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SURVEY ARTICLE

WAVELET BASED IMAGE FUSION APPLICATIONS – A LITERATURE STUDY

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Abstract— Image fusion is the process by which input images are fused in order to increase the quality. The input images must be the images of the same scene with different quality measures. The quality of the output image will be better than any of the input images. The main methods of the image fusion involve simple image fusion, pyramid based image fusion and wavelet based image fusion. Image fusion methods can be used in areas of medical imaging, remote sensing, entertainment etc. This paper focuses on the different image fusion methods evolved so far and their comparison based on the quality of the output image. It also discuss about the different quality metrics that can be used to assess the quality of the output image.

I. INTRODUCTION

An image represents more than ten thousand words. An image can be represented both in spatial domain and in spectral domain. Image Fusion [1] is the process of fusing perfectly registered input images, which can represent both spatial and spectral information. It retains important information and produces an image, which is better for human, and computer perception for further processing. Since spatial representation is simple, spatial fusion methods are also simple. Spectral representation can clearly define the edge features of the image.

Different types of image fusion [3] are Multiview Fusion, Multimodal Fusion, Multi focus Fusion, Multi Sensor Fusion and Single Sensor Fusion. Multi view Fusion fuses the images obtained from multiple cameras. These images will be taken from different views of the same scene. Multimodal image fusion fuses images took from different modalities of the same scene. It is widely used in medical imaging. In multi focus fusion, the input images will be focusing in different scenes. Some images may focus on the foreground and some on the background. In multi sensor fusion, the input images will be taken from different sensors. This method is widely used in remote sensing application where the sensors lack quality.

1.1 Image Fusion Basic Process

The commonly classification of image fusion is based on the image attribute, which divides image fusion into three levels, namely picture element level, characteristic level and policy- making level fusion. The object of image fusion data may can be divided into the optical image and the non-optical image according to the image formation way. The basic processes of multi-spectrum image and full-color image fusion system are as shown in Figure 1.

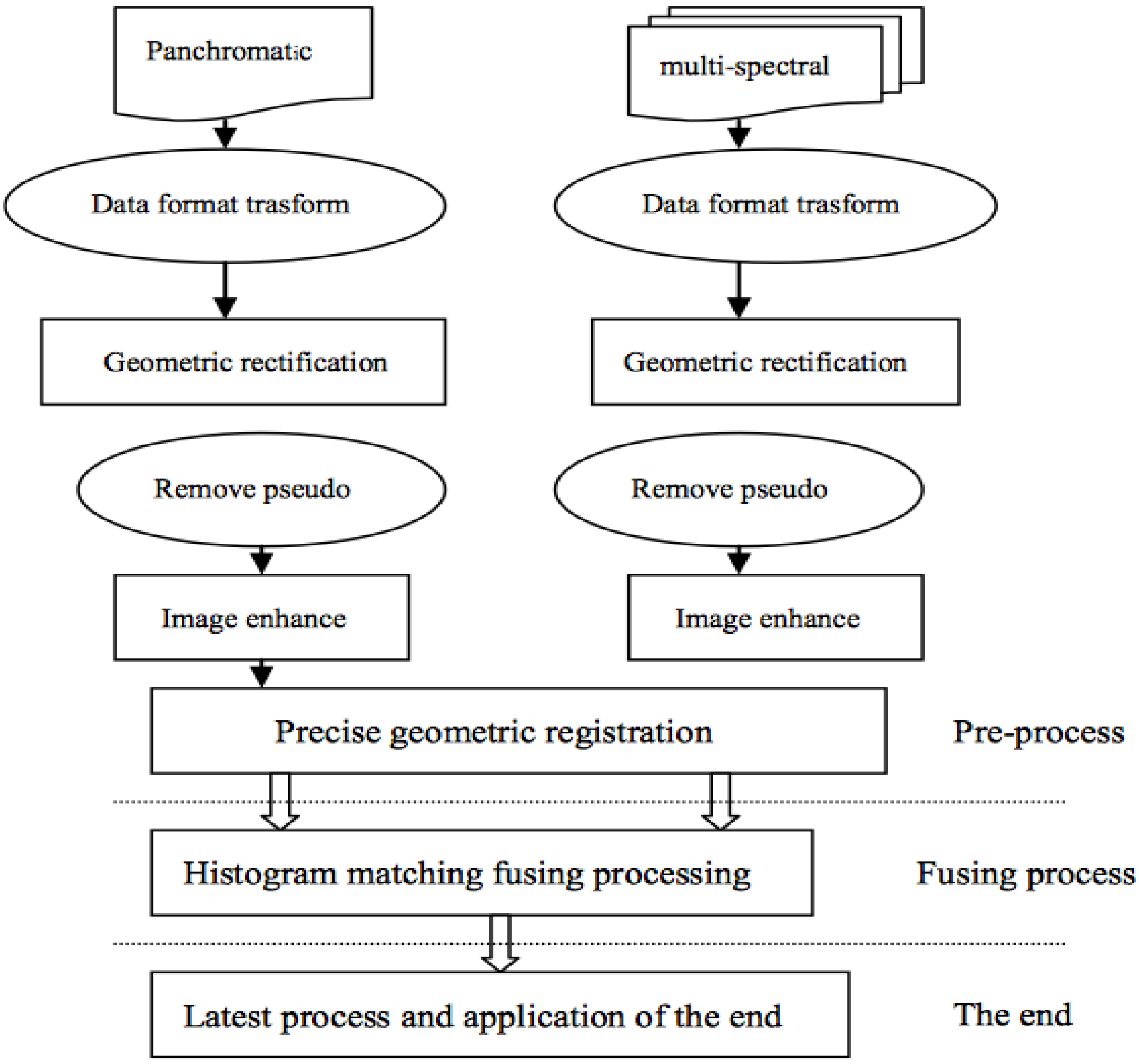

Figure 1 Basic procedure of image fusion between multi- spectral images and panchromatic images

Image fusion works with multi-sensors, multi-spectrum, multi-angle viewing and multi-resolutions remote sensing images from various with aiming at achieving improved image quality to better support improved image classification, monitoring and etc. Fused image will enhance reliability and speed of feature extraction, increase the usage of the data sets, and extend remote sensing images application area. There have been a lot of research efforts on image fusion, and many fusion methods have been proposed. The advantages of wavelet transform are that it can analyze signal in time domain and frequency domain respectively and the multi-resolution analysis is similar with Human Vision System.

1.2 Medical Image Fusion

Medical image fusion encompasses a broad range of techniques from image fusion and general information fusion to address medical issues reflected through images of human body, organs, and cells [2]. There is a growing interest and application of the imaging technologies in the areas of medical diagnostics, analysis and historical documentation. Since computer aided imaging techniques enable a quantitative assessment of the images under evaluation, it helps to improve the efficacy of the medical practitioners in arriving at an unbiased and objective decision in a short span of time. In addition, the use of multi-sensor [1] and multi-focus image fusion methods offer a greater diversity of the features used for the medical analysis applications; this often leads to robust information processing that can reveal information that is otherwise invisible to human eye. The additional information obtained from the fused images can be well utilized for more precise localization of abnormalities.

II. TYPES OF METHODS IN IMAGE FUSION

2.1. Morphological Methods

The morphology operators has been explored by image processing community for long, and the concept is used by the medical imaging community to detect spatially relevant information from the medical images. The morphological filtering methods for medical image fusion have been applied, for example, in brain diagnosis [3]. An example of modalities used in morphology-based fusion can be seen in the fusion of CT and MR images [3]. In such applications, the morphology operators depend heavily on the structuring operator that defines the opening and closing operations.

2.2. Knowledge based methods

In medical imaging, there are several instances where the medical practitioner's knowledge can be used in designing segmentation, labeling and registration of the images[4]. Generally, the domain dependent knowledge is needed to set constraints on region-based segmentation and to make explicit the expectation of the appearance of the anatomy under the imaging modality at the stage of grouping the detected regions of interest. There is a range of applications where the domain dependent knowledge is useful for image fusion such as for segmentation [7], micro-classification diagnosis [8], tissue classification [9], brain diagnosis [9], classifier fusion [10], breast cancer tumor detection [10] and delineation & recognition of anatomical brain object [7]. The knowledge-based systems can used in combination with other methods such as pixel intensity [9]. These methods place a significant amount of trust in the medical expert in labeling and identifying the domain knowledge relevant to the fusion task. The advantage is the ability to benchmark the images with the known human vision standards, while the drawback is the limitations imposed by human judgment in images that are prone to large pixel intensity variability. The use of preprocessing techniques in images can improve the imaging quality and increase the accuracy of ground truths.

2.3. Wavelet based methods

The primary concept used by the wavelet based image fusion [11, 12] is to extract the detail information from one image and inject it into another. The detail information in images is usually in the high frequency and wavelets would have the ability to select the frequencies in both space and time. The resulting fused image would have the "good" characteristics in terms of the features from both images that improve the quality of the imaging. There are several models for injection, the simplest being substitution. There exist several mathematical models for injection, such as simple addition operation and aggregator functions to more complex mathematical models. Irrespective of the models used, for practical reasons, the image resolution remains same before and after the fusion. In addition, the image resolution of the reference image enforces the required number of multiple levels of decomposition, such that a high-resolution image would require more number of decomposition levels than a low-resolution image.

III.DIFFERENT KIND OF APPROACHES

3.1 Fusion using Principle Component Analysis (PCA)

The PCA image fusion method [8] basically uses the pixel values of all source images at each pixel location, adds a weight factor to each pixel value, and takes an average of the weighted pixel values to produce the result for the fused image at the same pixel location. The optimal weighted factors are determined by the PCA technique. The PCA image fusion method reduces the redundancy of the image data.

3.2 Super-resolution image reconstruction

Super-resolution (SR) image reconstruction [9] is a branch of image fusion for bandwidth extrapolation beyond the limits of a traditional electronic image system. The general strategy that characterizes super-resolution comprises three major processing steps which are low resolution image acquisition, image registration/motion compensation, and high resolution image reconstruction. Techniques used in image fusion, such as the Dual-Tree Wavelet Transform. The proposed method can outperform the wavelet approaches.

3.3 Region-based multi-focus image fusion

Li and Yang first describe the principle of region-based image fusion in the spatial domain [11]. Then two region-based fusion methods are introduced. They proposed a spatial domain region-based fusion method using fixed-size blocks. Experimental results from the proposed methods are encouraging. More specifically, in spite of the crudeness of the segmentation methods used, the results obtained from the proposed fusion processes, which consider specific feature information regarding the source images, are excellent in terms of visual perception. The presented algorithm, spatial domain region-based fusion method using fixed-size blocks, is computationally simple and can be applied in real time. It is also valuable in practical applications. Although the results obtained from a number of experiments are promising, there are more parameters to be considered as compared to an MR-based type of method, such as the wavelet method.

3.4 Image fusion techniques for non-destructive testing and remote sensing application

The authors present several algorithms of fusion based on multi-scale Kalman filtering and computational intelligence methodologies [12]. The proposed algorithms are applied to two kinds of problems: a remote sensing segmentation, classification, and object detection application performed on real data available from experiments and a non- destructive testing/evaluation problem of flaw detection using electro-magnetic and ultrasound recordings. In both problems, the fusion techniques are shown to achieve a modest superior performance with respect to the single-sensor image modality. The joint use of the eddy current and ultrasonic measurements is suggested because of the poor results that are obtained by processing each single recorded type of signal alone. Therefore, both measurements are jointly processed, and the information used to perform the classification has been extracted at three different levels: pixel, feature, and symbol. Using the probability of detection and probability of false alarm has compared the numerical performance of these techniques.

3.5 Image fusion schemes using ICA bases

Mitianoudis and Stathaki demonstrate the efficiency of a transform constructed using Independent Component Analysis (ICA) and Topographic Independent Component Analysis based for image fusion in this study [10]. The bases are trained offline using images of similar context to the observed scene. The images are fused in the transform domain using novel pixel-based or region-based rules. An unsupervised adaption ICA-based fusion scheme is also introduced. The proposed schemes feature improved performance when compared to approaches based on the wavelet transform and a slightly increased computational complexity. The authors introduced the use of ICA and topographical ICA based for image fusion applications.

3.6 Multi-resolution Pyramidal Image Fusion

Hierarchical multiscale and multiresolution image processing techniques, as mentioned previously, are the basis for the majority of sophisticated image fusion algorithms. The usefulness of such approaches to image processing was initially established by Burt and Adelson [13, 14]. Multiresolution processing methods enable an image fusion system to fuse image information in a suitable pyramid format. Image pyramids are made up of a series of Sub-band signals, organized into pyramid levels, of decreasing resolution each representing a portion of the original image spectrum. Information contained within the individual sub-band signals corresponds to a particular scale range, i.e. each sub-band contains features of a certain size. Fusing images in their pyramid representation therefore, enables the fusion system to consider image features of different scales separately even when they overlap in the original image. These properties make multiresolution fusion algorithms potentially more robust than other fusion approaches. Multiresolution image processing was first applied to pixel-level image fusion using derivatives of the Gaussian pyramid representation [13] in which the information from the original image signal is represented through a series of (coarser) low-pass approximations of decreasing resolution. The pyramid is formed by iterative application of low-pass filtering, usually with a 5x5 pixel

3.7 Intensity Hue Saturation (IHS)

IHS is a color fusion technique. It effectively separates spatial (intensity) and spectral (hue and saturation) information from an image (Chavez et al.,1991; Carper et al., 1990). The fusion method first converts a RGB image into intensity (I) hue (H) and saturation (S) components. In the next step, intensity is substituted with the high spatial resolution panchromatic image. The last step performs the bands. In this method three multispectral bands R, G and B of low resolution. Finally, an inverse transformation from IHS space back to the original RGB space yields the fused RGB image, with spatial details of the high resolution image incorporated into it .The intensity I defines the total color brightness and exhibits as the dominant component . After resolution using the high resolution data, the merge result is converted back into the RGB After applying IHS [7].

IV. CONCLUSIONS

The study of the image fusion based on wavelet transformation, on the basis of studying the general methods, proposes a new thought: different fusion rules will be used in low frequency image and high frequency image. The simple weighted average in low frequency uses; as for high frequency, according to the image statistical property, a fusion method, based on the biggest criterion of partial region standard deviation, is designed to carry on the processing. The future step is to apply the weighted fusion technique on multi sensor image to detect objects.

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