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Research on Image Fusion Technology Based on Representation Learning

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Abstract: Image fusion technology is a concept put forward in the late 70s of the 20th century, is a category of information fusion in image as the research object, the information fusion technology based on the theory of image processing technology. This paper is in the framework of image fusion based on, combined with the structure is widely used in the field of signal processing and its applications -- sparse, puts forward a said learning for image fusion method based on, through learning, the image is divided into the low frequency part of the sparse and can be approximately regarded as the high frequency part of sparse, then frequency part of sparse representation, are fused by using different fusion rules, finally the fused low frequency part and high frequency part after inverse discrete wavelet transform for, the final fusion image can be obtained.

Keywords: Discrete wavelet, image fusion, representation learning.

1. INTRODUCTION

1.1. Image Fusion in Spatial Domain

In the spatial domain of image fusion, the input image is fused in the spatial domain, for example, the application of local spatial features. If g (•) indicates the fusion rule [1], the spatial domain method can be summarized as follows:

$$I_f(x,y) = g\left(I_1(x,y),\ldots,I_T(x,y)\right) \quad (1)$$

1.2. Image Fusion in Transform Domain

Based on transform domain image fusion algorithm the basic idea is to deal with the fusion image of image transformation (such as the wavelet transform, DCT transform, etc.), obtained after image decomposition coefficient, and according to some fusion rules for the obtained coefficients, a fusion coefficient, then inverse transform to get the fused image [2].

F{•} represents the transformation operation, g(•) represents the fusion rule, the transform domain image fusion method can be expressed as:

$$I_f(x,y) = F\left\{g\left(F\left\{I_1(x,y)\right\},\ldots,F\left\{I_T(x,y)\right\}\right)\right\} \quad (2)$$

The commonly used transform domain image fusion method has component replacement fusion method and multi-resolution decomposition fusion. Component replacement method includes image fusion based on IHS transform and image fusion based on principal component analysis. Multi - resolution fusion is based on the fusion of multi - scale decomposition [3]. Multi scale decomposition from research in computer vision of the human eye perception process simulation. Multi - scale decomposition coefficients of all levels show that the resolution of the image information is gradually reduced. This structure describes the feature information in the image, and its coefficient is used to characterize these features. The characteristic of a multi - scale decomposition, which makes it as a primary processing form of a neural vision. Multi scale decomposition can effectively perform many basic image operations that can generate a set of low-pass or images. Through the interconnection between the level and the level, the multi - scale decomposition provides the connection between the local processing and the global processing.

2. IMAGE FUSION BASED ON WAVELET TRANSFORM

2.1. Wavelet Transform

In essence, the wavelet transform is an extension of the high pass filter, which uses the idea of space and space details. In vision, image detail is between features high contrast results, and corresponds to the high contrast in the frequency domain large values in the spatial domain, frequency information can extracted by Fourier transform. However, it is no longer with any spatial information have any relevance [4]. The wavelet transform is more useful than the Fu Liye transform, because they are based on the function of both space and frequency. The use of wavelet transform to extract the details of the image can be used in many ways to inject into another image, such as substitution, addition, or based on the frequency domain or airspace method. Wavelet decomposition is non-redundant, so that the image after wavelet decomposition, the amount of data will not increase and wavelet decomposition has a direction, using this feature may according to the human eye to different direction high frequency components with different resolution of the visual properties, image of the visual effect is better.

Wavelet transform has been widely used in the field of image processing [5]. The wavelet transform is used in image fusion. The Mallat binary discrete wavelet image

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decomposition algorithm is generally used. The decomposition can be expressed as:

$$\begin{aligned} a_{j+1}(m,n) &= \sum_{l\in Z}\sum_{k\in Z} h_{l-2m}h_{k-2n}a_j(l,k) \\ D^1_{j+1}(m,n) &= \sum_{l\in Z}\sum_{k\in Z} h_{l-2m}g_{k-2n}a_j(l,k) \\ D^2_{j+1}(m,n) &= \sum_{l\in Z}\sum_{k\in Z} g_{l-2m}h_{k-2n}a_j(l,k) \\ D^3_{j+1}(m,n) &= \sum_{l\in Z}\sum_{k\in Z} g_{l-2m}g_{k-2n}a_j(l,k) \end{aligned} \quad (3)$$

2.2. Image Fusion Based on Wavelet Transform

Based on wavelet transform image fusion method is the source images were wavelet transform, the image is decomposed into a series of different resolution, different directional sub band diagram, to different by using different fusion algorithms and flexible in the fusion images to preserve the image source important features. As shown in Fig. (**1**) Fusion rules for high frequency sub band diagram of fusion rules and the low frequency sub band diagram fusion rule, wavelet transform high frequency component of the image reaction the detail information of the image, such as texture, edge, mutation [6]; low frequency component reflects the approximation of the image information, such as contour region; so in different frequency domain using different fusion algorithms, get a synthetic Image decomposition, resulting in a synthetic image preserving source image in the salient features of the different frequency domain. Based on wavelet transform image fusion algorithm research focus mainly concentrated in the high frequency domain. This is due to the image after wavelet decomposition, the detail information of the image mainly concentrated in the high frequency domain, and low frequency mainly includes the approximate information of fusion image, the image contains the main energy, whether human observation or machine recognition is the image of the main energy based, low frequency coefficients reflect the contours of the image, low frequency coefficients influence the visual effect of image fusion, the fusion image quality is good or bad play to the very important role as shown in Fig. (**2**) [7].

Wavelet method for natural image fusion, Wavelet Weighted average method as an example of the experimental results.

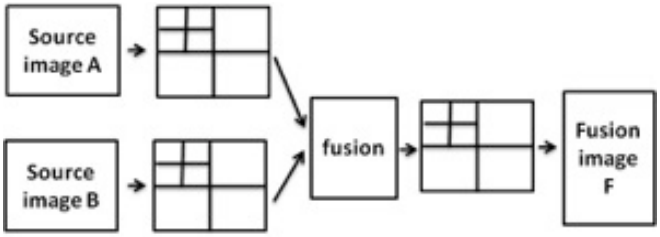

Fig. (1). Image fusion based on wavelet decomposition.

3. IMAGE FUSIO METHOD BASED ON REPRESENTATION LEARNING

3.1. Express Learning

The method of image fusion can be divided into two categories: image fusion based on spatial domain and image fusion method based on transform domain. Based on the spatial domain image fusion methods often in the fusion image generated spatial distortion, which is not conducive to the subsequent image processing tasks, this shortcoming can transform domain image fusion method to solve. Among them, multi resolution decomposition strategy is very popular in remote sensing image fusion, the fusion method including the pyramid based method, transform, wavelet transform and so on. The wavelet based method is superior to other methods, but all of these methods require a priori knowledge of the source image. Thus, a problem is naturally produced - whether the image can be fused in the absence of a source image [8].

The compressed sensing theory provides a method for obtaining the sampling of a priori knowledge without any prior knowledge of the source image. Moreover, with the information demand increasing, more and more wide signal bandwidth, in access to information on the sampling rate and processing speed is getting higher and higher requirements are put forward, the Nyquist sampling under the guidance of the theory of information acquisition and processing, storage and transmission become a major bottleneck in information field [9]. Compressed sensing theory in data acquisition method breaks through the traditional Nyquist sampling theorem, in the sampled while achieving the signal compression, and the sampling rate does not depend on the bandwidth of the signal, and with the of the signal related. Compressed sensing theory about sparse or compressible signal can be from a small amount of irrelevant projection to exact reconstruction, irrelevant number of projection is far

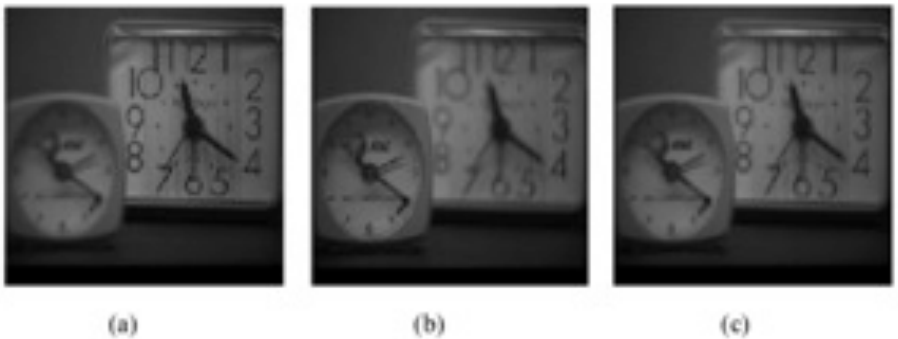

Fig. (2). Fusion image. (**a**, **b**) source images with Wavelet Weighted Averaging, (**c**) Wavelet Weighted average fusion image.

less than the signal at the Nyquist sampling the number of samples, so greatly reduces the sampling rate and computational complexity.

Therefore, sparse representation has been widely used in the field of image fusion. Signal sparse said is also compressed sensing a major research content is exhausted possible number of non-zero coefficients to represent the signal of the main information, so as to simplify the problem solving process. In the past ten years, has become one of the structure is widely used in the field of signal processing and its applications. In recent years, researchers working in signal over complete dictionary of the research on the expression of the different from traditional said, because it provides a broad students into range of atomic elements and redundant room said signal's charm lies in its ability to economic (compact) represent a class of signals (or images). Traditional signal, the signal can usually to sparse representation and sparse approximation by a linear combination of a set of orthogonal bases of atomic, but this in the practical application of signal processing and not very useful and efficient, by increasing the number of basis vectors will complete basis into after preparing the base when the signal representations is compact. The basis of this redundant means learning.

3.2. The Development of Image Fusion Based on Representation Learning

As shown in Fig. (**3**), Before the CS literature has defined many different CS matrix, Donoho consider the set of uniform spherical and using partial Fourier matrix and show the set several features in CS, due to the special structure of the partial Fourier set of Fourier transform, the use of this kind of matrix greatly extends the application of CS in the mass data, such as the 2-dimensional images. L1-magic toolbox with a two-dimensional fast Fourier transform, the CS matrix phi is in the Fourier plane by star sampling mode to construct. Wan Tao put forward "double star" and "star ring" sampling mode, sampling mode is composed of the white line, the white line that is used to calculate the location of the observation y frequency compression, and once the observation y, from the observation y reconstruct the original image using a certain algorithm. Therefore, the selection of different sampling modes will lead to different observations, Wan Tao proposed an image fusion method based on the "double star" sampling mode. The fusion strategy used in the wavelet domain is used in the compressed domain, and the image fusion is performed on the compression observation rather than on the wavelet coefficients.

Fusion method is: first of all source images in complete dictionary is expressed in the form of a sparse coefficient, and then use the fusion rule is used to fuse the sparse coefficients, the fusion coefficients to reconstruct the fused image. Among them, the sparse representation of the process using the OMP algorithm. At the same time, Bin Yang proposed a based image fusion method, algorithm ensures that the different source image sparse decomposition to the base dictionary with a subset, and different signals can be from the same base atoms of sparse sets from the coefficients of different reconstruction. Because sensors to observe related phenomena [10]. A kind of relation structure and relation, distributed compressed sensing, mining the relationship between the signal and the signal, and the source images can be expressed as the common features and unique features of the two part.

3.3. Image Fusion Based on Wavelet Transform and Representation

Yang Bin proposed a multi focus image fusion method based on sparse representation in 2010. The method can be used to make noise and fusion in the same time. Fusion method is: first of all source images in complete dictionary is expressed in the form of a sparse coefficient, and then use the fusion rule is used to fuse the sparse coefficients, the fusion coefficients to reconstruct the fused image. Inspired by this method, a new image fusion method based on discrete wavelet representation is proposed in this paper.

The basic idea of the method is: the image of discrete wavelet transform (DWT), the low frequency part and high frequency part, and low-frequency part is not sparse, the high frequency part can be seen as a sparse, so the high frequency part and the low frequency part of the application of different fusion rules are fused. Here is the high frequency part is over complete dictionary for sparse representation, the sparse coefficients were fusion. After fusion, the high-frequency part; and the low frequency part, the fusion rules and fusion, fusion low-frequency part. At last, after the fusion of the high frequency part and the low frequency part of the fusion, the fusion image is obtained by inverse discrete wavelet transform [11].

3.4. Fusion Strategy

In the first step, the discrete wavelet transform is performed on the source image I1 and I2, and the low frequency part and the high frequency part are obtained. The low frequency part of the source image I1 and I2 were recorded in CA1 and CA2. High frequency part is divided into levels of CH, vertical part of CV and the diagonal part of CD were recorded for ch1, CV1, CD1 and CH2, CV2, CD2.

The second step, because the low frequency part is not sparse, and the high frequency part can be considered as sparse, so the high frequency part in the over complete dictionary D, the use of OMP algorithm for sparse representation [12].

The third step, the low frequency part of CA1 and CA2 fusion, the fusion of the low frequency part of the CA.

The fourth step, using sliding window technique, the high frequency image ch1, CV1 and CD1 and CH2, CV2, CD2 from the upper left corner to the lower right corner into the size of N x n image blocks, and then each image blocks are arranged in a column vector, all of the images of a high frequency per image block rows of column vector group into vector in the VCH1, VCV1, VCD1 and VCH2, VCV2 and VCD2 -. Using OMP algorithm for all of the column vector of sparse decomposition, the sparse coefficient matrix is SCH1, SCV1, SCD1 and SCH2, SCV2, SCD2. When the error limit, the OMP algorithm will stop the iteration.

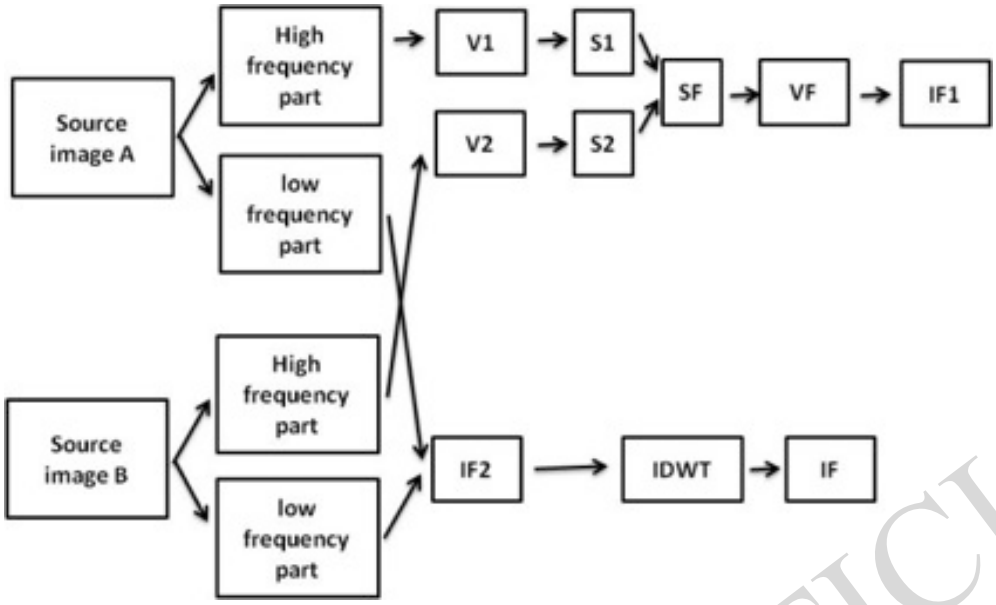

Fig. (3). Image fusion based on discrete wavelet transform and representation.

The fifth step, SCH2 and SCH1, SCV2 and SCV1, SCD2 and SCD1 in a certain fusion rule, the fusion of the sparse coefficient matrix SCH, SCV and SCD.

The sixth step, according to the VF of SF = D respectively blend VCH, VCV and VCD.

The seventh step, respectively, VCH, VCV and VCD to revert back to the size n x n image blocks, into the corresponding position in the image, for each pixel, pixel values is several blocks of image pixel values and then divided by the superposition of the times can after fusion, the high-frequency figure like ICH, ICV and ICD [13].

The eighth step, after the fusion of the low frequency part and the high frequency part of the fusion, the fusion image is obtained by the discrete wavelet transform, IF.

3.5. Experimental Result Analysis

This experiment in 7.10. Intel (0R2010a) and Matlab (R) Core (TM) CPU 2.40GHz i5-2430M, memory for RAM 2.00GHz notebook running.

The first set of images is CT image and MRI image, the size of the image is 256 x 256. CT and MRI images have very strong and contrast. CT images can clearly reflect the high density bone structure, combining the advantages of the two images of soft tissue imaging effect is relatively poor, and MRI images of soft tissue imaging is very clear, by CT image and MRI image fusion can effectively, and is helpful for diagnosis and treatment. The fusion results are shown in Fig. (**4**), and the fusion results are shown in the local image:

The second set of images is the multi focus image Clock, the image size is 512*512. A picture on the left side of the image is clear, and the left side of the image is clearly on the right side. The experimental results are showin in Fig. (**5**).

The third groups of images are visible light image and near infrared image, the image size is 256*256. Visible light images provide the outline of the scene, while the infrared image is able to provide specific target information, such as hidden guns and people [14]. And the image fusion is to integrate the contour of the scene and the specific target into an image. Experimental results are shown in Fig. (**6**).

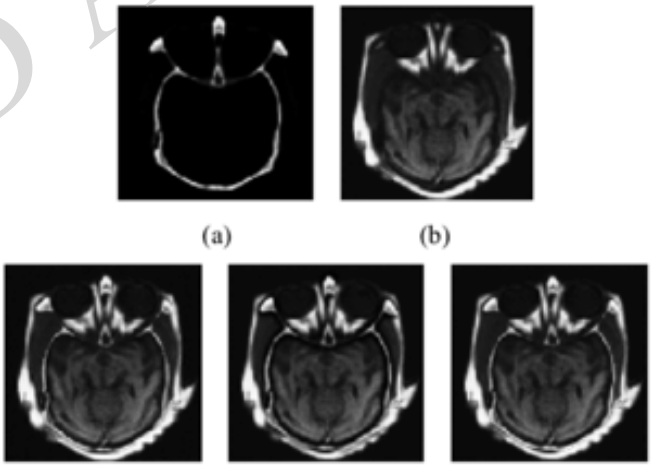

Fig. (4). Fusion results of MED images. (**a**, **b**) DWT; (**c**) SR; (**d**) method; (**e**) DWT-SR.

Image fusion from multiple images in different sensor fusion image to obtain the scene more accurate and clear, which is more suitable for human visual perception and subsequent image processing. The traditional image fusion method with the increasing amount of data, has brought tremendous pressure to the storage and transmission of signals, and compressed sensing theory of the proposed new data access effectively solved this problem, therefore, compressed sensing theory research has been more and more attention. It is the most widely used signal structure in the present compressed sensing theory. This paper studies and discusses the image fusion method based on sparse representation.

Many signals in under the over complete dictionary based stationary and can be sparse representation, so there is

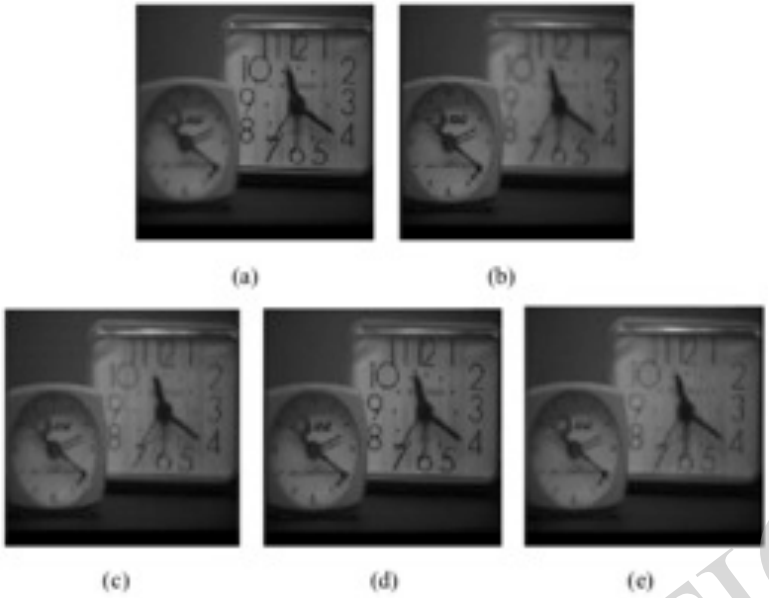

Fig. (5). Fusion results of multi focus images. (**a**, **b**) DWT; (**c**) method; (**d**) SR method; (**e**) DWT-SR method.

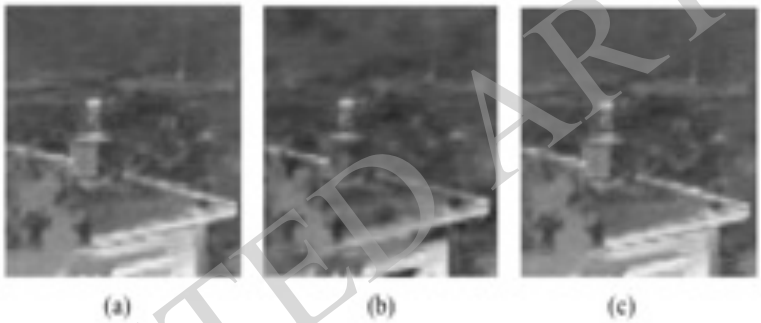

Fig. (6). Fusion results of infrared and visible images. (**a**) DWT; (**b**) SR method; (**c**) DWT-SR.

no need to direct sampling and compression of all the data, and only need to find out the most important factor for storage and compression through the signal of linear measurement. This is a challenge to the traditional sampling theory and the compression theory. With the increase of the sampling rate and the signal bandwidth, the amount of data needed to be processed is increasing, and the new data acquisition method proposed by the concept of compressed sensing is greatly affected by the signal processing field.

CONCLUSION

In this paper, based on the representation of image fusion method, a new image fusion method based on discrete wavelet transform and representation is proposed. Because of the high-frequency part of the image sparse, and low frequency part is not sparse, so will image after discrete wavelet transform (DWT), the low frequency and high frequency, on high frequency part by based on sparse representation of the fusion method, respectively, the high frequency part and the low frequency part respectively are fused and the IDWT through get the final fused image. In three types of images verify the fusion effect and based on DWT and image fusion method based on the SR image fusion methods are compared, by subjective and objective indicators to verify the effectiveness of this method. Overall, this method in medical image and infrared, visible light image fusion turns out to be significantly better than the other two methods, in the multi focus image fusion, slightly worse in the SR based image fusion method. One core principle of signal processing and information theory is that signals, images, and other types of data usually contain some type of structure, which makes it possible to represent and process intelligently [15]. The problem of this paper is that the sparse property of the signal is only used for the structure characteristics of the signal, and there is no concept of joint. In the following research, the full use of the signal and the inter relationship between the signal and the signal, make full use of the joint sparse model, to do image fusion based on the joint sparse model.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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