A Multi Sensor Image Fusion Algorithm Based On Multi Resolution Analysis

Zhong Qi

College of Mathematics and Computer Science, Gannan Normal University,
Ganzhou, China
zhongqi@126.com

***Abstract* — Based on pixel level multi resolution analysis and current 3 multiresolution algorithms for Wavelet Transform (WT), Contour-let Transform (CT) and Non-Subsampled Contour-let Transform (NSCT), we present a new hybrid multi resolution algorithm. We use different types of images and extensive simulations combined with subjective and objective evaluation criteria to compare and analyze the pros and cons of each algorithm. We study: i) principles of multi-resolution analysis and the improvement of common multi-resolution analysis in WT, CT and NSCT algorithms and fusion rules; ii) the mixed framework of multi-resolution analysis, and combine it with single multi resolution algorithm, and propose a hybrid multi resolution algorithm with two-dimensional multi-scale WT and NSCT; iii) multi focus image, infrared and visible images, medical images and images of four types based on WT, NSCT, WT and hybrid CT algorithm respectively, and determine the effectiveness of subjective analysis and objective parameters to validate the algorithm; and iv) we use Matlab platform to build a suitable demonstration and do comparative analysis of the image fusion system.**

Keywords- Multiresolution analysis; image fusion algorithm; multi-sensor data acquisition; wavelet transform; NSCT transform

I. INTRODUCTION

In recent decades, the rapid development of technology and hardware technology has brought the rapid development of computer technology and large-scale integrated circuits. Because of the different imaging mechanisms of different image sensors, they also have different performance in the changing working environment. At present, a large number of sensors are used in information processing; these instruments bring plenty of information, but also bring a large number of complex and diverse information. So if you want to get the needed information from the large amount of information, we must implement effective handling of this information, which requires an efficient information processing technology, the emergence of a multi sensor information fusion technology (Multi-sensor Information Fusion). Human brain can deal with a large number of complex information efficiently at the same time, multi-sensor information fusion is a high-level, comprehensive simulation of human brain processing information. The technology of image processing is multi-level and multifaceted; the final fusion image covers rich and reliable information of the source image. Multi source data fusion is one of the most important research parts, and image fusion is the most abundant and intuitive fusion result in data fusion. Image sensor at the end of 1970s, a large number of scholars worldwide on the research upsurge of image fusion, the image fusion technology is developing very fast, but also for the multi-sensor data fusion to add a new member of multi-source image fusion [1]. Image fusion is not a single subject, its range is very wide, including a variety of modern chemistry, sensor technology, computer technology and image processing technology, it can pass on from two or more image information for the same objects using different reasonable algorithms are studied, the purpose is to get a picture more reliable, more comprehensive and more accurate description of the new image. This technique is useful information will not homologous image into one image, this fusion makes the human eye can see more information processing computer is also convenient, help human beings to make effective decisions about things. Image fusion technology is not the multiple images together, nor image enhancement, it will make good use of every piece of fusion in favorable information in the image, the final fused image can effectively cover more information. At present, although a large number of researchers continue to study and develop a variety of high-quality image sensors, and made great progress. The image sensor can only provide a single data information limited in specific working conditions and within the scope of work, in order to make full use of multi-source data, the need for effective combination of those who can work in different environment specific image sensor, this information is more complete and detailed, and has robustness and fault tolerance more good. In this kind of thought and atmosphere under the guidance of multi-source image fusion technology has played a great role in computer intelligence, medical image processing, remote sensing image and high-tech military application fields and aspects. Now, more and more image fusion applications, involving the range more widely, such as in the military field can be used for navigation and target recognition; in the field of medicine, can assist the doctor to patient's CT images and magnetic resonance images of MRI were analyzed, help doctors to make accurate diagnosis; in the field of aviation, pilots can be fusion of infrared and visible light images

collected by observation, accurately determine the route, to ensure flight safety [2]. In short, image fusion technology has a very realistic and important significance to national economy and social development. The traditional multi-resolution algorithm is a multi-resolution algorithm based on image fusion processing, so to achieve the integration of image to a certain extent, but the implementation of the algorithm performance has a limit in a great extent, the reason is that every algorithm itself has a basic function to construct their own performance and algorithm. The scope of this function will limit the algorithm. Based on the above characteristics, scholars have introduced the fusion framework of multi-resolution analysis, and its framework Figure 1 hybrid multiresolution analysis framework. In the whole process of image fusion, fusion rules are essential, and the appropriate selection will directly affect the image fusion quality. From the perspective of multi resolution analysis algorithm, the fusion rule selection and structure there is a corresponding theoretical basis, that is after the decomposition of multiresolution analysis will be high and low frequency coefficients of the image, and the high frequency subband coefficients represent the image details, reflecting the low frequency subband coefficients is the approximate part of the image them. The value of high frequency coefficients generally active in zero, the absolute value of gray transform coefficients more representative of Shaoxing here strongly that contains the source images of long lines, edge and other important elements. Image fusion rules classification schematic shown in Figure 2.

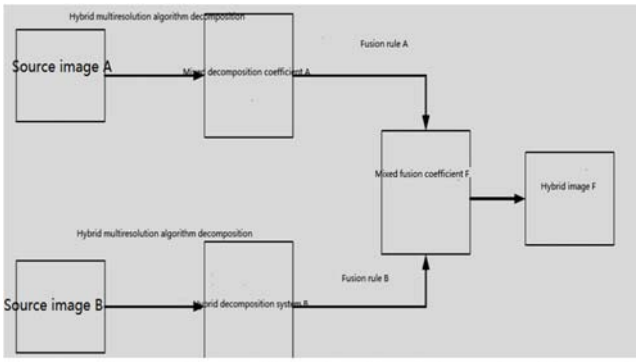

Figure 1. Schematic diagram of hybrid multiresolution analysis framework

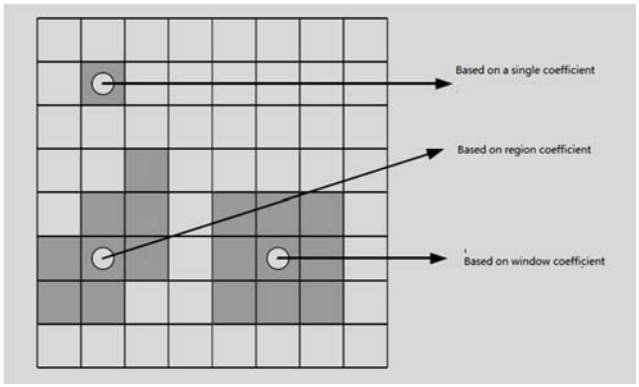

Figure 2. Schematic diagram of classification of image fusion rules

Based on the pixel level in multi resolution analysis principle and implementation, and the current research hot single multi resolution wavelet transform algorithm, Contourlet transform and Nonsubsampled Contourlet transform, finally put forward an algorithm of multi resolution of this. Then, based on different types of images, combined with subjective and objective evaluation criteria, to compare and analyze the pros and cons of each algorithm. The research and Realization of the principle of multi-resolution analysis, focuses on the analysis of multi resolution of wavelet transform, Contourlet transform and improved sampling Contourlet transform algorithm and fusion rules; as for the same input image by choosing different wavelet bases, the contrast test was large, the optimal wavelet base used in this paper. In addition, after determining the wavelet basis, the decomposition level of 2~8 layer is compared, and the better decomposition layer is obtained. Two kinds of multi resolution algorithm can mix, mixing effect, is a mixture of multi resolution algorithm in the study focus on the need to consider, based on the mixed framework of multiresolution analysis, combining with the nature of a single multi resolution algorithm is proposed in this paper, the hybrid multi resolution algorithm, two-dimensional multi-scale wavelet transform and Nonsubsampled Contourlet transform; in the realization of the two kinds of multi resolution hybrid algorithm based on the fusion rules will be improved, such as the high frequency coefficients in the decomposed, this is no longer a fusion of traditional rules, but in different layers of decomposition, using different fusion rules. Finally, the image of multi focus images of four types based on a hybrid algorithm based on wavelet transform, NSCT transform, wavelet transform and the mixed Contourlet respectively, given the effectiveness of subjective analysis and objective parameters to validate the algorithm; in order to compare the display and algorithm easily, using Matlab platform, build a multi-source image fusion system, this system can also realize the two algorithms, and can be carried out on the subjective visual evaluation of the final fusion results, at the same time the objective parameters are evaluated objectively and convenient[3].

II. BASIC THEORY OF MULTIRESOLUTION ANALYSIS ALGORITHM

A. Multiresolution Analysis with MALLAT Algorithm

The idea of multiresolution analysis (multi resolution) is an effective understanding of the phenomenon, understand the nature of the problem that the idea of AHP, it is very obvious, can be analyzed from the overall shape of things to the details of things, and can also be analyzed from the inside to the outside. The idea of multi-resolution analysis is to find problems and solve problems in engineering construction, which is a step by step analysis theory when S.Mallat studies many different image solving problems. In 1987, Mallat proposed a wavelet multi-resolution analysis of the concept, he will be in the field of computer vision multiscale analysis reference to research in the theory of wavelet decomposition and reconstruction, through careful study of wavelet and

wavelet transform, finally synthesizes the previous proposes by other scholars of various wavelet transform. The research work of Mallat not only advances the theory of wavelet analysis to a higher direction, but also makes the multi-scale analysis obtain fruitful theory and application results in many important fields. Mallat spatially interpreted the multi-resolution properties of the wavelet, for example, the resolution ratio as the camera lens. When the viewing angle is large, only observed the whole contour profile can be objective things in the camera lens; when the viewing angle is small, the camera can be observed in the target details. Therefore, with the observation angle from large to small changes, at each scale or resolution can be observed from the whole to the fine part of the target, which is multi-scale (multi-resolution) thinking. At present, the research of image fusion focuses on the research of pixel level image fusion algorithm, and the research focus of pixel level is centered on multi-resolution analysis. The analysis of multi-resolution image fusion algorithm has many advantages: a large number of experiments show that the multiresolution image analysis and multi-channel visual decomposition inherent principle consistent, multiresolution analysis is fused with different fusion rules in different scales, so human retinal image processing; combining multi-resolution analysis advantage the researchers, we can construct the fusion algorithm has lower complexity. Therefore, the image fusion analysis method based on multi-resolution analysis can produce better fusion effect, which is also the important reason of the multi resolution image fusion algorithm [4]. In 1987, Mallat and Meyer proposed Multi-resolution Analysis (multiresolution analysis), which smoothly unifies the other wavelet function before the construction method. Such as Stromberg wavelet, Meyer wavelet, etc. On the basis of this study, the Mallat on the multi resolution analysis of the idea in 1989 and applied to the analysis of algorithm of wavelet transform, the wavelet transform and the properties of extended to a hitherto unknown range within a short period of time. Finally, he obtained the fast discrete wavelet transform through the rigorous mathematical derivation, also known as the Mallat algorithm in the field of algorithm. Multi resolution algorithm schematic shown in Figure 3, Mallat algorithm schematic shown in Figure 4. Related formulas such as formulas (1) and (2) are shown.

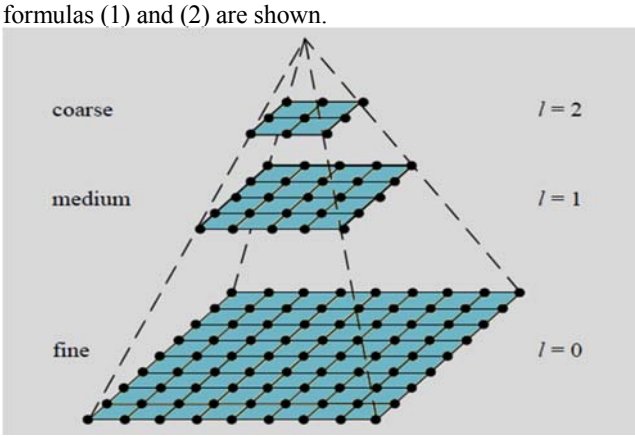

Figure 3. Schematic diagram of multi resolution algorithm

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \tag{1}$$

$$G(x_i, y_i, \sigma) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(x-x_i)^2 + (y-y_i)^2}{2\sigma^2} \right) \tag{2}$$

The scale space of an image is L(x, y, σ), which is defined as the original image I(x,y) and a variable scale 2 dimensional Gauss function G(x, y, σ) convolution operation. Namely scale space form can be expressed as formula (1) and (2).

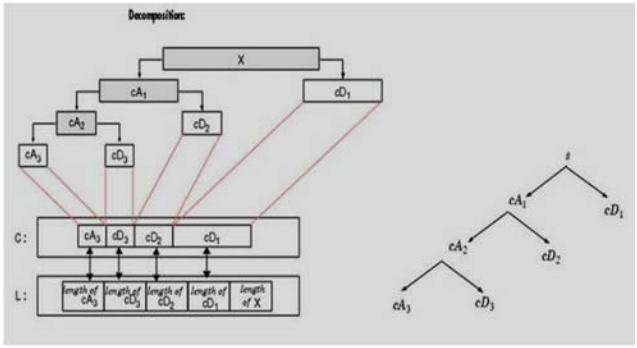

Figure 4. Mallat Algorithm Working Schematic Diagram

B. *Wavelet Transform*

Wavelet transform is a new analysis method, it inherited and developed the short-time Fu Liye transform the idea of localization, but also overcomes the disadvantages of window size does not change with frequency, can provide a time - frequency with the frequency change of the window, is an ideal tool for time-frequency analysis and processing of signals. Its main feature is the prominent feature of image can be some problems, on time (space) frequency analysis of localization, through the telescopic translation operations to signal (function) step by step multi scale refinement, the final breakdown of time at high frequency, low frequency subdivision, can automatically adapt to the requirements of time-frequency signal analysis thus, can focus on any signal details, to solve the difficult problems of Fourier transform, become a major breakthrough in the scientific method since the Fourier transform. The traditional signal theory is established on the basis of the Fourier analysis, Fourier transform as a kind of global change, it has some limitations, such as do not have local analysis ability, cannot analyze non-stationary signals. In practice, people began to improve the Fourier transform to improve this limitation, such as STFT (short-time Fu Liye transform). As the sliding window function used by STFT is fixed, the time frequency resolution is fixed and does not have adaptive ability, and wavelet analysis solves the problem well. Wavelet analysis is a new branch of mathematics, it is a function, Fourier analysis, harmonic analysis and numerical analysis of the most perfect crystallization; in the application domain, especially in signal processing, image processing, speech

processing and wide field of nonlinear science, it is considered to be an effective time-frequency after Fourier analysis the analysis method [5]. Compared with the wavelet transform and Fourier transform, the local transform is a time and frequency domain which can effectively extract information from signal, multiscale analysis of functions or signals by translation and dilation (Multiscale Analysis), to solve many difficult problems could not be solved by Fourier transform. Compared with Fourier transform, wavelet transform is the local transform of space (time) and frequency, so it can extract information from signal effectively. By scaling and translation functions, the function or signal can be refined by multi-scale analysis, which solves many difficult problems of Fourier transform. Wavelet transform relates to applied mathematics, physics, computer science, signal and information processing, image processing, seismic exploration and other disciplines. Mathematicians thought that wavelet analysis is a new branch of mathematics, it is the functional analysis, Fourier analysis, spline analysis, numerical analysis of the perfect crystal; signal and information processing experts believe that the wavelet transform is a time scale analysis and multiresolution analysis, a new technology, it in the signal analysis, speech synthesis, image recognition, computer vision, data compression, seismic exploration, atmospheric and ocean wave analysis are made with scientific significance and the application value of the results. The main purpose of signal analysis is to find a simple and effective signal transformation method, so that the important information contained in the signal can be displayed. Wavelet analysis belongs to signal time-frequency analysis. Before wavelet analysis, Fu Liye transform is one of the most widely used and effective methods in signal processing. Fu Liye transform is time domain to frequency domain conversion tools, from a physical sense, the essence of the Fu Liye transform is to decompose the waveform into different frequency sine wave superposition and. It is the important physical meaning of Fu Liye transform that determines the unique position of the Fu Liye transform in signal analysis and signal processing. Fu Liye transform with sine curve in two directions are infinite wave as orthogonal base function, the periodic function into Fu Liye series, the non-periodic function into Fu Liye integral, analyze the frequency spectrum of the function using Fu Liye transform, time frequency spectrum characteristics of the reflected signal, can reveal the characteristics of stationary signal. Wavelet transform is a new analysis method, it inherited and developed the short-time Fu Liye transform the idea of localization, but also overcomes the disadvantages of window size does not change with frequency, can provide a time - frequency with the frequency change of the window, is an ideal tool for time-frequency analysis and processing of signals. Its main characteristic is the transform can fully highlight some aspects of characteristics, therefore, wavelet transform has been successfully applied in many fields, especially in digital discrete wavelet transform algorithm has been widely used in the study of many problems in transformation. Since then, wavelet transform has attracted more and more attention, and its application field is more and more widely. The sketch map of wavelet transform is shown in Figure 5. Application of wavelet analysis in fact is very extensive, it includes many disciplines in the field of mathematics; signal analysis, image processing, physics; quantum mechanics theory; intelligent military electronic warfare and weapons; computer classification and identification; artificial synthesis of music and language; medical imaging and diagnosis; seismic data processing; large scale mechanical fault diagnosis; for example, in mathematics, it has been used in numerical analysis, constructing fast numerical method, curve and surface construction, solving differential equations, control theory, etc.. In the signal analysis of filtering, denoising, compression, transmission, etc. Image processing in image compression, classification, identification and diagnosis, decontamination, etc. In medical imaging to reduce B ultrasound, CT, MRI time, improve resolution, etc [6].

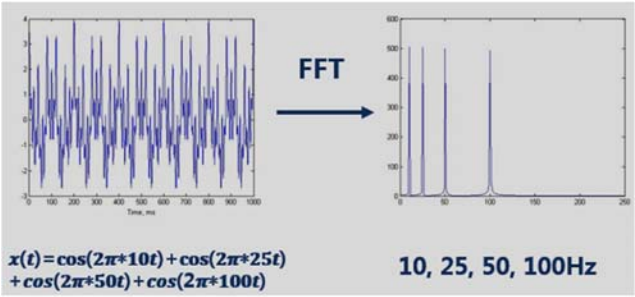

Figure 5. Schematic Diagram of Wavelet Transform

C. Multisensor Data Fusion Algorithm

Multi sensor data fusion is the source of information data and information are combined, and combined to obtain more accurate estimates of the position estimation and identity, so as to realize the process of battlefield situation and threat and the importance of real-time and complete evaluation. Data fusion began in 1970s, since 90s has been rapid development. The United States Department of Defense Laboratory expert group published 1991 in its data fusion in the dictionary, the definition of data fusion are as follows: the perception layer from the network to the application layer, type and quantity of all kinds of information are increasing exponentially, analysis of the amount of data required to become increasing, also involves fusion of heterogeneous networks or among multiple the system data, how the data from the massive to dig out the hidden information and effective data, has brought great challenges to data processing, so how to reasonably and effectively integrate, mining and intelligent processing of sea quantity data networking problem. Combined with P2P, cloud computing evenly distributed computing technology, to become a way to solve the above problems. Cloud computing Networking provides a new efficient computing model, cheap computing provided by the network dynamically scalable on-demand, which has relatively reliable and secure data center, with internet service convenient, cheap and large machine capacity, you can easily achieve the data between different devices and application sharing, user no need to worry about information leakage, hacking and other thorny issues. Cloud computing is

a milestone in the development of information technology, it emphasizes the aggregation, optimization and dynamic allocation of information resources, saving information costs and greatly improving the efficiency of data centers. Human instinct is the various organs of the body (eye, ear, nose and limbs, etc.) of the detected information (scene, sound, smell and touch) comprehensive ability and prior knowledge, so as to assess their surroundings and what is happening now. Multi sensor information fusion is a functional simulation of complex processing of human brain. Compared with the single sensor, the use of multi sensor information fusion technology in solving problems in detecting and tracking and target recognition system, can enhance the survival ability, improve the reliability and robustness of the whole system, enhance the credibility of the data, improve the accuracy of the expansion of the system in time and space coverage, increase the real-time system and information utilization the rate of. As one of the research hotspots of multi-sensor fusion, the fusion method has been paid more and more attention. A lot of researches have been done abroad and many fusion methods have been proposed. At present, the common methods of multisensor data fusion can be roughly divided into two categories: stochastic and artificial intelligence methods. The different levels of the corresponding information fusion of different algorithms, including the weighted average fusion, Calman filtering, Bayes estimation, statistical decision theory [7], probability theory, fuzzy logic, artificial neural network and D-S evidence theory. The definition of sensor data fusion can be summarized as the local data resource distribution provided in a number of similar positions or similar sensors to be integrated, using computer technology to carry on the analysis, the elimination may exist between multi-sensor information redundancy and contradiction, to complement each other, reduce the uncertainty, obtain a consistent interpretation and description of the measured object, so as to improve the rapid and correct decision-making, planning and response system, allowing the system to get more information. Its information fusion appears on different information levels, including data layer fusion, feature level fusion, decision level fusion. (1) data level fusion. According to the data collected by the sensor, it depends on the sensor type. Data level fusion to deal with the data is collected in the same category of sensors, so data fusion cannot deal with heterogeneous data. (2) feature level fusion. Feature level fusion refers to extracting the feature vector contained in the collected data, which is used to reflect the attributes of the monitored physical quantity. As in the image data fusion, edge feature information can be used instead of all data information. (3) decision level fusion. The decision level fusion, which is in accordance with the data obtained by the feature level fusion, discrimination, classification, and simple logic operations, a senior decision according to the application demand, advanced fusion. Decision level fusion is application oriented fusion. For example, in the forest fire monitoring and control system, through the integration of data such as temperature, humidity and wind force, we can determine the degree of forest drying and the possibility of fire. In this way, the data need to be sent is not the value of temperature and humidity and the size of the wind, but only to send the possibility of fire and the degree of harm. In the specific data fusion of sensor network, the fusion method can be selected according to the characteristics of application. Multisensor data fusion has the following advantages over single sensor information, such as fault tolerance, complementarity, real-time, economy, so it is gradually popularized and applied. Field of application in addition to military has been applied to automation technology, robotics, Marine Surveillance, seismic observation, construction, air traffic control, medical diagnosis, remote sensing technology, etc. In view of the miniaturization, intelligent sensor technology, based on access to information on a variety of functions, so as to further integration of fusion, this is an inevitable trend, multi-sensor data fusion technology to promote the development of sensor technology. Multi sensor data fusion algorithm schematic shown in Figure 6, the core code listed as follows [8].

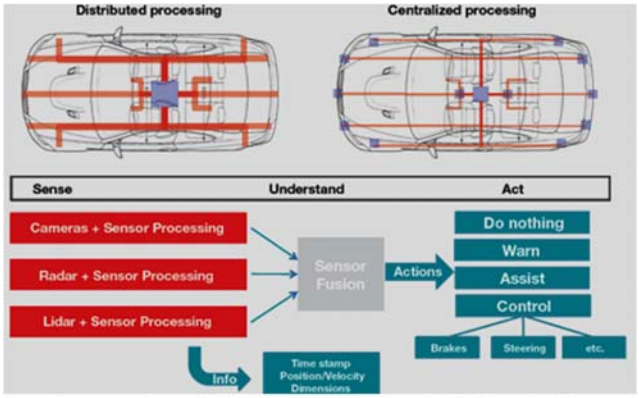

Figure 6. Schematic diagram of multisensor data fusion algorithm

```
x3=double(x3);
x4=double(x4);
[c1,l1]=wavedec(x3,2,'sym4');
[c2,l2]=wavedec(x4,2,'sym4');
c=(c1+c2)*0.5;
x=waverec2(c,l1,'sym4');
x=uint8(x);
subplot(223)
title(' Image fusion based on Wavelet Transform ');
imshow(x);
set(handles.text4,'visible','off')
set(handles.pushbutton1,'visible','off')
X1=imread('e:\1181.jpg');
X2=imread('e:\1182.jpg');
subplot(221)
[m,n]=size(X1);
imshow(X1);
subplot(222)
imshow(X2);
hold on;
subplot(223)
X1=double(X1);
X2=double(X2);
```

```
[C1,L1]=wavedec2(X1,2,'sym4');
[C2,L2]=wavedec2(X2,2,'sym4');
C=(C1+C2)*0.5;
X=waverec2(C,L1,,'sym4');
X=uint8(X);
subplot(224)
imshow(X);
```

III. RESEARCH ON SINGLE MULTIRESOLUTION IMAGE FUSION ALGORITHM

A. System Feasibility Analysis

Through the wavelet transform of image fusion before, first select a good base function, and select the number of decomposition, then the source images were processed to obtain transform, image transform coefficient, these information are distributed in different frequency and different feature domains, it can be multi scale analysis of these bands, fusion rules of information processing application set in advance, a new wavelet Pyramid structure, the inverse wavelet transform of wavelet bases for the same fusion image is obtained. This method can decompose the source image flexibly and stably, the decomposition is obtained after the multi-scale coefficients of low frequency and high frequency coefficients, the high frequency coefficients in order to highlight the information processing large image brightness in the scene, on the low frequency coefficient, can let people see the whole picture of the image. Assume that the use of wavelet transform to the fusion of a two-dimensional image, so if the selection of decomposition level is X, 3X+1 will eventually generate different sub bands in these sub bands only a low frequency sub-band coefficient, high frequency sub-band coefficients are the rest of the 3X. The corresponding high and low frequency coefficients of the image are different parts of the source image, the meaning is different, the low frequency part of the image reflects the approximation of image information, can be regarded as the source of the low resolution results, including the gray spectral information of the source image, it can effectively deal with the low frequency coefficient makes fusion the image has better visual effect, the high-frequency part of the image represents the image edge of the whole content. The fusion image using wavelet transform has many characteristics: 1) with different scale wavelet transform; features of things in the real world are in different size scales, which uses the wavelet transform to image processing, very good, the fusion results must coincide with the source image. 2) it also has the characteristics of frequency domain and spatial domain; the transform to the source images are decomposed into different resolution, so in images of different frequency channels for image processing in more detail, and the human retina image and get the image principle is very similar. 3) the wavelet transform has directionality; after wavelet transform, we can get horizontal, vertical and diagonal decomposition images in three different directions. 4) the decomposition coefficient can be divided by the hierarchical frequency division rate; the so-called hierarchical here is on different decomposition scales, each scale has different directions, these parts can choose different fusion methods. Such image processing features can be targeted to highlight what the researchers are interested in. There are many kinds of wavelet transform, different wavelet bases reflect different wavelet transform. Wavelet has a concept of "compact" length, compactly supported length when the wavelet basis is large, is conducive to retain more image information; when wavelet compact support length is smaller, can well retain image spectral information. It can be seen that different wavelet bases bring different quality of fusion images, so it is necessary to select appropriate wavelet bases. Wavelet transform can be decomposed many times, but each decomposition is for the upper layer decomposition of low-frequency information components, that is, further characterization of the low-frequency image information. With the increase of decomposition layer, the frequency range of decomposition tends to 0 frequency direction, and the frequency range is smaller and smaller.

B. Research on Fusion Algorithm based on Contourlet Transform

The content of the research is the image fusion of wavelet transform. The frame and processing of the algorithm are given. Though the image wavelet transform can handle some types, can also be obtained by wavelet is better, but it lacks the direction, but also not long edge expression very good image in, if you encounter complex image, it is incapable of action. After that, some scholars extend the one-dimensional wavelet tensor to Separable wavelet (two-dimensional separable wavelet transform), although it increases the scale of image fusion, but still does not solve its lack of directionality. The Contourlet transform is to solve the image to be fused with a lot of curves, long edges and other complex graphics, to get a sparse representation of image lines, surface singular. This algorithm can well describe the one-dimensional image of the singular points of the two-dimensional image line and surface expression was also very good, can be said to be the "best" interpretation, singular two-dimensional image. As shown in Figure 7 Contourlet decomposition process, this is the decomposition structure of the Contourlet transform diagram. In the diagram we can clearly see the decomposition of the Contourlet transform is done in two steps. The first is the multi band decomposition by PDFB (tower type DFBS) image to be fused into different resolution, produce multiple subband. This process is mainly Laplacian pyramid (Laplasse Pyramid decomposition, referred to as LP transform) at work, can "explain" the singular point in the image. Then, the direction transformation is done[9], that is, the singular points in the same direction are processed by DFB (directional filter bank), and these singularities are combined into a meaningful coefficient. The most important thing is that the Contourlet transform can be prescribed at each scale in advance of the number of required direction, it can be said that it is a flexible multi resolution multi direction transform. Contourlet transform has wavelet transform does not have the characteristics, it is this feature, so that Contourlet transform in the field of fusion has its own place. It has the characteristics of wavele, such as multi-resolution, time-

frequency localization; at the same time has its own unique advantages, such as good multi-directional and directional. These unique advantages make the Contourlet transform have a more powerful sparse representation of image features. It may be easier for many different characteristics. For image fusion, but also a detailed description of the image features such as edges, which makes the final fusion results contain more useful information? Image fusion example shown in Figure 8.

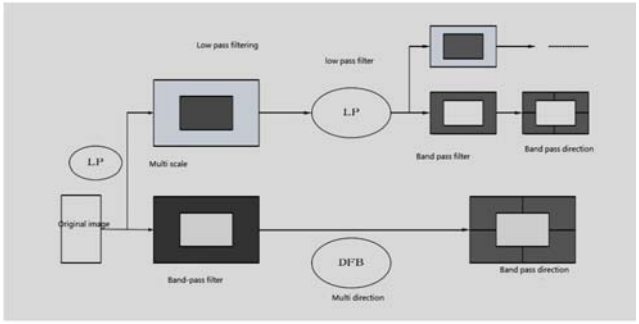

Figure 7. Schematic diagram of Contourlet transform decomposition process

Figure 8. Image Fusion Algorithm Example Schematic

C. Research on Image Fusion Algorithm based on NSCT

Detailed introduction of the non-sampling Contourlet (NSCT) transform the structure and principle, we understand the NSCT transform filter bank structure includes NSP and NSDFB two part. The function of these two parts plays a different role in the process of image fusion. The function of NSP is to decompose the image multi-scale, and the multi direction decomposition of NSDFB to the source image. Since we can reconstruct these two sets of filters perfectly, NSCT can be used as an effective multiresolution analysis method to decompose and reconstruct images in multi-scale and multi-directional directions. Next, an image is taken as an example to study the decomposition and reconstruction of NSCT. Similar to the Contourlet transform, NSCT transform is composed of two filters, different is the difference between the two filter construction, one is removed under the Pyramid filter group sampling (Non subsampled Pyramid Filter Banks, referred to as NSPFB); the other is removed under the direction of sampling filter (Non subsampled Directional Filter Bank, referred to as NSDFB). This kind of transformation and with reference to a trous algorithm, is a very flexible and effective multi resolution transform. NSCT transform decomposition process schematic shown in figure 9. NSCT transform process: first, the multi-scale image decomposition, where the use of NSPFB. Then, the decomposition of each scale subband image implemented in different directions is obtained by using NSDFB. Among them, NSPFB and NSDFB are the Contourlet transform in the LP and DFB removal of the sampling and sampling, after the reconstruction of the new non sampling filter banks. So NSCT and Contourlet have a great similarity in structural framework. With the number of decomposition increased, the image contrast is more and more low; image information contained in different directions at different levels are different, it is this characteristic, using NSCT transform can get better fusion results perfect. Image fusion rules are used to deal with the coefficients obtained after the algorithm decomposition, reasonable and effective fusion rules can continue to improve the quality of fusion. A large number of studies show that the low-frequency coefficient of the image represents the contour information of the image, while the high-frequency part reflects the edge information of the image. Since the high frequency coefficients of representative images of different information, we also need to take different methods separately these coefficients, which are the targeted coefficient of treatment, was finally able to achieve the desired effect.

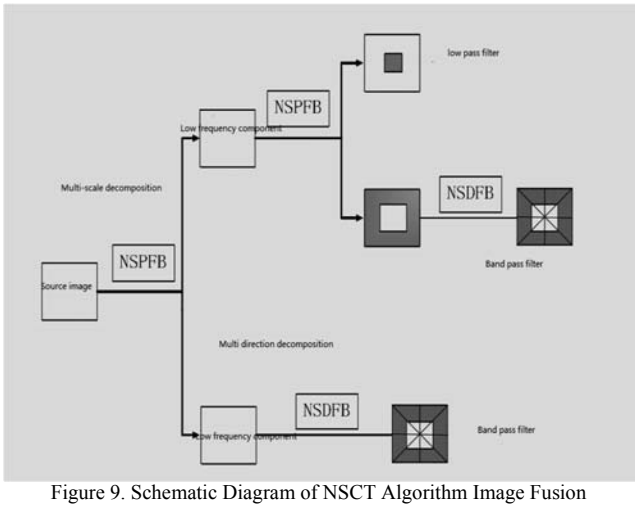

Figure 9. Schematic Diagram of NSCT Algorithm Image Fusion

Next, we study the fusion rules of high and low frequency coefficients of NSCT transform. The average weighting method is often used in the fusion of low frequency coefficients. Of course, we can also according to different image source, based on the purpose of different fusion, make the corresponding adjustment. The reason why the weighted average method to deal with low-frequency information, because it can be good to retain the source image spectrum. At the same time, this fusion rule is simple, it will not increase the complexity of image fusion, but also well reflect the original information of the image to be fused. So, the fusion rule of NSCT low frequency coefficient is weighted average. The details of the image mainly in the high-frequency coefficient. The high frequency coefficients

obtained by NSCT transform will be distributed in different directions of different decomposition levels, the most commonly used image fusion rules have the maximum absolute value, the minimum absolute value, the largest variance, etc.. In order to highlight the details of the image, especially the target characteristics of large brightness, the processing method of high-frequency coefficients is based on the maximum absolute value[10].

IV. Research on Image Fusion Algorithm Based on Hybrid Multiresolution Analysis

The starting point for the study of hybrid multiresolution is that each multiresolution algorithm has its own different properties. Here you can enumerate many examples, such as Wedgelet can well reflect the image contour. Compared with the wavelet transform, the Contourlet transform increases the direction, making it better and more detailed to represent the source image. There are different wavelet basis also has different characteristics, the quality of the image fusion are different. The different properties of these single multiresolution algorithms bring an idea that can take advantage of the characteristics of these single multiresolution analysis to exploit their respective strengths. This will improve the image fusion quality will have a significant impact on the algorithm to provide a larger design space. Prior to this, some scholars have done some research in this area, Starck and Donoho in order to get good denoising effect, after research, proposed a comprehensive wavelet and Curvelets denoising method. The idea of hybrid multiresolution algorithm is not only derived from a single multi-resolution method has its own shortcomings, more importantly, their defects cannot be changed, and the two single algorithm can make up for each other. Therefore, a new algorithm combining two kinds of single resolution algorithms is proposed. In the method of wavelet transform, wavelet transform single scale has many advantages in processing information, but its main advantage in one dimension is obvious[11], when the two-dimensional image signal or higher dimensional, the description and the approximation image becomes insufficient, especially the long edge of the continuous image therefore, selection of two-dimensional multi-scale wavelet transform, in order to adapt to the processing of the two-dimensional image. NSCT transform is based on the Contourlet transform to improve and upgrade, NSCT transform to solve the Contourlet transform does not have the translation invariance, therefore, the hybrid algorithm to choose another NSCT transform. In order to study the complementary properties of two-dimensional multi-scale wavelet transform and NSCT transform, we need to study their advantages and disadvantages, and then find their complementary possibilities. We compare the well-known wavelet transform (wavelet transform usually refers to the one-dimensional wavelet transform), theory and research it in the field of image has been very mature, is a common image fusion method, but it has limitations in the direction of decomposition coefficient, it can only get three directions. But NSCT can obtain any direction information after transformation, which can make up the deficiency of wavelet transform direction. Plus they are multiresolution analysis algorithms that deal with similar image methods (both get high and low frequency images). Following the image analysis and experiment alone to study the characteristics of the two. Two dimensional wavelet transform is a typical multi-scale wavelet transform. Compared with single scale wavelet transform (DWT), it can be decomposed at any level, the decomposition of the more detailed, the utility model has the advantages of retention can be the best images to be fused texture details, such as the character's mouth and eyes, see Figure 10 wavelet transform fusion edge detection map. Its shortcomings are limited in the direction previously mentioned, can only express horizontal, vertical and diagonal information in three directions. Especially when the image contains a lot of long edges, the wavelet transform cannot be described well. The hybrid multiresolution algorithm is composed of two multi-resolution algorithms. Can be wavelet transform in the first level, NSCT at level second; can also be NSCT at the first level, the wavelet transform at level second. Since NSCT on the first level can be decomposed in many directions of high-frequency information, followed by wavelet decomposition, will decompose more detailed. Therefore, this paper uses second ways: NSCT+Wavelet2D. Two multi-resolution algorithm decomposition will produce low-frequency coefficients, which need to be processed separately. The first is the low frequency coefficient of the first level NSCT decomposition, this paper uses the Wavelet2D transform to deal with, it is used as the input image wavelet transform; and the low frequency coefficients of wavelet transform, in the third chapter, we study the single best wavelet decomposition level and wavelet basis, there is still the same parameter selection. For its low frequency coefficients using weighted average, so you can try to retain two source image contour information. Firstly, the high frequency coefficients are decomposed by wavelet transform, and the complexity of fusion algorithm is minimized as the image fusion quality is kept. Methods based on the maximum absolute value of the high frequency coefficient, the maximum absolute value method, comparison of two images pixel position corresponding to the absolute value of the absolute value, finally will remain true coefficient larger as the source image fusion coefficient, rather than its absolute value. Followed by NSCT decomposition to get multi direction high-frequency coefficient. Usually the fusion rule of processing coefficients is based on summation of single pixels or absolute value. In this paper, we make some corresponding improvements, and the high-frequency coefficients adopt region based fusion rules which can consider the information of the image. This kind of fusion rule and wavelet transform in single pixel based fusion rules is different, it can take into account the image near the range of information in the process, to ensure the algorithm processed information more reliable and effective. Usually region based fusion rules include regional energy, regional variance, region summation, etc.. Because the image's high frequency coefficient reflects the image details and brightness information, contains more energy image. Therefore, the regional energy will be selected method. However, the high frequency coefficients of NSCT

decomposition are distributed in different directions in different layers. The idea of this paper is to select different fusion rules on different decomposition layers, including the maximum absolute value and the regional variance. Then the next decomposition layer of the high frequency coefficient, the use of different from the first layer of the fusion rules, which is where improvement, different levels of different directions using different fusion methods. Here the fusion rules for improved region energy maxima. The advantage of this rule is not only to calculate a pixel to get the fusion results of this position, but also refer to the information around this point. The intensity of local area can reflect the intensity of the intensity change of the local region, which reflects the pixel clarity of the region, especially for the rich image [12].

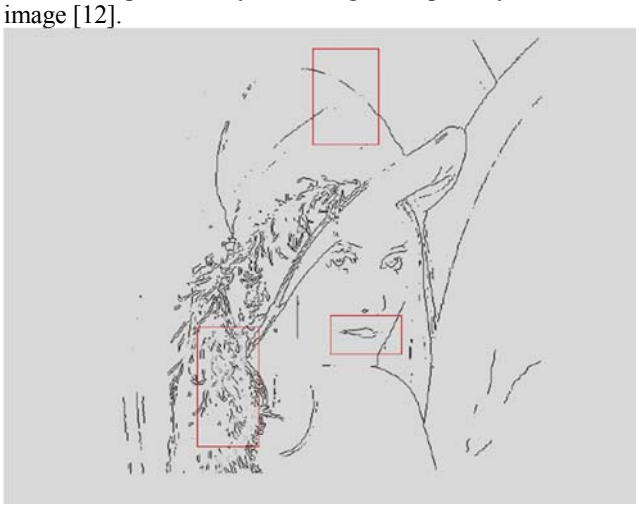

Figure 10. The Result of our Mixed Multiresolution Image Fusion Algorithm.

V. CONCLUSIONS

Image fusion is an important branch of data fusion, it refers to a number of different image sensors to collect the same scene or the same target, first after a pretreatment, and then design a set of reasonable and effective fusion process, choose appropriate fusion algorithm and fusion rules, finally get a picture image fusion. This image can fully reflect the scene or target information for observers to further judgment to give some guidance. This paper focuses on pixel level image fusion. In pixel level image fusion, the main focus of this paper is multiresolution analysis. This paper mainly extends from single multiresolution algorithm to hybrid multiresolution algorithm, and then analyzes and compares their fusion effects. In order to improve the quality of image fusion, the process of image fusion and the processing of high and low frequency coefficients are studied in detail. Firstly, NSCT is used to carry out multi-scale wavelet transform. The two-dimensional multi-scale wavelet transform using low-frequency coefficients generated by the NSCT method, hierarchical processing using the high frequency coefficients, top with maximum absolute value method, retain the image brightness and more mutation information; the remaining layers using a fusion rule based on regional energy.

REFERENCES

[1] Geng Boying, Yang Jingyu. An image fusion method based on spatial frequency characteristics. Systems engineering and electronics, 2000, 22 (4): 18-22.

[2] Zhang Bin, Zheng Yongguo, Li Daoquan, et al. Research on multi sensor image fusion algorithm based on lifting wavelet transform. Engineering Journal of Zhengzhou University, 2011, 32 (2): 106-109.

[3] Song Yang, Wang Feilu. Multi sensor remote sensing image fusion method based on multi resolution analysis. Journal of Anhui University (NATURAL SCIENCE EDITION), 2011, 35 (2): 47-51.

[4] Liu Zhe, Hao, Feng Wei, et al. A remote sensing image fusion algorithm based on wavelet coefficient features. Journal of Surveying and mapping, 2004, 33 (1): 53-57.

[5] Chen Shaohui, Zeng Zhiyuan, Zhang Qiuwen, et al. Multi sensor image fusion method based on weighted correlation moment. Research and application of computer, 2005, 22 (12): 150-151.

[6] Feng Dening, Wang Yan. Wavelet direction contrast image fusion algorithm is an adaptive. Journal of ShenYang Ligong University, 2010, 29 (6): 28-30.

[7] Zhu Ruihui, fan Guobin, Wan min. An image fusion based on multi resolution analysis method. The optical and optoelectronic technology, 2007, 5 (5): 82-84.

[8] Liang Dong, Li Yao, Shen Min, et al. A multi focus image fusion algorithm based on wavelet -Contourlet transform [J]. Acta Sinica Sinica, 2007, 35 (320-322.): (in Chinese).

[9] Lin Hui, Zhang Lianpeng, Zhang Qingli, et al. Study on gray modulation image fusion method based on multi-resolution analysis. Journal of remote sensing, 2007, 11 (1): 62-68.

[10] Sun Junping, Liu Yang. Multi resolution remote sensing image fusion algorithm based on fast independent component analysis. Journal of China Institute of Electronic Science, 2007, 2 (3): 228-233.

[11] Sun Junping, Liu Yang. Multi resolution remote sensing image fusion algorithm based on independent component analysis. Journal of Electronic Science and technology, 2007, 5 (2): 109-114.

[12] Fu Desheng, Xie Yonghua. Method and Realization of multi channel remote sensing image data fusion based on wavelet multiresolution analysis. Computer applications and software, 2003, 20 (1): 41-43..

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