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The Algorithms of Image Wavelet Optimize Splicing and Fusion based on Improved Region Energy

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Abstract: When the wavelet image mosaics, first of all have to wavelet decomposition, the mosaic image is decomposed into multiple scales. In this paper, based on the improved area energy fusion method matching the appearance of negative, through the introduction of absolute value, eliminate the negative phenomenon. The paper presents the algorithms of image wavelet optimize splicing and fusion based on improved region energy. The algorithm to achieve the mosaic effect chart maintained from the source image information is the largest while eliminating the seams, and verify the validity and rationality. The simulation results verify the correctness and the validity of the algorithm, but also to enhance the clarity of the image fusion provides an effective way.

Keywords: Wavelet optimize, Region energy, Image mosaic, Image fusion.

1. Introduction

Fusion refers to the imaging of the multi-sensor of the same target, or the same scene or a single imaging sensor in accordance with certain rules, certain processing, generating a comparison with the original image information is more comprehensive and accurate and stable and having a the new image of redundant and complementary information [1]. Image fusion in the military field and non-military fields such as remote sensing images, medical images, machine vision has been widely used.

The image is reflected to the objective things or process space, time, the array of information of the amount of interrelated features. The digital image with various observing systems in different forms and means of observation of the objective world can be direct or indirect role in the human eye and thus produce visual perception entity. The meaning of the image quality mainly includes two aspects: image fidelity and image intelligibility. The fidelity of the image refers to the degree of similarity between an image and reference image, image processing or usually distorted after transmission or experiencing interference, it is compared with the original image, will be able to reflect the processing or in the image quality of the transmission system aspects of the performance of the pros and cons. The intelligibility image Relevance refers to the image with some purpose people, for example, the beautiful, clear, rich layers of clear goals highlight characteristics reflects the value of the other aspects of the case.

Image fusion is generally divided into three categories: the pixel level, feature-level and decision-level fusion. The pixel-level fusion as basic fusion, feature fusion and decision level fusion. Pixel-level image fusion process can generally be divided into four steps: pre-processing, transformation and inverse transform (reconstructed image). The pretreatment includes a filtering and the registration processing on the original image to be fused. Alignment to the original image is to be fused to make the necessary

conversion, are aligned so that each of the pixels of the fused image.

Seamless image stitching technology today photogrammetry, and it is very active in the field of computer vision, digital image processing and computer graphics, remote sensing image processing, medical image processing, such as disciplinary research focus. Everyday life, ordinary camera to get wide-field must adjust the camera focal length, shot through the zoom lens to complete the scene, but the acquired panoramic photo resolution is relatively low, because the camera's resolution is certain, so shoot scene larger scene image of lower resolution, in order to obtain high-resolution scene photographs had by zooming the camera lens to reduce the field of vision of shooting, but it is not a complete scene photos and therefore require in the size of the scene and compromise between high and low resolution, so produce multiple images together to form one big scene.

Seamless image stitching technology widely used in the field of remote sensing processing, virtual reality, has aroused extensive attention of domestic and foreign researchers and research. Only from the impact of the visual evaluation patchwork eliminate aspects of seamless process multiple images in a two-dimensional plane of the research object to explore the following questions: based the existing stitching fusion algorithm, consider the image to be processed there is a big gray scale differences, the image distorted and partial mismatching may make the processed image in the mosaic, mosaic border at double boundary and a rough transition issues, put forward a more perfect stitching fusion algorithm.

Image fusion based on regional energy proposed a fusion method based on image fusion algorithm based on wavelet transform. Wavelet transform-based image fusion algorithm is mainly the fact that the use of the human eye is more sensitive to the changes in the local contrast according to certain fusion rule, selected the most significant feature in the original image, multiple, for example edge segment, and these characteristics are retained in the final synthesized image. Wavelet transform of an image, the absolute value of the wavelet coefficients corresponding to the edge of the more significant characteristics, largely based on wavelet transform image fusion algorithm to study how to select the wavelet coefficients in the composite image, that is, three the direction of the high-frequency coefficients, so as to achieve the purpose of preserving image edges. The paper presents the algorithms of image wavelet optimize splicing and fusion based on improved region energy.

2. Image Fusion Method Based on the Regional Energy

Region-based fusion rules and it is based on regional energy, regional variance, and regional gradient. Which, based on the integration of the regional energy rules consider the correlation between each pixel in the region and it is the local characteristics of the image can be further manifestation, therefore, this rule has been widely adopted in image fusion [2]. Larger regional energy center pixel represents a distinctive feature of the image, the image edge segment corresponds to the absolute value of the wavelet coefficients, so will measure the size of the area of energy as fusion rules.

Two image (or multiple images) through the decomposition of the two-dimensional wavelet transform, respectively, to obtain a low frequency component and high frequency components of the corresponding image. High-frequency component includes a horizontal high-frequency component, a vertical high-frequency component and a diagonal high-frequency component. The low frequency component corresponding to the low frequency coefficients and it is the high frequency component corresponding to the frequency coefficient (wavelet coefficient).

For the low-frequency coefficients, select a simple weighted average fusion algorithm as the fusion rule; while for the high-frequency coefficient (wavelet coefficient), since the larger the center pixel of the region energy represents the obvious features in the image corresponding to the edges of the image, the line segment characteristics such absolute the large value of wavelet coefficients, determines the size of the area of energy, directly after the decomposition of the corresponding image is selected larger regional energy of the wavelet coefficients as a fusion image wavelet coefficient.

Image Fusion is a new concept in the late 1970 s, it is a modern high-tech combination of sensors, image processing, signal processing, computer and artificial intelligence technology. (Wide spatial and temporal coverage, high goals and measuring dimension reconstruction ability, redundancy, complementarily, time superiority and relatively low cost, etc.), highlight the superiority of the probe image fusion system has advanced technology in the international countries are highly valued, and has made considerable progress, as is shown by equation (1).

$$\begin{aligned} S_x &= E[(Y - EY)(Y - EY)^T] \\ &= E[AX - E(AX)][AX - E(AX)]^T \\ &= E[(A - EA)X][(A - EA)X]^T \end{aligned} \quad (1)$$

Original image fusion algorithm based on regional energy introduced the concept of "matching" of matching the degree of closeness represents the energy of two images corresponding to the local area, or away from the degree [3]. Artificially defined threshold (typically 0.9). If the match is greater than this threshold, it shows that the area of the two images corresponding local energy is relatively similar, take a weighted fusion algorithm, the comprehensive two regional energy wavelet

coefficients corresponding final draw wavelet coefficients of the fusion image.

Improved image fusion method based on the area of energy, a detailed analysis of the reasons for this phenomenon, as the introduced matching degree plus the absolute value of the corresponding fusion algorithms. If we add the absolute value of the match less than a defined threshold, the wavelet coefficients taken directly select the corresponding local area energy; plus the absolute value of the matching degree greater than a defined threshold.

The wavelet transform has a "mathematical microscope" focus function, and thus the pace of reunification of the time domain and frequency domain, but also be able to orthogonal frequency domain decomposition, wavelet transform image fusion growing. Dyadic wavelet transform is more commonly used the three enters or more into the wavelet algorithm, however, expected to achieve better results in this regard, as is shown by Fig. 1.

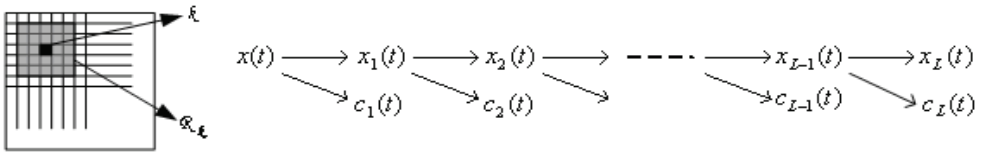

Fig. 1. Improved image fusion method based on the area of energy figure.

Finally, the fusion of the wavelet coefficients inverse wavelet transform fusion image fusion algorithm based on wavelet transform is the first image is decomposed wavelet coefficients of different frequency bands, and then using the fusion rules of wavelet coefficients for each frequency band fusion image [4]. Wavelet coefficients fusion rules can be divided into two major categories of pixel-based and region-based. For pixel-based fusion rules, by the size of the wavelet coefficients directly compare the image transformed to select the wavelet coefficients of the fusion image.

Fully consider regional energy-based image fusion of the local features of the image often can not be expressed by one pixel, it is characterized by a plurality of pixels in a local area and embodied within a local area of the normal image tend to have a strong correlation between each pixel, so to overcome the one-sidedness of the pixel-based fusion rules, and get a further manifestation of the local features of an image. Now the use of regional energy integration as image fusion rules article after another has become a hot research, as is shown by equation (2).

$$x = \sum_{i=1}^{n} x_i + \prod_{j=1}^{m} x_j' \tag{2}$$

This method is relatively pixel-based fusion rules tend to have a strong correlation this characteristic, due to the consideration of the respective pixels within the local region between fusion results obtained better visual characteristics, details richer and prominent effects, information amount to get a raise. However, relative to the original two local regional energy similar case directly to select area larger energy wavelet coefficients based on regional energy image fusion and improved image fusion based on regional energy likely to cause relative loss of information.

Original image fusion algorithm based on regional energy, as opposed to the simple fusion algorithm based on the regional energy, with some improvement, considering the energy of two images corresponding to the local area in the case of similar regional energy wavelet coefficients means a combination of the information included in the two images among the fused image. However, because the images are often incomplete with prospective situations exist, often makes the application of traditional rules based on the integration of the regional energy regional energy obtained matching degree negative lead the energy proximity between the areas is difficult to determination will result in some loss of information, affect the clarity of the fusion image.

In this paper, based on wavelet transform, a detailed analysis of the image fusion method based on the area of energy, for the original suggestions for improvement based on the existing problems in the regional energy image fusion method, namely improved image fusion method based on the regional energy; in pixel-based and region-based fusion method two categories, the selection of wavelet basis function.

Wavelet analysis is a signal and information processing tools, at the time - described in the scale plane non-stationary signals overcome a Fourier analysis of the function of a single variable (time or frequency) signal disadvantage. As a new multi-resolution analysis method has been widely used in the field of engineering studies.

Application of wavelet transform in another important advantage is that: the computational complexity. Fast Fourier transform has complexity, however fast wavelet transform only. Now consider a continuous signal which is in the space (all square integral function), and produced the following approximate sequence [5]. If the size of the image as the basis for the principle of halving the pixels of the

image decomposition, the largest for the decomposition times, but in practical applications, it is not possible to take so much, otherwise the sub-picture pixel too few points will cause severe distortion. Conversely, the decomposition level too little not reflect the multi-scale thinking, generally take 3 to 4 layers appropriate (scholars believe that 2 to 3 layers appropriate), as is shown by equation (3).

$$p' = W(p, D, \theta) = s\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} p + \begin{pmatrix} d_1 \\ d_2 \end{pmatrix} \quad (3)$$

As long as it meets the above requirements, so in the following discussion content can be applied to any kind of wavelet function. In the absence of special conditions, for simplicity and effectiveness, we will be Hear wavelet as the example. Chart depicted in one of two binary tree recursive relations. Assuming that there is a time sequence, the sequence in the two forks tree at the same sampling interval is projected onto the scales.

The wavelet transform as a new mathematical tool, the time between function domain (spatial domain) representation and a frequency domain representation. It in the time domain and frequency domain at the same time has a good localized nature, to gradually fine time domain (spatial domain) The sampling step can be "in focus" to any of the details of the object on the high-frequency component and thus known as the "mathematical microscope". A signal it can be decomposed into a separate part of the signal on the space and time, without loss of the information contained in the original signal and can be found in the orthogonal basis, to achieve non-redundant signal decomposition.

Fusion the basic idea of the image data is the first multi-source image, the two-dimensional wavelet decomposition; then to compare the details of the image information, at different angles to achieve fusion, to extract important wavelet coefficients in the wavelet transform domain through; finally, an inverse wavelet transform image can be obtained after the data fusion. The basic steps are as follows:

1) Calculated according to equation (3) the image of the two-dimensional wavelet transform and decomposition level is it;

2) The wavelet transform domain in the two images, respectively, of the horizontal, vertical and diagonal components fusion [6]. The high frequency coefficients of the two images of each scale will be compared to the position corresponding to the larger absolute value coefficient as significant wavelet coefficients retained;

3) After the two images by the wavelet transform approximation coefficients for processing, since the image is fuzzy representation of the details (or high-frequency information) lost more contrast, the overall information (or the low frequency information) to maintain good two image the difference between the approximation coefficients after wavelet decomposition to be much smaller than the difference between the wavelet coefficients, and therefore the fusion after the approximation coefficients by equation (4).

$$STD = \sqrt{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(F(i,j) - MEAN)^2 / (M \times N)} \quad (4)$$

At present, the fusion performance evaluation mainly includes subjective and objective evaluation method. The objective evaluation method is often divided into three categories:

1) According to a single image source image and fused image statistical characteristics);

2) According to the fused image and the reference image;

3) According to the fused image and the source image relationship. Let M× N image area F (x, y) of the total gray series L, Pi said the gray value of pixels and the pixels total ratio.

Entropy reflects the size of the image carrying information number; average image is the pixel gray mean value, to the human eye as reflected in the average luminance; standard deviation reflected the image relative to the average gray value of the discrete case, to some extent, can also be used to evaluate the image contrast and visibility of size; evaluation of image clarity is the key index. Entropy, mean, standard deviation and visibility of 4 parameter value is increasingly big, shows that the effect of image fusion.

Image fusion demising effect principle of evaluating information, whether to improve noise is suppressed, homogeneous region noise suppression is strengthened, the edge information is retained, enhance image mean does [7].

Wavelet transform first choose a wavelet function on the image first layer wavelet decomposition, a low frequency image and a three high frequency image, and then for the low-frequency images of second layer wavelet decomposition, and so on, the number of decomposition, wavelet decomposition, fusion frequency range and more abundant, the fusion result details the more abundant, but this is not to say that the number of wavelet decomposition, image fusion quality is higher, but the fusion effect will decrease, of course the decomposition layer cannot exceed image size range [8].

3. Wavelet Optimization Method

Wavelet transform image processing, the selection of wavelet base in image processing effect has a great influence on. General wavelet basis the main basis of the choice (1) (2) orthogonal linear phase (symmetry) (3) compact support (4) continuous four features, only with these characteristics, image decomposition of spatial image to each other, have better local and smooth degree, which can completely reconstruct the original image information.

However, this can also have a few wavelet function almost does not exist, in order to adapt to the different requirements of image processing technology, the characteristics of the different trade-offs, produced with different characteristics of wavelet algorithm [9]. Orthogonal wavelet decomposition algorithm can guarantee the subspace image processing independently of each other, realize splicing can be on low frequency sub image multi-scale decomposition, and according to the different frequency selecting different stitching width, will be spliced image according to its content features targeted splicing, has realized the seamless, smooth transition, as is shown by Fig. 2.

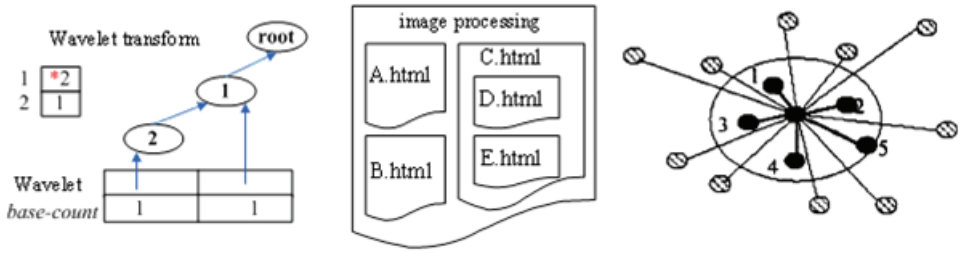

Fig. 2. Wavelet transform image processing figure.

Orthogonal wavelets derived low-pass and high-pass filter, and the four functions are decomposed image frequency information, high level, high frequency vertical detail information of high frequency details and diagonal detail information, and the subspace decomposition of the sub picture information is orthogonal to each other, and there is no redundant information, thus effectively to improve the efficiency of information transmission and reduce the storage capacity [10]. At the same time, the image of each frequency band characteristic details of expression very image, lifelike, ensure the sub-band image reconstruction when the integrity.

Orthogonal wavelet in image stitching application, can make the image is decomposed into different frequency bands on a sub-graph without correlation, it can maintain the energy decomposition without loss. And Fourier transform, Gabor transform, wavelet transform can in time and frequency domain local analysis, it can be telescopic, translation operation will signal or function multi-scale gradually thinning, ultimately achieve high frequency time breakdown at low frequency, frequency segmentation, automatic adaptive time-frequency signal analysis requirements, which can focus signal any details.

For seamless image stitching technology research, this paper mainly discusses the effective elimination is flat-fell seam [11]. As we know, the influence of different factors may lead to different joints, and joints have generally can be divided into: the rules of seam and random process. This chapter first discusses when there is rules seam processing method when the seams and the most common correction method are in the stitching region using the weighted average method.

In recent years, multire-solution techniques have been proposed in efficient image mosaic algorithm, such as Laplasse of Pyramid, according to the different frequency band overlapping width selection structure function of weighted, and the overlapping width is and the band into a certain proportion; multire-solution spline technique also has very good effect of stitching. The multire-solution signals decomposition and reconstruction technology in the unique advantages, it is widely used in the field of image processing. But based on the Laplasse gold tower algorithm, Gauss pyramid algorithm, in different scales of the sub image without wavelet transform that has a direction (the better able to explain the subgraph features), so this paper uses wavelet transform to complete a seamless image mosaic, as is shown by equation (5) [12]:

$$\begin{cases} \{x_1, \cdots, x_d\} = \arg\max J(x) \\ x_i^T x_j = 0, i \neq j, i, j = 1, \cdots, d \end{cases} \tag{5}$$

The first step after stitching image stitching is seam as an example to illustrate the rules of one-dimensional weighting function selection method. General splicing processing effect in the vicinity of the pixel values of the required seam size must be continuous gradient that is smooth transition, in order to make the seam to eliminate, and ideal gradient should meet three conditions: 1 is a gradual process resulting in the intermediate state should keep the monotone smooth change; 2 is the intermediate state boundary surface should be kept smooth; the initial object and the target object is shared by a number of features in a gradual process should be retained.

To solve this problem, through continuous regulation of sine function and obtain better results, or looking for a better weighting function, but if use the example of mosaic source may still see the splice region, so need to be designed with the weighted value [13]. Such rules can be used for splicing the arctangent gradient weighted function, but they must satisfy the above gradient conditions, if specific to the splicing of weighting function selecting principle.

Because the MEM algorithm successfully breaks through the Rayleigh limit, thus further to attract the

majority of scholars on this issue in-depth and extensive research, such as the double linear prediction algorithm. These LP algorithm research for feature subspace algorithm for the rise of foundation, but also promote the LP algorithm research. LP type algorithms have a common drawback is the spectrum peak search will appear when the artifact peaks, but through some method to suppress.

Objective assessment of image quality and visual effect of the results are often inconsistent, sometimes better image makes the vision to accept. But the subjective image quality evaluation by the observer, preferences, mood and mind, the severe refashion of the element, it is difficult to make an objective judgment. So the image quality evaluation of the trend is able to balance the two, from both subjective and objective to obtain precise evaluation system. Because the final identification image quality is the human vision, so the reasonable evaluation of the image quality of the method should fully conform to the characteristics of human vision (HVS), as is shown by equation (6):

$$\begin{cases} \left[\langle \phi, \phi \rangle\right] = I & \left[\langle \psi, \psi \rangle\right] = I \\ \left[\langle \phi, \psi \rangle\right] = 0 \end{cases} \tag{6}$$

Generally speaking, different weighting functions corresponding to different splicing effect, and different effect of stitching and corresponding to different evaluation index. Single factor evaluation indicators can be from one side of the image after stitching evaluation to measure the effectiveness of the algorithm, so the single factor index often has very strong specific aim, can objectively reflect the image content distribution, frequency of activity, carry information on local details characteristics, contribute to the processing algorithm improvement or correction.

In order to make the image after stitching and to be spliced image deformation and the degree of twist is as small as possible; the pixel value variation amount should be as small as possible, and so as to maintain to be spliced images in the mosaic effect diagram characteristic integrity. More and more small, then spliced to be spliced image from image is extracted from the information quantity is more, its deformation and distortion is smaller, ideally = 0; but if = 0, then spliced image and image mosaic no gray value difference, then the image of the joint will not be modified.

The image is essentially a source; it can be used to describe the information entropy. Image entropy is expressed by image carrying information volume, i.e., the image information more rich, gray change wind speed, the contrast is better, the details of the more prominent, the clearer the image, its entropy is also bigger [14]. In addition, the image entropy transform, entropy size only with local gray distribution relation, and with a single pixel gray value size, by a single noise impact is small, thereby improving the image of real content description precision, as is shown by Fig. 3.

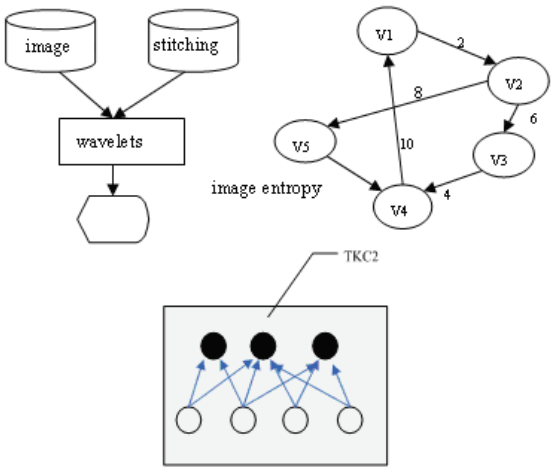

Fig. 3. Image entropy and stitching image figure.

Mutual information in information theory is an important concept, it is the two variable correlations metric, or as a variable to contain another variable information quantity measuring, so you can use this concept to measure image mosaic with the source image mutual information, thus the evaluation of splicing effect.

Based on the mechanism analysis of visual "attention" and it is if in the mosaic processing results of seam will cause great attention to visual perception, thereby undermining the overall effect. Assuming the image mosaic processing, only the presence of a mosaic area, so the mosaic image effect diagram may only exist in the following two situations: one is the embedded boundary exists together, another is mosaic area compared to other regional brightness is not harmonious sex.

Image mosaic, mosaic final processing results are judged by human performance, and from the visual psychology point of view, the vision is a kind of positive feelings, and physiological factors related to not only, still of considerable extent depends on the psychological factors. People in the observation and understanding image are often unconsciously on some regional interest.

4. The Algorithms of Image Wavelet Optimize Splicing and Fusion Based on Improved Region Energy

First introduced the two dimensional wavelet image decomposition method, and then introduces the general image fusion method based on wavelet transform, finally introduces the fusion results evaluation index. Wavelet transform in time domain and frequency domain at the same time has good localization, the high frequency components using a

progressively finer time domain (spatial) sampling step length, can be "focused" any object to details, thus known as the "mathematical microscope", so the image fusion has been used widely.

Static image mosaic manner generally using batch processing image sequences in the image at the same time are converted into the same coordinate system for registration, and then select different filter methods for image seamless fusion, thereby obtaining optimal stitching effect. The coordinate system is often based on regular users select their own, but the splicing process this coordinate system is fixed. What tell here refers to the splicing process coordinates do not transform, does not refer to the scene motionless.

When the mosaic image registration, splicing is the main task to eliminate the seam, to achieve gray fusion splicing, even after the image in the joint smooth and natural. Vertical or horizontal seam elimination rule is based on the thought of effective fusion rules. In this rule, overlap with intensity of average and weighted fusion is the simpler of the two kinds of fusion algorithms. The use of average light intensity is very narrow, it is only in the direct combination based on a little progress, and the weighted fusion method is simple, fast method is more commonly used. Weighted fusion mainly focused on how to select the weighting function, in order to obtain more appropriate fusion weights, as is shown by equation 7.

$$p(s(k)) = \frac{1}{\left(2\pi\sigma^2_{s(k)}\right)^{1/2}} \exp\left[-\frac{(s(k)-S_0(k))^2}{2\sigma^2_{s(k)}}\right] \quad (7)$$

In order to verify the validity of the improved algorithm, using traditional algorithm and the improved algorithm for image fusion results of comparative study, observation is improved, at the same time compared with using traditional algorithm and the improved algorithm the fusion image information entropy size. Fusion images of the entropy value is greater, the better the performance of fusion method.

A considerable part of image region corresponding to the energy matching degree is less than zero, as can be seen, the improved based on area energy fusion image obtained than the original area energy fusion rules based on the fusion image sharpness is high, and the image edge features more obvious. We can see from the improved fusion method to obtain the fusion image entropy than by the traditional fusion methods the fusion image entropy increase, the amount of information is increasing, as is shown by Fig. 4.

The paper presents the algorithms of image wavelet optimize splicing and fusion based on improved region energy. Stitching image algorithm from the mosaic image pixel distortion degree and the image after processing in joint space near the continuous degrees two aspects, through the fuzzy integral evaluation values in different frequency bands for wavelet realize splicing optimum weighting function. Pixel distortion describes the images before and after processing of information loss degree, spatial continuity describes to eliminate the seam degree, but they are conflicting. Through the fuzzy integral comprehensive evaluation value of the feedback to optimize the seamless image stitching algorithm, realized the mosaic effect graph is maintained from the source image information is the largest while eliminating the seams, and verify its effectiveness and rationality.

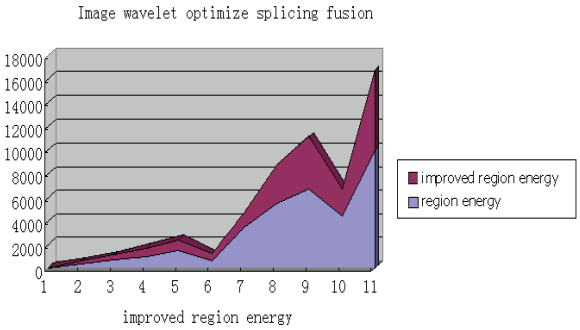

Fig. 4. Compare of algorithms of image wavelet optimize splicing and fusion based on improved region energy.

5. Conclusions

Region based image fusion rule is currently one of the hot topics. In this paper, it is based on the regional energy fusion method. "Match "the appearance of negative, through the introduction of absolute value, eliminating the matching negative phenomenon, and based on this idea the corresponding fusion rules. The simulation results verify the correctness and the validity of the algorithm, but also to enhance the clarity of the image fusion provides an effective way. The paper presents the algorithms of image wavelet optimize splicing and fusion based on improved region energy. Image mosaic technology (Mosaic) is defined for a given image sequence, the image registration and positioning, and then fusion splicing, produce a seamless, high resolution and large scene image.

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