various spatial, sequential and spectral resolutions so that get multi-temporal, multi-resolution and multi-frequency image information for functions of characteristic removal, modelling and categorization. The merged or fused image is more helpful for human perception as well as for automatic computer testing task such as characteristic removal, segmentation and object detection. Indian Space Research Organization has recently launched RISAT-1 having microwave imaging antenna and microwave SAR information for image fusion technique analysis has been explored.

Xiangda Sun et al. (2013) [17] has been discussed that the source image was decayed into the low pass and directional band-pass coefficients by non-sub-sampled contourlet transform (NSCT) for multi-sensor image fusion of the similar view. The low-pass component uses the fusion technique of better the energy contrast, it fully obtain into account the energy contrast of coefficient as well as the adjacent coefficient features. The value of the coefficient in the directional band-pass coefficient is connected to its neighbouring coefficients, and the directional band-pass coefficient uses the fusion technique based on context. Experimental results show that the proposed technique can improve the feature of fusion image compared with regional energy maximum and regional variance maximum has been explored.

4. Gaps in Literature Survey

By conducting the review it has been found that the most of the existing literature has neglected at least one of the following.

As most of the existing methods are based upon transform domain therefore it may results in some color artifacts which may reduce the performance of the transform based vision fusion methods.

It is also found that the problem of the uneven illuminate has also been neglected in the most of existing work on fusion.

Most of the existing work has focused on gray scale images not much work is done for color images.

5. CONCLUSION AND FUTURE WORK

This paper has shown that every image fusion technique has its own benefits and limitations. As most of the existing methods are based upon transform domain therefore it may results in some color artifacts which may reduce the performance of the transform based vision fusion methods. It is also found that the problem of the uneven illuminate has also been neglected in the most of existing work on fusion. Most of the existing work has focused on gray scale images not much work is done for color images.

In near future a new technique will be proposed which will integrate the joint trilateral filter and PCA domain to reduce the color artifacts which will be introduced due to the transform domain method i.e. PCA. To do the performance analysis dissimilar metrics will be considered in this dissertation. The performance of vision fusion is usually evaluated in terms of accuracy, PSNR and speed etc.

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