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Image Fusion

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Abstract— Image Fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input images. Image fusion techniques can improve the quality and increase the application of these data. This paper presents a literature review on some of the image fusion techniques for image fusion like, primitive fusion (Averaging Method, Select Maximum, and Select Minimum), Discrete Wavelet transform based fusion, Principal component analysis (PCA) based fusion etc.

Keywords—Discrete Wavelet Transform (DWT), Mean Square Error (MSE), Principal Component Analysis (PCA), artificial neural network (ANN), Image Fusion

I. INTRODUCTION

Image fusion means the combining of two images into a single image that has the maximum information content without producing details that are non-existent in the image[1][2]. With rapid advancements in technology, it is now possible to obtain information from multi source images to produce a high quality fused image with spatial and spectral information [2][3]. Image Fusion is a mechanism to improve the quality of information from a set of images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics.

A. Advance of image fusion

In the past decades it has been applied to different fields such as pattern recognition, visual enhancement, object detection and area surveillance[4].In 1997, Hall and Llinasgave ageneral introduction to multi-sensor data fusion[1].Another in-depth review paper on multiple sensors data fusion techniques was published in 1998[4].it explained the concepts, methods and applications of image fusion as a contribution tomulti-sensor integration oriented data processing., Simone et al. describe three typical applications of data fusion in remote sensing, such as obtaining elevation maps from synthetic aperture radar (SAR) interferometers, the fusion of multi-sensor and multi-temporal images.

a. Image Fusion Rules

The designing of fusion rules is: after wavelet transform the low frequency part represents the approximation of images, the high frequency part represents the details of images. The coefficients of high frequency part (wavelet coefficients) are fluctuating around the zero, the larger the absolute value of the coefficients, the more dramatic the change of intensity at that location. That means some salient information, such as edges, lines and region borderlines [8,9]. In addition, the images of the same scene taken from different sensors are similar in the coefficients of approximation, whereas distinct in the wavelet coefficients. There are many literatures refer to the fusion rules in former research. This paper puts them into three groups due to their features: The rules based single pixel; The rules based the neighborhood features of pixel; The rules based an interesting area of image or target.

b. Artificial neural network based fusion method

Artificial neural networks (ANNs) have proven to be a more powerful and self-adaptive method of pattern recognition as compared to traditional linear and simple nonlinear analyses[6]. The ANN-based method employs a nonlinear response function that iterates many times in a special network structure in order to learn the complex functional relationship between input and output training data. The general schematic diagram of the ANN-based image fusion method can be seen in Figure

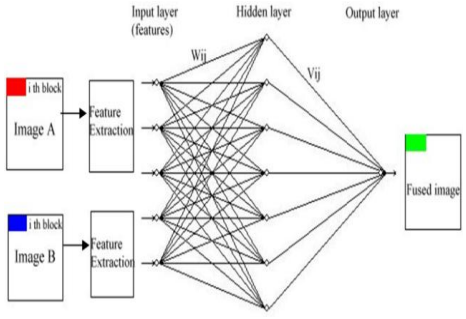

Figure1: Diagram of ANN-Based image fusion method

II. IMAGE FUSION TECHNIQUES

The process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images .Image fusion method can be broadly classified into two groups –1.Spatial domain fusion method 2.Transform domain fusion.

For example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics etc [7][8]. There are various methods that have been developed to perform image fusion. Some well-known image fusion methods are listed below [3]:-

(1) Intensity-hue-saturation (IHS) transform based fusion

(2) Principal component analysis (PCA) based fusion

(3) Multi scale transform based fusion:- (a) High-pass filtering method (b) Pyramid method:-(i) Gaussian pyramid (ii) Laplacian Pyramid (iii) Gradient pyramid (iv) Morphological pyramid (v) Ratio of low pass pyramid (c) Wavelet transforms:- (i) Discrete wavelet transforms (DWT) (ii) Stationary wavelet transforms (iii) Multi-wavelet transforms (d) Curvelet transforms

A. Image fusion algorithms

Due to the limited focus depth of the optical lens it is often not possible to get an image that contains all relevant objects in focus. To obtain an image with every object in focus a multi-focus image fusion process is required to fuse the images giving a better view for human or machine perception. Pixel-based, region-based and wavelet based fusion algorithms were implemented [9].

a) simple average

It is a well-documented fact that regions of images that are in focus tend to be of higher pixel intensity.

b) select maximum

The greater the pixel values the more in focus the image. Thus this algorithm chooses the in-focus regions from each input image by choosing the greatest value for each pixel, resulting in highly focused output [7] [9].

B. Discrete wavelet transform (dwt)

Wavelets are finite duration oscillatory functions with zero average value**[1]**. They have finite energy. They are suited for analysis of transient signal. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities. Wavelets can be described by using two functions viz. the scaling function f (t), also known as „father wavelet" and the wavelet function or „mother wavelet". Mother wavelet (t) undergoes translation and scaling operations to give self-similar wavelet families as given by Equation.

ψa , b (t)= 1/ $a\psi(t-b/a)$,$(a, b\epsilon R)$, a> 0

The wavelet transform decomposes the image into low-high, high-low, high-high spatial frequency bands at different scales and the low-low band at the coarsest scale which is shown in figure2.

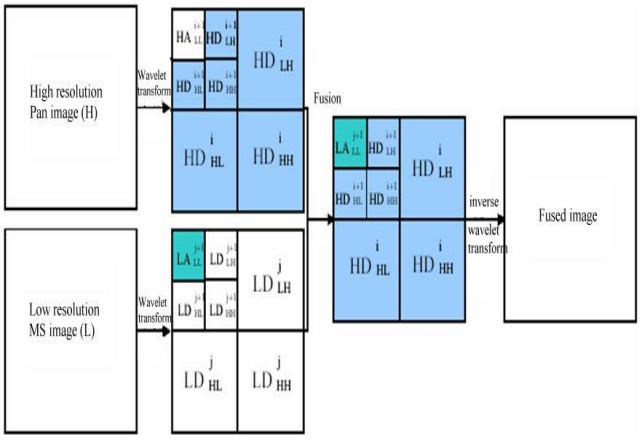

Figure2: Wavelet Based Image Fusion

The wavelets-based approach is appropriate for performing fusion tasks for the following reasons:- (1) It is a multi-scale (multi resolution) approach well suited to manage the different image resolutions. Useful in a number of image processing applications including the image fusion [3][7]. (2) The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information. Such coefficients coming from different images can be appropriately combined to obtain new coefficients so that the information in the original images is collected appropriately. (3) Once the coefficients are merged thefinal fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved.

C. Principal component analysis (pca)

PCA is a mathematical tool which transforms a number of correlated variables into a number 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.

III. APPLICATIONS OF IMAGE FUSION

Remote sensing techniques have proven to be powerful tools for the monitoring of the Earth's surface and atmosphere on a global, regional, and even local scale, by providing important coverage, mapping and classification of land cover features such as vegetation.

A. Object identification

The feature enhancement capability of image fusion is visually apparent in VIR/VIR combinations that often results in images that are superior to the original data. In order to maximize the amount of information extracted from satellite image data useful products can be found in fused images [4].

B. Classification

Classification is one of the key tasks of remote sensing applications. The classification accuracy of remote sensing images is improved when multiple source image data are introduced to the processing [4].Interesting result was achieved mainly for the high speed classification and efficient fusion of complementary information. Land-use/land-cover classification had been improved using data fusion techniques such as ANN and the Dempster -Shafer theory of evidence [6]. The experimental results show that the excellent performance of classification as compared to existing classification techniques. Image fusion methods will lead to strong advances inland use/land cover classifications by use of the complementary of the data presenting either high spatial resolution or high time repetitiveness.

C. Change Detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Image fusion for change detection takes advantage of the different configurations of the platforms carrying the sensors.

Related Research Fields of Image Fusion

- Automatic object detection
- Image processing
- Parallel and distributed processing
- Robotics
- Remote sensing

IV. OTHER APPLICATION OF IMAGE FUSION

A. Intelligent Robots

The Intelligent Robotics Group explores extreme environments, remote locations, and uncharted worlds. We conduct applied research in computer vision, geospatial data systems, human-robot interaction, planetary mapping and robot software [5]. Example - Stereo camera fusion, intelligent viewing control.

B. Medical Image

Digital neutron and X-ray images fusion method based on contourlet and IHS transformation is proposed [10]. The results show that our method preserves more image detail and hence provides more accurate information, which is superior to IHS and wavelet-IHS based fusion approaches. Example- MRI and X-Ray, surgery.

C. Manufacturing

Manufacturing is the term used to refer to the process of using tools, machines and labour to produce goods that are either for use or for sale[10]. The term is commonly used or applied to industrial production but it may also refer to human activity and also high-tech processes. Example- Electronic Circuit and component inspection, Manufacture process monitoring, Complex Machines

D. Military Law enforcement

It plays an increasing role in today's military. Its proliferation at all levels of command reflects a deep hunger on the part of decision makers for remotely collected imagery that helps them see threats and, if necessary, deploy soldiers and weapons[10]. This data is all the more important in maximizing the effectiveness and minimizing the vulnerability of forces as troop levels decrease in theaters of war and, in the future, as the overall footprint changes. Example- Detection, tracking Battle field monitoring, Night Pilot guidance

E. Remote Sensing

Remote sensors collect data by detecting the energy that is reflected from Earth.It gathering data on an object or area from a considerable distance, as with radar or infraredphotography, to observe the earth or a heavenly body.These sensor can be on satellites or mounted on aircraft.Example-

- Using various parts of the electro-magnetic spectrum
- Fusion technique are classified into photographic method and numerical method

V. CONCLUSION

Although selection of fusion algorithm is problem dependent but this review results that spatial domain provide high spatial resolution. But spatial domain have image blurring problem. The Wavelet transforms is the very good technique for the image fusion provide a high quality spectral content. But a good fused image have both quality so the combination of DWT & spatial domain fusion method (like PCA) fusion algorithm improves the performance as compared to use of individual DWT and PCA algorithm. Finally this review concludes that a image fusion algorithm based on combination of DWT and PCA with morphological processing will improve the image fusion quality and may be the future trend of research regarding image fusion.

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