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A Survey on Various Image Fusion techniques

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***Abstract*—During the last two decades the require for better image quality and functionality has led to search for novel algorithms of enhancement which overcome the technology limitations. Various high-resolution images are suggested along with sensor technology development, image fusion is still a popular and important method to understand the image data for acquiring a more appropriate image for a range of applications. Among such algorithms, image fusion is utilized in a wide variety of fields such as aerial photos, astronomy, dynamic processes, machine vision, remote sensing, monitoring, optical microscopy or medical imaging.**

I. INTRODUCTION

Image fusion is the progression of combining information from two or more images of a view into a single composite image that is more revealing and to integrate different data in order to obtain more information than that can be consequent from each of the single sensor data alone , image fusion has been applied to accomplish a number of idea like image sharpening, improving geometric correction, complete data set for improved classification, change detection, substitute missing information, replace defective data. and it is more appropriate for visual observation or computer processing. The idea in image fusion is to decrease ambiguity and decrease redundancy in the output while maximizing appropriate information exacting to an application or task. Given the same set of input images, dissimilar fused images may be generated depending on the explicit application and what is considered relevant information.

The term "fusion" gets numerous words to become visible, such as merging, grouping, synergy, integration and several others that put across more or less the same idea have since come out in literature [1]. Different definitions of image fusion can be found in literature, each author understands this term in a different way depending his research importance's, such as [2-3]. A general definition of data fusion can be adopted as following "Data fusion is a formal framework which expresses means and tools for the alliance of data originating from different sources. Image fusion forms a subgroup within this definition and aims at the invention of a single image from multiple image data for the extraction of information of advanced quality. Having that in mind, the attainment of high spatial resolution, while sustaining the provided spectral resolution, falls precisely into this framework [4].

Image fusion is performed on pixels, features, and decision levels [9]. Pixel-level methods fuse at each pixel and hence reserve most of the information [10]. Feature-level methods extract features from source images (such as edges or regions), and join them into a single concatenated characteristic vector[12]. Decision level fusion [10], [13] comprises of sensor information fusion, after each sensor has processed an image and a preliminary determination has been made (entity's location, attributes, and identity). Pixel-level methods include addition, subtraction, division, multiplication, minimum, maximum, median and rank as well as more complicated operators like Markov random field and expectation-maximization algorithm [14]. Besides these, pixel level also includes statistical methods (Principal Component Analysis (PCA), linear discriminant analysis, independent component analysis, canonical correlation analysis and non-negative matrix factorization). Multi scale transforms like pyramids and wavelets are also types of pixel level fusion [10], [13]. segment fusion, edge fusion [12] and contour fusion [11]. They are usually robust to noise and mis-registration. However, the method provides limited performance for noisy images due to the use of Gaussian filter and two level weight maps.

Recently, joint bilateral filter [7] has been proposed which is effective for detecting and reducing large artifacts such as reflections using gradient projections. More recently anisotropic diffusion [6] has been utilized for detail enhancement in exposure fusion [8], in which texture features are used to control the contribution of pixels from the input exposures. The guided filter is preferred over other existing approaches because; the gradients present near the edges are preserved accurately. We use guided filter [5] for base layer and detail layer extraction which is more effective for enhancing texture details and reducing gradient reversal artifacts near the strong edges in the fused image. Multi resolution approach is used to fuse computed base layers across all of the input images. The details layers extracted from input exposures are manipulated and fused separately.

Image fusion is a technique of obtaining images with high spatial and spectral resolution from low spatial resolution and high spatial resolution images. There is often an inverse relationship between the spectral and spatial resolution of the image. Due to the demand for higher classification accuracy and the need in enhanced positioning precision there is always a need to improve the spectral and spatial resolution of remotely sensed imagery.

II. TYPES OF FILTERING FOR IMAGE FUSION

Bilateral Filter: The bilateral filter calculates the filter output at a pixel as a weighted average of neighboring pixels. It smoothes the image at the same time as preserving edges. Suitable property, has been extensively used in noise reduction [18], The joint bilateral filter is exacting preferential when the filter input is not consistent to make available edge information, e.g., when it is extremely noisy or is an transitional result. The joint bi-lateral filter is appropriate in flash/no-flash denoising [17]. The motivation is that when a pixel (often on an edge) has a small number of similar pixels around it, the Gaussian weighted average is unstable. Another matter concerning the bilateral filter is its effectiveness. a high quantization degree to accomplish reasonable speed, but at the disbursement of quality degradation.

Optimization-based Image Filtering: A series of come within reach of optimize a quadratic cost function and answering a linear system, which is comparable to implicitly filtering an image by an inverse matrix. In image segmentation [20] and colorization the affinities of this matrix are Gaussian functions of the color similarities. Although these optimization based approaches frequently generate high quality consequences, solving the consequent linear system is time-consuming. It has been found that the optimization-based filters are closely linked to the explicit filters. These explicit filters are frequently simpler and faster than the optimization-based filters.

Guided Filter: We primary define a general linear translation-variant filtering process, which occupy a direction of image I, an input image p, and an output image q. Both I and p are given earlier according to the use, and they can be equal. The filtering output at a pixel i is communicated as a weighted average:

$$q_i = \sum_j W_{ij}(I)p_j$$

where i and j are pixel indexes. The filter kernel W_{ij} is a function of the supervision image I and independent of p. This filter is linear regarding p.

Now we define the guided filter and its kernel. The key assumption of the directed filter is a local linear model between the supervision I and the filter output q. We suppose that q is a linear transform of I in a window ω_k centered at the pixel k:

$$q_i = a_k I_i + b_k, \forall i \in \omega_k,$$

where (a_k, b_k) are some linear coefficients supposed to be constant in ω_k. We use a square window of a radius r. This local linear model make sure that q has an edge only if I has an edge, for the reason that $\nabla q = a\nabla I$. This representation has been confirmed useful in image matting [19].

III. TYPES OF FUSION TECHNIQUES

Wavelet Based Fusion: Generally most of fusion methods are base on wavelet transforms. The fusion methods [15] are most frequently utilized. In this two or more registered images say I_1, I_2 all from the similar sight are taken, then any one of the transform W can be practical to each image. Then the transformed images are fused using any one of the recommended fusion rule Ø. Then inverse transform is functional to the fused image to rebuild the image which has better than the all registered images. The registered images are taken as $I_1(x, y)$, $I_2(x, y)$ the fused reconstructed image is $I(x, y)$ and $W^{-1}$is inverse transform then fusion is defined as :

$$I(x, y) = W^{-1}(Ø\,(W(I_1\,(x, y)), W(I_1\,(x, y))))$$

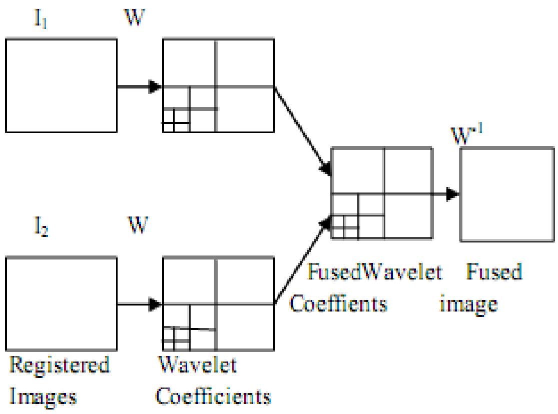

Fig: Fusion of two images using wavelet transforms

Wavelet based fusion make available more advantages over additional pyramid based fusion methods. The wavelet make available directional information. No blocking consequence happens in region where input images are extensively dissimilar. Wavelet based fusion offers better signal-to-noise ratio. The fusion method then takes the following steps:

- Obtain the wavelet transform of each source image. Here, DWT, DWFT or other wavelet transform appropriate to the application can be used.
- Measure an action level from the wavelet coefficients, by delighting each coefficient separately (coefficient-based activity (CBA)) or by averaging over a small window at each coefficient location (window-based activity (WBA)). WBA can be further classified as WA-WBA(weighted-average WBA), in which a weighted average is used, or RF-WBA (rank-filter WBA), which simply picks the largest coefficient inside the window.
- Combine the multiple sets of wavelet coefficients together. The most popular method is to select the coefficient with the largest activity level at each pixel location(choose-max (CM)). Alternatively, one can also take a weighted average of the different sets of coefficients(weighted average (WA)), where the weights are determined by the activity levels of the source coefficients.
- Alternatively, execute uniformity verification, which make sure that a combination coefficient does not come from a different source image from most of its neighbors. Usually, this is implemented by using a small majority filter(window-based verification (WBV)). In the sequel, NV denotes that no consistency verification is performed.
- Make use of the inverse wavelet transform to get better the fused image.

The Region Level Fusion Method: The majority of applications of a fusion scheme are interested in features within the image, not in the actual pixels. Therefore, it seems reasonable to incorporate feature information into the fusion process [22]. There are a number of distinguished advantages of this, together with:

Intelligent fusion rules: Fusion rules are based on combining groups of pixels which form the regions of an image. Thus, more useful tests for choosing the regions of a fused image, based on various possessions of a region, can be implemented;

Highlight features: Regions with certain properties can be either accentuated or attenuated in the fused image depending on a variety of the region's characteristics;

Reduced Sensitivity to Noise: Processing semantic regions rather than at individual pixels or arbitrary regions can help overcome some of the problems with pixel-fusion methods such as sensitivity to noise, blurring effects and mis-registration [22].

Registration and Video Fusion: The feature information extracted from the input images, could be used to aid the registration of the images. Region-video fusion schemes could use motion estimation to track the fused features, allowing the majority of frames to be quickly predicted from some fully fused frames.

Pixel-based fusion using multi-resolution decomposition schemes: A generalized pixel-based multi-resolution image fusion algorithm is used to input source images are transformed using a given multi-resolution image decomposition technique[16] T. One fusion rule is employed to fuse the estimatation coefficients at the highest decomposition level. A second fusion rule is employed to fuse the feature coefficients at each decomposition level. The consequential inverse transform give up the final fused outcome. Even though image fusion algorithms are anticipated to survive minor registration
differences, the source images to be fused are supposed to be registered.

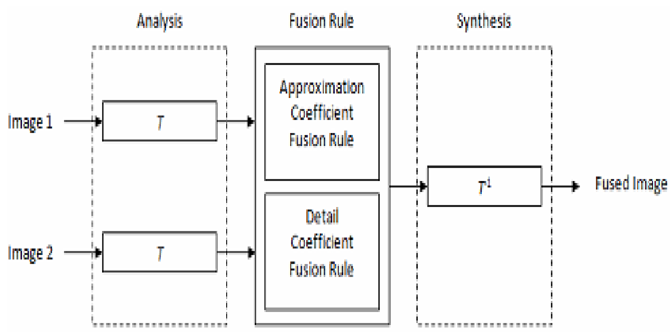

Fig: A generalized pixel-based multi-resolution image fusion algorithm.

Mis-registered source images should be issued to registration preprocessing steps self-determining to the image fusion algorithm. The estimatation coefficients at the highest level of decomposition N are most frequently fused via uniform averaging. This is because at the highest level of decomposition, the estimation coefficients are understand as the mean intensity value of the source images with all relevant features encapsulated by the feature coefficient sub-bands at their various scales [16]. Consequently, fusing approximation coefficients at their highest level of decomposition by averaging upholds the suitable mean intensity required for the fusion result with minimal loss of salient features.

IV. Literature Review

One method of achieving feature-level fusion[21] is with a region-based fusion scheme. An image is initially segmented in some way to produce a set of regions. Various properties of these regions can be calculated and used to determine which features from which images are included in the fused image. This has advantages over pixel-based methods as more intelligent semantic fusion rules can be considered based on actual features in the image, rather than on single or arbitrary groups of pixels.

This paper has demonstrated that comparable results can be achieved with region and pixel-based methods. While region-based fusion methods are generally more complex, there are a number of advantages of such schemes over pixel-based fusion. The advantages demonstrated here include novel more intelligent fusion rules and the ability to treat regions differently depending on a variety of properties such as average activity, size and position relative to other regions in the scene.

This paper explains [23] how Discrete Wavelet Transform (DWT) can be used for merging the lower frequency component of a multi-spectral image and its higher spatial resolution images by means of rules. Due to the demand for higher classification accuracy and the need in enhanced positioning precision there is always a need to improve the spectral and spatial resolution of remotely sensed imagery. In DWT the different parts of the image after decomposition, different fusion rules are adopted. The intensity of the high frequency information is merged with the low frequency In DWT the different parts of the image after decomposition, dissimilar fusion imperatives are assumed. The intensity of the high frequency information is merged with the low frequency information to match the intensity component to get the feasible and effective method for image fusion.

Since fused images [23] are used to enhance visual information for human users, performance assessment of image fusion should be first judged by the users, based on the mission of specific applications. In situations where it is hard to take decision about the quality of fused image objective measures are calculated. Quantitative measures should only serve as a useful tool to assist human users to make difficult judgments whenever necessary. The performance assessment of image fusion should continue to be shared between qualitative and quantitative methods, with increasing weight being placed with quantitative assessment techniques.

Improved guided image fusion for magnetic resonance and computed tomography imaging is proposed[24]. Existing guided filtering scheme uses Gaussian filter and two level weight maps due to which the scheme has limited performance for images having noise. Different modifications in filter (based on linear minimum mean square error estimator) and weights maps (with different levels) are proposed. The acquired medical images are usually of low quality (due to artifacts), which degrade the performance in terms of human visualization and quantitative analysis. The saliency maps are linked with detail information in the image. The main issue with 0 and 1 weight assignments arises in GFF when different images have approximately equal saliency values. In such cases, one value is completely throw away. For noisy[24] MR images, the saliency value possibly higher at a pixel because of noise.

In this paper we propose [25] a novel detail-enhancing exposure fusion approach using non-linear translation-variant filter (NTF). With the captured Standard Dynamic Range (SDR) images under different exposure settings, first the fine details are extracted based on guided filter. Next, the base layers (i.e. images obtained from NTF) across all input images are fused using multi-resolution pyramid. Exposure, contrast and saturation measures are considered to generate a mask that guides the fusion process of the base layers. Multi-resolution approach is used to fuse computed base layers across all of the input images. The details layers extracted from input exposures are manipulated and fused separately. The final detail enhanced fused image is obtained by integrating the fused base layer and the fused detail layer. The framework is inspired by the edge-preserving property of guided filter that has better response near strong edges. The two layer decomposition based on guided filter is used to extract fine textures for detail enhancement.

The proposed method [26] is based on a two-scale decomposition of an image into a base layer containing large scale discrepancy in intensity, and a specify layer confining small scale features. A new guided filtering-based weighted average method is proposed to create full use of spatial reliability for fusion of the support and specify layers. Experimental outcomes shows that the proposed method can acquire modern concert for fusion of multispectral, multi focus, multimodal, and multi exposure images. A novel weight construction method is proposed to combine pixel saliency and spatial context for image fusion. Instead of using optimization based methods, guided filtering is adopted as a local filtering method for image fusion. An important observation of this paper is that the roles of two measures, i.e., pixel saliency and spatial consistency are quite different when fusing different layers. In this paper, the roles of pixel saliency and spatial consistency are controlled through adjusting the parameters of the guided filter.

More importantly, the guided filter is used in a novel way to make full use of the strong correlations between neighborhood pixels for weight optimization. In this researches illustrate that the proposed method can well maintain the original and corresponding information of multiple input images. Positively, the proposed technique is very robust to image registration. Additionally, the proposed technique is working out efficient, making it quite qualified for real applications.

In this paper,[27] here they proposed a new explicit image filter called guided filter. The filtering output is locally a linear transform of the supervision image. Alternatively, the guided filter has good edge-preserving smoothing properties like the bilateral filter, but it does not endure from the gradient reversal work of arts. Alternatively, the guided filter can be used ahead of smoothing: With the help of the guidance image, it can make the filtering output more arrangement and less smoothed than the input. Here they show that the guided filter executes very well in a huge range of applications, together with image flash/no-flash imaging, atting/feathering, dehazing ,smoothing/enhancement, HDR compression, and joint up sampling. Furthermore, the guided filter physically has an O(N) time (in the number of pixels N) no estimated algorithm for both gray-scale and high dimensional images, not considering of the kernel size and the intensity range. Characteristically, our CPU implementation accomplish 40ms per mega-pixel performing gray-scale filtering: so, this is one of the fastest edge preserving filters.

V. CONCLUSION

Various method of these image fusion can be computed and used to find out which characteristics from which images are consist of the fused image. Image Fusion intends at the mixing of dissimilar and complementary data to improve the information perceptible in the images in addition to increase the consistency of the understanding. This show the ways to more precise data and increased effectiveness in various application fields like segmentation and classification.

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