Image Fusion Using Improved Threshold Logic Method

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Image fusion can provide the abundant useful information and remove the useless information, and then the image becomes easy understanding for the computer-aided diagnosis. The addressed problem is how to enhance or depict the useful and expected information and remove the useless information. To solve this problem, we developed the improved threshold logic (ITL) method for the medical image fusion. So, this work has great theoretical importance and the clinical significance. Firstly, the image edge M_1 of the original medical image M_0 is detected by using Sobel operators in 8 directions. Secondly, the improved threshold (IT) method is given to find the optimal parameter T, and the image $M_2$was obtained by segmenting the original image M_0 using the optimal threshold T. Thirdly, the image M_3 is caught by using the Boolean NOT operator to image M_2. Finally, the fused image M was obtained by using the Boolean OR operator to the image M_2 and the image M_3. The experimental results show, the ITL fusion method could obtain the smooth image edge and remove the spatial noises, meanwhile it could avoid the over-segmentation or too much useful information loss.

Index Terms— image fusion, edge detection, segmentation, threshold, logic operation.

1. Introduction

Image fusion is a very special and important part in image processing. It can provide the abundant useful information and remove the useless information, and then the image becomes easier understanding for the computer-aided diagnosis. The addressed problem is how to enhance or depict the useful and expected information and remove the useless information [1].

For the medical purpose, the imaging approaches [2] of ultrasound image, computed tomography, nuclear magnetic resonances were developed. However, the limits of the imaging mechanism of the device, the acquisition conditions, the display equipment and other factors, could sometimes lead to a misunderstanding and misdiagnosis when doctors observed the images. In addition, the medical images are usually with noises because of the uneven organ and the peristalsis or the other disturbances.

When a doctor diagnoses the brain disease according to a medical image, the image should provide the specially detailed information which is favorable for describing the disease and easy to understand. Therefore, the study of this paper, image fusion using the improved threshold logic (ITL) method, has important theoretical importance and the clinic significance.

To solve the problems mentioned above, the computer-aided image processing is used to provide the specially detailed information favorable for describing diseases and making the image easy to understanding. The processed image could be more suitable for human vision and machine vision. It is also more conducive to further understanding, analysis, detection, recognition and tracking of the target region.

Edge detection is very useful for providing the shape information which could be utilized to diagnose the corresponding organ. In 2008, Guo-bao Xu et al. [3] presented edge detection algorithm based on cellular neural network. In the algorithm, image filtering, gray threshold segmentation, dilation and erosion, and edge detection using CNN worked together to processing the remote sensing image successively. However, this method needs a lot of training samples.

In 2010, M. Alipoor et al. [4] proposed a logarithmic algorithm which is an extended and modified version of PLIP Sobel edge detection algorithm. Six new kernels are suggested to achieve a higher level of independence from scene illumination and provide obvious distinction between edge and non-edge pixels. In addition, an adaptive facet model-based edge detection algorithm is proposed. Although the performance of anti-noise is obviously better than the classical methods [5] in this paper, more future work should be down.

For the object segmentation, Australian scholars, Vikas Reddy et al. [6] proposed a robust foreground object segmentation technique. In this technique, a probabilistic foreground mask generation approach exploited the overlapping of patches and ensured the smooth contours of the foreground objects. This technique was better both qualitatively and quantitatively than methods based on Gaussian mixture models. However, the priori information of likelihood was involved, which is usually difficult to obtain.

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In order to overcome the causality dilemma by using a priori information in the form of background objects, a background foreground segmentation method is proposed by Padraig Corcoran et al.[7] in 2011. Background objects are modeled as objects that were consistently located at a given spatial location. However, this segmentation method was robust only to partial object occlusion.

For the medical image segmentation and volume estimation, Chuan-Yu Chang et al. used the radial basis function neural network to classify the region into the object area and non- medical areas [8]. Although the object region segmentation and volume estimation were promising, it is difficult to choose the scaling parameter of the radial basis kernel function [9]. In addition, the features of a medical image, such as mean, variance, coefficient of local variation feature, histogram feature, and homogeneity, were extracted for the object segmentation and classification [10]. But the accuracy should be improved when these features are used.

For the medical image fusion, scholars used the discrete wavelet transform to decompose the gray scale image, and then the wavelet coefficients were combined to reconstruct the medical image by using inverse wavelet transformation [11]. For the description of the swollen node of a medical image, the variable background active contour model were incorporated with the level set region-based active contour without edges model to depict the geometry characteristic and the image background of the human brain. However, the description accuracy of 91% has to be improved [12].

Different from the above methods, we developed ITL method for medical image fusion in this paper. In part 1, we stated the meaning and the actuality of this study. Then we described the relative works about the ITL method in section 2. It included the image edge detection, and the improved threshold (IT) segmentation, the logic operations of ITL method of medical image fusion. Furthermore, we described the proposed the ITL method in section 3. In addition, the experiments and comparison analyses were given to demonstrate the ITL method in section 4. Finally, the conclusion was in section 5.

2. Relative works

In the ITL method, there are 3 parts of the edge detection, the segmentation and the logic operations.

2.1 Image edge detection with eight directions

Edge detection extracts substantially the image border between object and the background. It is the most important foundation of the image segmenting and the region shape extracting. The edge is also an important attribute of human organ. Edge detecting is often the first step when understanding and analyzing the image. At present, it has become one of the most active topics in area of machine vision research, and it holds the very important state in the engineering application.

The organ edge in a medical image appears in the form of local discontinuous characteristic. The edge is the image part where the local feature values changere markably. The local feature may be the gray value, the color or the texture structure and so on. Meanwhile, the edge of the object is also the boundary of the different regions. The edge of the image has two characteristics of direction and amplitude. The change of grayscale is usually placid along the edge trend, and the change of the grayscale of pixel which is perpendicular to the edge trend is fiercely. The common points of edge include the follows [18].

1).Step-edge, it is from a grayscale to another grayscale which is much higher or much lower than the former.

2).Roof-edge, its grayscale gradually increases or decreases and then slowly decreases or increases to a certain value.

3).Line-edge, the grayscale change of this kind of edge is a pulse which appears in the linear grayscale variation.

The basic idea of image segmentation by using edge detection is firstly to determine the image edge points, and then link the edge points into the contour to constitute a fragmented region according to a certain strategy. The edge detection technology is very important to the digital image processing because of the fact that the edge is the boundary between an organ and the background and an image can be separated only by the edge.

The territory of pixels at boundary of an object will be a belt of the changed grayscales. The top two effective characteristics to measure the changes are the change rate and the change direction of the grayscale. They respectively are expressed by the amplitude of gradient vector and the direction of gradient vector. For a continual image $f(x, y)$, the directional derivative has the local maximum in the normal direction of the edge. Therefore, the edge detection is to calculate the local maximum value of the direction gradient $\partial f/\partial r$ of $f(x, y)$.

It is known that the image grayscale gradient $\partial f/\partial r$ in direction r is defined [13] as follows:

$$\frac{\partial f}{\partial r}=\frac{\partial f}{\partial x}\frac{\partial x}{\partial r}+\frac{\partial f}{\partial y}\frac{\partial y}{\partial r}=f_x\cos\theta+f_y\sin\theta \tag{1}$$

Where θ is the angle of the direction r. The condition for the gradient to reach the maximum is

$$\frac{\partial(\partial f/\partial r)}{\partial\theta}=0 \tag{2}$$

That is

$$-f_x \sin\theta_g + f_y \cos\theta_g = 0 \tag{3}$$

So

$$\theta_g = \arctan f_y / f_x \tag{4}$$

The maximum gradient value is

$$g = \left(\frac{\partial f}{\partial r}\right)_{\max} = \sqrt{f_x^2 + f_y^2} \tag{5}$$

It is generally called the gradient module operator which has the characteristics of shift-invariance and the isotropic nature. It is suitable to detect the edge. While the direction of the grayscale changes and the boundary direction can be obtained by $\theta_g = \arctan\ f_y / f_x$.

For simplicity, the operators are generally expressed by the differential operators in the practical applications. Then the fast convolution function is used to image with the differential operator, so the edge dictation is realized. This method is quick and effective. The common gradient operators for image edge detection are Roberts operator, Sobel operator, Prewitt operator, Laplace operator.

It is known that a satisfied edge detection method should have the ability to inhibit each kind of noise and maintain the complete edge characteristic.

The Sobel operators were selected to detect the medical image edge in this paper. They are a group of direction operators which detect the edge from different directions. Instead of the simple averaging and differencing, Sobel operator strengthens the weight in the four directions, up, down, left and right, of the central pixel. The operation result is an edge image. This operators are usually indicates by following formula .

$$\begin{aligned} F_x(x,y) = {} & [F(x-1,y+1)+2F(x,y+1)+F(x+1,y+1)] \\ & -[F(x\text{-}1,y\text{-}1)+2F(x,y-1)+F(x+1,y-1)] \end{aligned} \tag{6}$$

$$\begin{aligned} F_y(x,y) = {} & [F(x-1,y-1)+2F(x-1,y)+F(x-1,y+1)] \\ & -[f(x+1,y\text{-}1)+2F(x+1,y)+F(x+1,y+1)] \end{aligned} \tag{7}$$

$$G[F(x,y)] = |F_x(x,y)| + |F_y(x,y)| \tag{8}$$

where F is a mapping from a pixel point to the pixel value. The operation process is similar to the first order derivative.

The corresponding horizontal template S_h and vertical template S_v are as follows.

$$S_x = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \tag{9}$$

$$S_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{10}$$

The two matrices above represent respectively the horizontal gradient and the vertical gradient of the image. When Sobel operator is used to detect the edge of the image *f*, two matrices Q_1 and Q_2 are generally obtained respectively by the convolutions of image *f* with the horizontal operator S_x, and the convolutions of image *f* with the vertical operator S_y. If the boundary factor is not considered, Q_1 and Q_2 which have the same size with the original image represent respectively the partial derivative of image *f* on S_x and S_y in the same position. Then a new matrix G is obtained from the sum of the two squares. G is the approximation of the grayscale gradient of pixels of *f*. Finally, the edge comes out after the threshold value operation. That is,

$$G = ((f \otimes S_x)^2 + (f \otimes S_y)^2) > T^2 \tag{11}$$

where T is the selected threshold. Each point of the image and the two templates are used in making convolution, and then it finally produces an edge amplitude image after taking the maximum value as the output.

The computation of the classical Sobel method (CSM) which has a high processing speed is usually simple, but it is only used in vertical and horizontal directions for detecting. So it is likely to ignore some information or cause miscalculation of the edge points of image with more detail information or complex texture, and then an un-ideal detecting result appeared. Besides, the image edge not only has the horizontal and vertical directions but has directions of $\pm 45°$ and $\pm 135°$, etc. Therefore, extra 6 templates in other directions is increased based on the traditional Sobel operators in the horizontal and the vertical directions for detecting the more comprehensive image edge according to the reference [14]. The eight templates are respectively written as S_1, S_2, S_3, S_4, S_5, S_6, S_7 and S_8.

$$S_1 = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \tag{12}$$

$$S_2 = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix} \tag{13}$$

$$S_3 = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{14}$$

$$S_4 = \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix} \tag{15}$$

$$S_5 = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{16}$$

$$S_6 = \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix} \tag{17}$$

$$S_7 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{18}$$

$$S_8 = \begin{bmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{bmatrix} \tag{19}$$

Sobel operator inspects the changes of the gradients of the eight adjacent points of each pixel of digital image in a form similar to convolution. Every point of the image is calculated clockwise from the negative horizontal axis by the templates in 8 directions. The maximum value is taken as the new gray value of the pixel. The template direction which corresponds to the maximum value is selected as the edge direction. The new gray value $G_{\max}$ of the central point of a region 3×3 is as fowllow.

$$\begin{cases} G_i = S_i \otimes P_{xy} \\ G_{\max} = \max(G_i) \end{cases} \quad i = 1,2,\cdots,8 \tag{20}$$

where S_i indicates the i-th template inthe8 directions above; G_i is the detection result by using the i-th template; P_{xy} is a region of 3×3 with the central point inspected in the original image; G_i is the detection result by using the i-th Sobel template. Because the sum of all elements in the template is 0, the computing result is 0in the region where the gray values is invariant, and the result may overflow in the region where gradation changes dramatically. Therefore, an attenuation coefficient k is taken to reduce effectively the result overflow. k=1/8 in this paper. The direction of $G_{\max}$ is the edge direction of the point.

2.2 Improved threshold segmentation

Image segmenting is a technology or a process. It divides an image or scenery into some specific and unique nature parts or subset areas according to a certain principle. It extracts the target interested. This is a fundamental problem in the field of image processing and is also the basis of feature extracting.

In the study and application of the medical images, people are always only interested in a certain part of the image which is often referred to the foreground. The other part is called the background. The foreground generally corresponds to the region which possesses the specific or unique property. The specific or unique property can be the gray values of pixels, the contour, color or texture of object and also can be the spectrum or the histogram feature which needs to be extracted from the image in order to recognize and analyze the target of image. Only in this way can it has the possibility to measure the target further and use the image. For the image segmentation, there are many methods and types which have been proposed so far, and there are also many new methods to appear every year. Image segmenting method can be divided into different types according to different standards of classification. Based on the essence of each method, the image segmenting methods have three different ways [15]:

1).Take the region as the objects to segment. The sub-domains of image are divided according to the similarity rule. In detail, the similarities of the image gray, color, transformation relationship or organizational structure are calculated and compared and matched to each other. Then the pixels are clustered and classified to the corresponding object or region. This method is also called the region method.

2).Take the boundary of the target as the object to segment. This is the boundary element method which realizes the image segmentation by determining directly the regional boundary.

3).Detecting the border of the image and connecting the edge elements to constitute the boundary.

These methods are complementary. A particular segmenting method may be suitable for some situations and another method may be fit to other occasions. Sometimes they are combined each other properly for better segmenting result.

It should be pointed out that there is no single and standard image segmenting method and no optimal segmentation standard which is invariable and suitable for all the situations and the appropriate segmenting method is taken on the base of the specific image and the different purposes of a application. In the technology of image processing, the most common method of image segmentation is the threshold value processing.

Image threshold segmenting is a widely used image segmentation technology which regards an image as the combination of the two kinds of regions with different grayscales. The two kinds of regions between the target area and the background area have the respective gray characteristic. In order to obtain the corresponding binary image, threshold segmenting method selects an appropriate threshold value to determine whether each image pixel should belong to the foreground or the background region. It not only can compress data and reduce the storage, but also can be greatly simplify subsequent analysis and processing process. The form of the transformation function of image threshold processing is as follows.

$$g(x,y)=\begin{cases}0 & f(x,y)\le T\\ 255 & f(x,y)>T\end{cases} \tag{21}$$

where, $f(x, y)$ is the gray value of a pixel.

Obviously, image threshold processing is a step function which belongs to the nonlinear operator of image grayscale. If a pixel grayscale value in the image is greater than the threshold, set the pixel grayscale value to be 255, otherwise set the grayscale value to be 0.

The selection of the threshold value has a great influence on the processing results of image segmentation. If the threshold value is too big, it will extract the redundant part of the image and come into the excessive segmenting; otherwise, the part of the required will be lost.

The simplest method of threshold choice is the twin peaks method. That is to say, the histogram of the image has the characteristic of the twin peaks. If the characteristic of gray histogram of the image is not clear, or the difference of the luminance between the object part of the image and the background is small, it will not easy to determine an appropriate threshold value directly with the histogram. For the time being, the minimum error threshold value method, the maximum error threshold value method, the discriminating analysis method or other reasonable methods can be used to determine the threshold value.

The traditional threshold segmentation (TTS) is the improvement of the twin peaks method. This kind of algorithm is based on the approximation thought. It firstly selects an initial threshold $T_0 = u_{max} + u_{min}$, u_{max} and u_{min} is respectively the maximum and minimum gray value of the image. T_0 is used to divide the image into two parts of R_1 and R_2. Then calculates the mean of pixel u_1 and u_2 of the regional R_1 and R_2, and chooses a new segmenting threshold value $T=(u_1+u_2)/2$. Repeat the previous steps until u_1 and u_2 is converged.

The iterative threshold segmenting result is usually better. The image segmentation method based on the iterative threshold value can distinguish the primary foreground and the background of the image, but it does not work well to the weak place of the image. For some particular image, the small change of data can cause the great change of the segmenting result.

Based on the traditional threshold segmentation method, the IT method is given by using the gray value of the pixels in the foreground and background, and the proportion coefficients c_f and c_b of the foreground part and the background part to the total image. The flow chart is given in figure 1. There are 4 steps in the IT segmentation method.

1).Set the initial threshold valueS_0.

$$S_0=\frac{1}{n}\sum_{k=1}^{n}G_{\max k} \tag{22}$$

where$n$ is the total number of pixels of M_{i1}. $G_{\max k}$ is the gray value of the k-th point of image M_{i1}.

2).Segment the original image M_i based on S_0 to obtain image M_{i2} with the foreground and the background，and then calculate the average grayscale values G_F and G_B of the foreground and the background respectively.

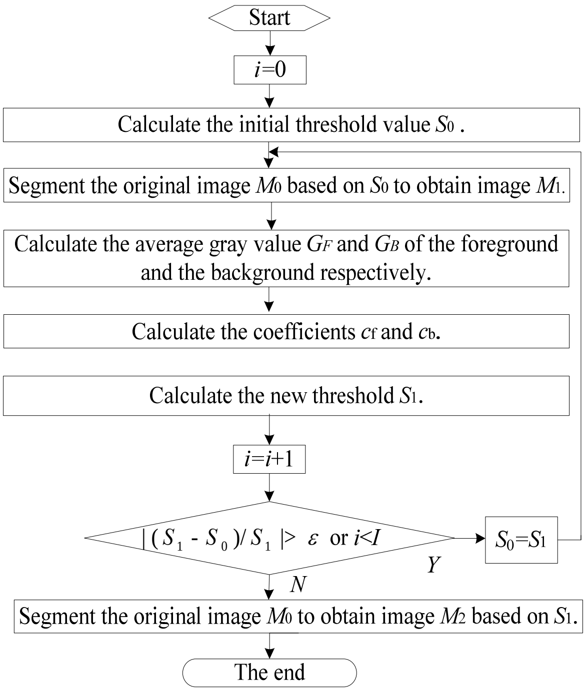

Figure 1: Flow chart of the IT method

$$\begin{cases}G_F=\dfrac{1}{p}\sum\limits_{p=1}^{p}G_p\\ G_B=\dfrac{1}{q}\sum\limits_{q-1}^{q}G_q\end{cases} \tag{23}$$

where p and q is the numbers of pixels of the foreground and the background respectively; G_p and G_q is respectively the gray value of the pixels in the foreground and background in the original image.

3).Calculate respectively the proportion coefficients c_f and c_b of the foreground part and the background part to the total image, then calculate the new threshold value S_1.

$$\begin{cases} c_f = \dfrac{p}{p+q} \\ c_b = \dfrac{q}{p+q} \\ S_1 = c_f * G_F + c_b * G_B \end{cases} \tag{24}$$

where c_f and c_b is respectively the proportion coefficient of the pixel number of the foreground to the image and the proportion coefficient of the pixel numbers of the background to the image.

4).Judge whether the final threshold S_f is obtained according to the follow rule.

$$\begin{array}{l} \text{If } \left|\dfrac{S_1 - S_0}{S_1}\right| > \varepsilon, \text{ then set } S_0 = S_1 \text{ and go back to 3),} \\ \text{Otherwise set } S_f = S_1 \text{ and the original image } M_i \text{ is segmented} \\ \qquad \text{by } S_f \text{ to obtained image } M_{i3} \end{array} \tag{25}$$

where ε is the critical value and S_f is the final threshold value to segment the i-th original image M_i.

3. ITL method for image fusion

After Sobel operator template detection in 8 directions with attenuation factors, the new grey values which are equal to or greater than the selected pixel threshold value are finally obtained. But it is not yet able to make sure that all of these pixels are edge points because the image inevitably contains some noises. The noises arouse the pixel grayscale values jumping and then the new grayscale values are equal to or greater than the threshold value. It results in that the inspected image will not be very smooth and the edge also contains many burrs. In order to remove the noise points and obtain a smooth result, the traditional iterative threshold segmentation algorithm is improved and the ITL fusion method based on the improved threshold is obtained. The flow chart of ITL fusion method is as follow.

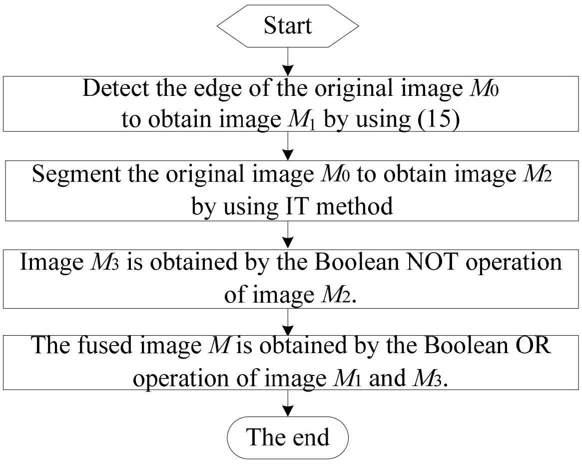

Figure 2: Flow chart of the ITL method for image fusion.

The specific steps of ITL Method are as follows.

Step 1: Detect the edge of the original image S by using Sobel operator templates in8 directions. Image M_1 is obtained.

$$\begin{cases} G_i' = (S_i \otimes f_{ij})/8 \\ G_{\max} = \max(G_i') \end{cases} \tag{26}$$

Where S_i is the the i-th template, f_{ij} is a region of 3×3, G_i' is the detecting result by using the i-th template, $G_{\max}$ is the new gray value of the central point of the region 3×3, and the direction of $G_{\max}$ is the edge direction.

Step 2: Calculate the initial threshold valueS_0.

$$S_0 = \frac{1}{n}\sum_{i=1}^{n} G_{\max i} \tag{27}$$

where n is the total number of pixels of M_1, G_{maxi} is the gray value of the point i of image M_1. It is close to the final segmenting threshold.

Step 3: Divided the original image based on T_0 into the foreground and the background, and then calculate the average grayscale values D_F and D_B of the foreground and the background respectively according (18).

Step 4: Produce the new threshold value S according to (19).

Step 5: If S_1=S_0 or i=I, S_1isthefinal threshold value. The original image $M_0$is segmented according to the threshold T and image M_2 is obtained. Otherwise, set S_0=S_1, and go back to step 3 to iterate threshold S.

Step 6: The image M_3 is obtained by using the Boolean operator NOT to image M_2.

$$M_3 = \text{NOT}\ (M_2) \tag{28}$$

Step 7: The final fusion image M is obtained by using the Boolean operator OR to the imageM_2 and the image M_3.

$$M = M_1 \text{ OR } M_3 \tag{29}$$

To sum up, the ITL method includes the edge detection, the IT segmentation and the logic operations.

4. Experiments and analyses

4.1 Experiment Environment

In order to demonstrate the effect and correctness of ITL method, some images were selected as the experimental object with 512×512 pixels. All the results were obtained by using software MATLAB R2011a.

4.2 Experiment results

Figure 3 demonstrated the results of IT method. Meanwhile the IT results were compared to the traditional threshold method and classical Sobel method. In figure 3, the original images were in figure 3 (a_1), (b_1) and (c_1); the traditional threshold result were in figure 3(a_2), (b_2) and (c_2); the classical Sobel results were in figure 3 (a_3), (b_3) and (c_4); the IT result were in figure 3(a_4), (b_4) and (c_4).

Figure 4 demonstrated the results of ITL fusion method. The image edges were obtained by the Sobel operators with eight directions in figure 4 (a_1), (b_1) and (c_1); the IT segmentation results were in figure 4 (a_2), (b_2) and (c_2); the ITL fusion results were in figure 4 (a_3), (b_3) and (c_4).

4.3 Experiment analysis

It can be seen from figure 3 that the traditional iterative threshold method causes over-segmentation and a lot of useful information are for saken; the classical Sobel edge detecting method may produce some breakpoints which can not depict the detail parts of the original image very well; the IT method results could obtain a better edge because it avoided the of over-segmentation and improved the segmenting accuracy, and then a good result was achieved.

In addition, the edges using Sobel operators with eight directions in figure 4 (a_1), (b_1) and (c_1) could obtain the rich information about the edges. The segmentation results in figure 4 (a_2), (b_2) and (c_2) ignored much space information about noise.

The final fusion image contains more detail edge information and has the smooth edge. Meanwhile it has strong ability to reduce the noise in the space.

Table 1 gives the comparison information about the several methods. They are the TTS method, the CSM, the IT method, and the ITL fusion method.

TABLE 1: ALGORITHM COMPARISON

Method	TTS	CSM	IT	ITL
Over-segmentation	*Yes*	*Yes*	*No*	*No*
Useful information lost	*Yes*	*Yes*	*No*	*No*
Remove the spatial noise	*No*	*No*	*Yes*	*Yes*
Clear edge	*No*	*No*	*Yes*	*Yes*

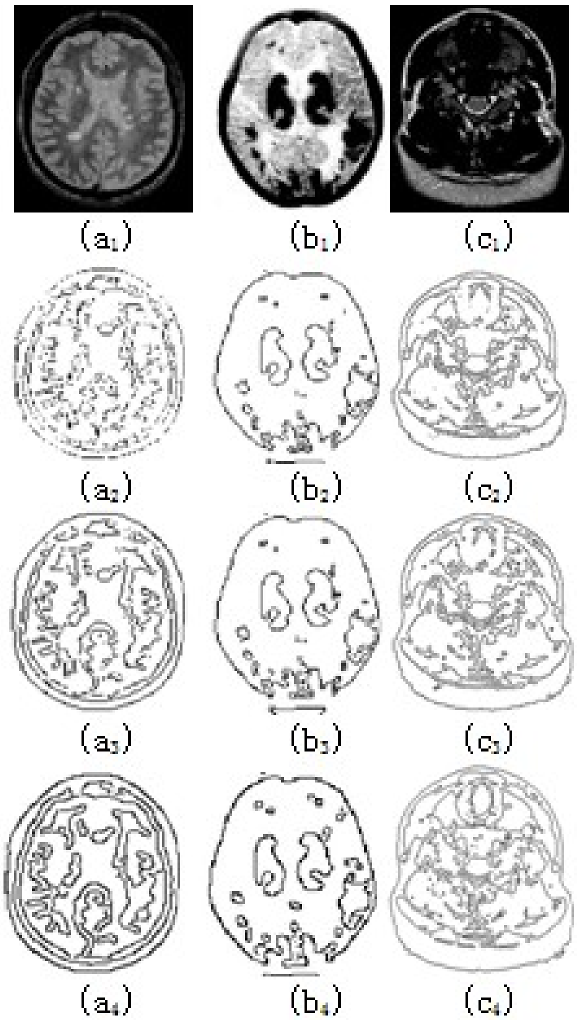

Figure 3: Image edges using different methods; (a_1), (b_1) and (c_1) Original image; (a_2), (b_2) and (c_2) Traditional threshold method; (a_3), (b_3) and (c_3) Classical Sobel method; (a_4), (b_4) and (c_4) IT method.

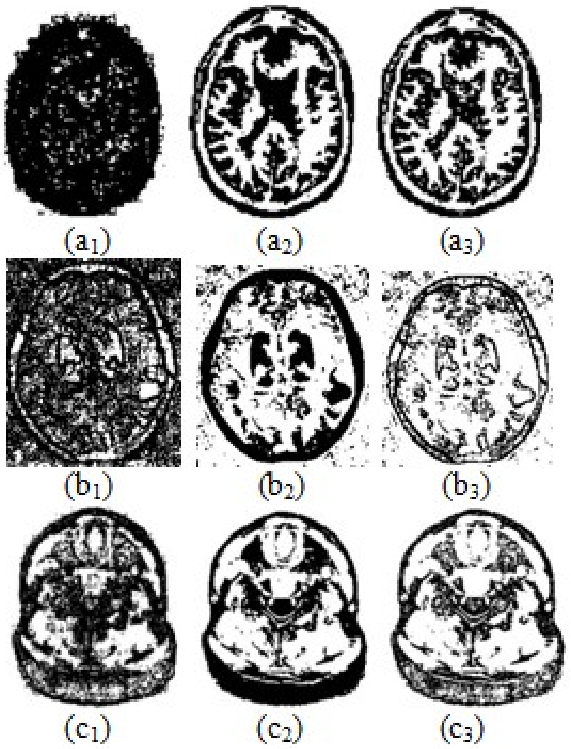

Figure 4: ITL fusion processes and results; (a_1), (b_1) and (c_1) edges using Sobel operators with eight directions; (a_2), (b_2) and (c_2) ; IT results; ITL fusion results.

It can be seen from the table above, the results of the ITL fusion method avoided the over-segmentations and the useful information losses; meanwhile it removed the spatial noises and had the clear edges.

5. Conclusion

Usually，a single original image can not show clearly the useful information of an object in an image. But the ITL fusion method was proposed in this paper which could obtain the smooth image edge and remove the spatial noises. Comparing with the traditional threshold segmentation method and the classical Sobel method，the ITL fusion method could avoid the over segmentation and useful information loss.

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