Multimodality Medical Image Fusion Algorithm Based on Multi-iteration

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Abstract—Currently, the efficiency of medical image fusion algorithms at pixel level is not very high and the algorithm is limited in the traditional one. Directing at the limitations, this paper put forward the improved algorithm and the multi-layer image fusion algorithm creatively, aiming at improving the quality of the fused image. Multi-layer image fusion algorithm means that, on the basis of the first image fusion, the fused image is fused again with one of the source image, and so on, for many times. It is mainly based on the Pixel gray value weighted average (PIXA) algorithm, Pixel gray value maxima (PIXM) algorithm, Laplacian Pyramid (LP) algorithm and Wavelet Transform (WT) algorithm. Through the comparison of the results of each fusion algorithm and the analysis of the data according to the objective evaluation method of image fusion, it has been found that multi-layer image fusion algorithm, in some ways, is superior to the traditional fusion algorithm. But it is not necessarily that the more times image fusion is conducted, the better the results are. The superiority of two-layer fusion algorithm is particularly more obvious in image clarity, information richness and image correlation, edge keeping degree and image difference.

Keywords-Medical image;Pixel-level; Multilayer-Fusion; Multi-iteration;

I. INTRODUCTION

CT and MRI images are with very extensive clinical application. The radiology and clinicians are increasingly common to put CT and MRI images together to compare and comprehensive analysis. CT has strong spatial resolution and geometric features, which is with lower contrast to the soft tissue of human body and clear to skeleton; MRI uses the relaxation that tissues magnetization of hydrogen ions in the static magnetic field is external radio frequency magnetic field excitation and imaging. It can get multi-angle and multi-dimensional fault image. The spatial resolution is high, can clearly reflect the soft tissues, organs, blood vessels and other anatomical structures, but is not sensitive to calcify point, and geometric distortion will happen when it get the interference of external magnetic field[1]. If it's able to make fusion of two kinds of image, making both of the advantages comprehensive, can see in the fusion image of CT image information, and can see the MRI image information, it will provide great convenience for clinical diagnosis. The image fusion algorithm now still exists certain defects in efficiency and imaging effect, and fails to break through the limitations of the traditional fusion method [2].

In conclusion, this article put forward multi-layer medical image fusion algorithm based on pixel level. This main research direction of this article is repeatedly using the traditional algorithm of image fusion based on pixel level to fuse the CT and MRI medical image and get multi-layer fusion results in order to obtain better fusion effect.

Introducing layers of medical image fusion algorithm transform to image fusion can keep the details of the original image better and extract the contour features of image, to provide more comprehensive characteristic information for image fusion. By six groups of image fusion experiments, the results showed that the proposed algorithm is a kind of practical image fusion algorithm, and also verify the good ability that the multi-level medical image fusion algorithm has in the expression of image information.

II. TRADITIONAL ALGORITHMS

A. The fusion experiments of Pixel gray value weighted average

The method of weighted average is referred that two images, $f_1(i,j)$and $f_2(i,j)$, fuse into a new image, $F(i,j)$, by respectively multiplied by a weight coefficient. Such as formula:

$$F(i,j) = af_1(i,j) + (1-a)f_2(i,j) \quad 0<a<1$$

Here, a is $1/2$*:*

$$F(i,j) = 1/2\, f_1(i,j) + 1/2\, f_2(i,j)$$

The fused image, as shown in the figure:

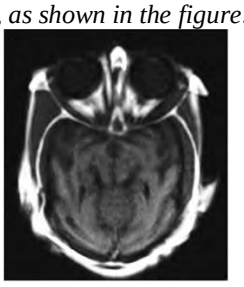


Figure 1. *The image fused by Pixel gray value maximum fusion method*

B. The fusion method of Pixel gray value maximum

Each pixel of fused image, $F(i,j)$*, is the maximum value of Pixel gray value under the same coordinate of original image,* $f_1(i,j)$*and* $f_2(i,j)$*. Such as formula:*

$$F(i,j) = Max\{f_1(i,j), f_2(i,j)\}$$

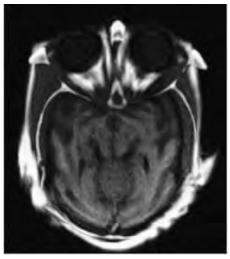


Figure 2. *The image fused by Pixel gray value maximum fusion method*

C. Laplacian pyramid transform fusion method

Different for different sub-sectors of the band, selecting the appropriate fusion operator conduct, then do the inverse Laplace transform of the fused image pyramid.

The fused image, as shown in the figure:

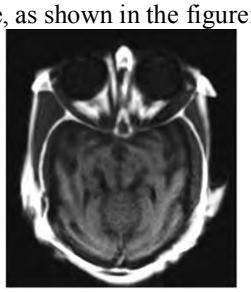


Figure 3. *The image fused by Laplacian pyramid transform fusion method*

D. Wavelet transform fusion method

Decomposition of each individual layer from high to low fusion process, using both high-frequency maximum variance method, low frequency using the weighted average method, get fused; for two source images were discrete Wavelet decomposition to obtain a series of sub-band image; discrete Wavelet transform, the reconstructed image is obtained by integration of the image.

The fused image, as shown in the figure:

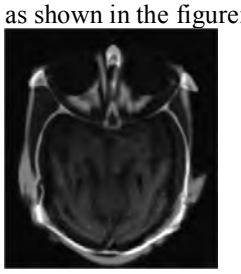


Figure 4. *The image fused by Wavelet transform fusion method*

III. FUSION ALGORITHM OF MULTI-LAYERED MEDICAL IMAGES BASED ON PIXEL-LEVEL

Currently there are several of image fusion algorithm, but it still remains to be improved in terms of effectiveness and efficiency of imaging. Also, currently the image fusion algorithm has not been completely broken through the traditional algorithms. This paper will propose a new fusion algorithm, namely multi-layer fusion algorithm, to break through the traditional algorithms and to improve the quality of the fused image.

Medical image fusion algorithm improvements can improve medical image fusion effect and make medical image information fusion richer, higher quality and enable doctors to quickly view information and accurately locate the lesion location.

After carrying out an image fusion, the resulting image will lose part of the source image information, the image quality may also be declined. However, comparing to the two source images, the information of once fused image is still increased. So, let the once fused resulting image fuse with the source image again by using which will improve information of fused image again. Of course, in the fusion process, the image quality will be declined, the image information cannot necessarily be completely saved so this is a misunderstanding that the more the number of fusion, the greater the amount of information of the image, the better the quality [3].

Multilayer image fusion algorithm is the algorithm that fuse the first fused imagine with one of the source image, and by analogy, that can be repeated fused. Hypothesis that P_1 and P_2 are two source images and after fusion they produce an image called p'_{12}.

$$p'_{12} = p_1 \# p_2$$

Here, # stands for image fusion. Fusion algorithms of two layers generate p'_{12}*::*

$$p''_{12} = p'_{12} \# p_1$$

Or

$$p''_{12} = p'_{12} \# p_2$$

By analogy, multi-image fusion can be expressed as

$$p^n_{12} = p^{n-1}_{12} \# p^{n-2}_{12} \# \ldots \# p'_{12} = \# p_1 \# p_2$$

N layer fusion algorithm as shown:

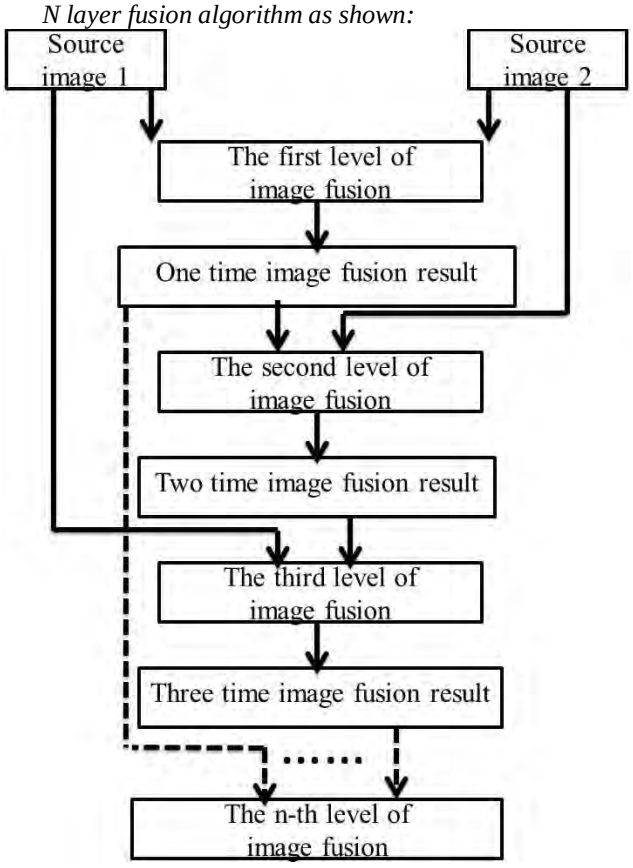


Figure 5. *N layer fusion algorithm*

In the multilayer fusion algorithm, each layer fusion algorithm can use the same or different traditions fusion algorithm, for example, in the three layer fusion algorithm, the first layer fusion algorithm can use Wavelet transform fusion method or Pixel gray value weighted average fusion method .The second layer fusion algorithm can use Wavelet transform fusion method, the Pixel gray value

weighted average fusion method, the Pixel gray value maxima method or Laplacian pyramid fusion algorithms, and the third layer fusion algorithm can be used Wavelet transform fusion method .Among them another source image of two layer fusion and three layer fusion can be chosen as CT or MRI images. Each layer image fusion algorithm selection is based on the image this layer want to be fused and expected fusion effect [4][5].

IV. EXPERIMENTAL RESULTS AND ANALYSIS

This paper designed two experiments, one of the experiment regards the Pixel gray value weighted average fusion method as base contrasted object, compared and evaluated with two layer fusion experiments image of four different plan respectively; the other one of the experiment regards Wavelet transform fusion method as base contrasted object, compared and evaluated with a two-layer fusion experiments image and a three-layer fusion experiments image respectively.

A. *The Pixel gray value weighted average fusion method based experiments*

Use Pixel gray value weighted average fusion method as fundamental part of the experiment

a) Comparing with the Pixel gray value weighted average two-layer fusion algorithm
b) Comparing with the Pixel gray value weighted average - Pixel gray value maxima two-layer fusion
c) Comparing with the Pixel gray value weighted average - Laplacian pyramid two-layer fusion
d) Comparing with the Pixel gray value weighted average - Wavelet transform two-layer *fusion*

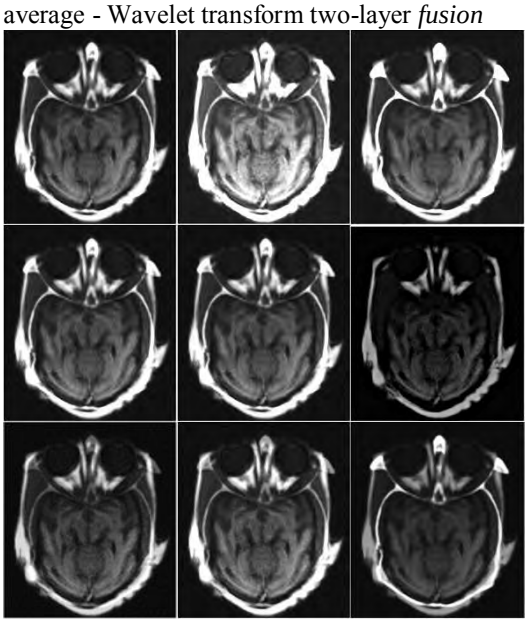
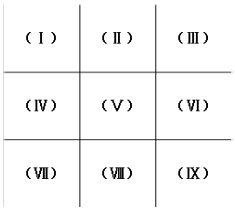


Figure 6. *Imges results of experiment A*



(I)PIXA-PIXA CT_MR
(II) PIXA-PIXA CT_MR-MR
(III) PIXA-PIXA CT_MR-CT
(IV) PIXA-PIXM CT_MR-MR
(V) PIXA-PIXM CT_MR-CT
(VI)PIXA-LP CT_MR-MR
(VII)PIXA-LP CT_MR-CT
(VIII)PIXA-WT CT_MR-MR
(IX)PIXA-WT CT_MR-CT

Objective evaluation[6]

According to the data in Table 1.

Gray value classification of gray value weighted average transformation method is larger.[7]

The brightness of Wavelet transform method and Laplace transform method is lower. The clarity of Laplace transform method is higher.

The reservation information of Pixel gray value weighted average method and gray value maximum method is larger, more consistent with the requirements of image fusion.

The changes caused by the Laplace transform method is less but the Pixel gray value weighted average method is more.

The information of Pixel gray value weighted average method obtained from the source image is larger and the fused effect is better, but the Laplace transform method is smaller.[8] The edge information of Pixel gray value maximum method retains more and the fused effect is better.

B. *The Wavelet transform fusion method based experiments*

Use Wavelet transform fusion methods as fundamental part of the experiment

a) Comparing with Wavelet transform two-layer fusion
b) Comparing with Wavelet transform three-layer fusion

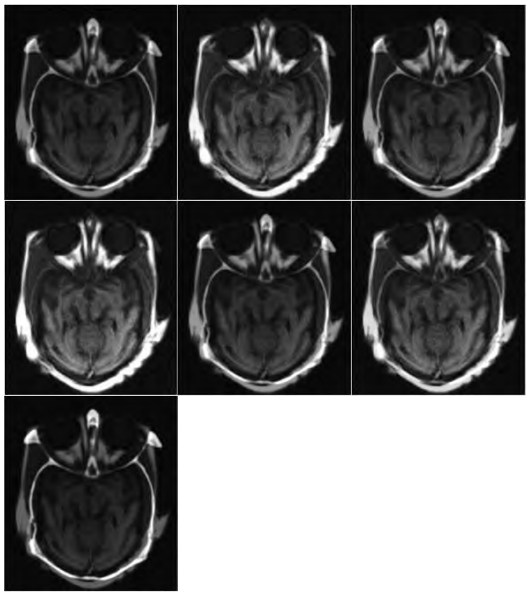
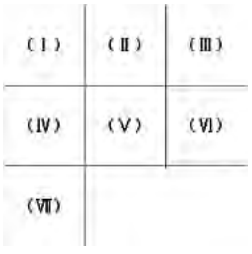


Figure 7. *Imges results of experiment B*



(I)WT-WT CT_MR
(II)WT-WT CT_MR-MR
(III) WT-WT CT_MR-CT
(IV) WT-WT-WT CT_MR-MR-MR
(V) WT-WT-WT CT_MR-MR-CT
(VI) WT-WT-WT CT_MR-CT-MR
(VII) WT-WT-WT CT_MR-CT-CT

Objective evaluation

According to the data in Table 1.

In the Wavelet - Wavelet Layer fusion, the fusion with CT images is only in cross-entropy and edge to keep on having a slightly higher value of two term, and the remaining values are lower than the MR fused image data.[9]

TABLE I. *EXPERIMENTS DAT*

	Relative Standard	*Average Value*	*Average Gradient*	*Information Entropy*	*Cross-Entropy*	*Mutual Information*	*Edge Retention*
PIXA-PIXA CT_MR-MR	*83.354876*	*106.250858*	*5.322118*	*6.78998*	*3.154609*	*6.098573*	*0.566691*
PIXA-PIXA CT_MR-CT	*72.591985*	*78.338893*	*4.692608*	*6.567655*	*3.099038*	*6.486849*	*0.78649*
PIXA-PIXM CT_MR-MR	*69.241821*	*69.70222*	*4.511898*	*6.691372*	*2.838348*	*6.774741*	*0.847193*
PIXA-PIXM CT_MR-CT	*69.228672*	*69.701365*	*4.505046*	*6.697398*	*2.830008*	*6.775325*	*0.847141*
PIXA-WT CT_MR-MR	*68.301353*	*69.233242*	*4.391791*	*6.72907*	*2.778173*	*6.34528*	*0.860713*
PIXA-WT CT_MR-CT	*55.718079*	*50.420119*	*3.678975*	*6.355413*	*2.76278*	*4.935843*	*0.831123*
PIXA-LP CT_MR-MR	*47.661803*	*31.016018*	*3.875955*	*5.757259*	*2.362949*	*2.901113*	*0.551309*
PIXA-LP CT_MR-CT	*35.40301*	*11.283409*	*2.134763*	*2.485185*	*5.430441*	*0.552176*	*0.245288*
WT-WT CT_MR-MR	*62.427193*	*58.646138*	*4.062039*	*6.707057*	*2.481682*	*6.290717*	*0.855234*
WT-WT CT_MR-CT	*50.339026*	*46.37389*	*3.396832*	*6.343148*	*2.488733*	*5.082079*	*0.861388*
WT-WT-WT CT_MR-MR-MR	*66.045833*	*62.722255*	*4.185212*	*6.671577*	*2.622791*	*6.306689*	*0.845373*
WT-WT-WT CT_MR-MR-CT	*49.197446*	*43.911437*	*3.345927*	*6.303692*	*2.422852*	*4.98986*	*0.830545*
WT-WT-WT CT_MR-CT-MR	*58.762486*	*55.763258*	*3.864776*	*6.641682*	*2.509689*	*5.900962*	*0.868469*
WT-WT-WT CT_MR-CT-CT	*46.234297*	*36.597906*	*3.062554*	*5.962116*	*2.441156*	*4.182708*	*0.539798*

In the Wavelet - Wavelet - Wavelet three fusion method, the fused image contains more CT images, the value of the evaluation index standard deviation, mean gradient, information entropy, cross entropy, mutual information, edge-keeping is worse. After the text edit has been completed, the paper is ready for the template.[10]

V. CONCLUSION

After comparison and analysis of the experimental data, we can draw the following conclusions:

（1） The two layer fusion algorithm of the second layer fusion Conducting with MRI perform better in most test results than the two layer fusion algorithm of the second layer fusion Conducting with CT.

（2） Comparing the first layer fusion using the one layer fusion algorithm of the same fusion algorithm with the two layer fusion algorithm the two layer fusion algorithm of the second layer fusion Conducting with MRI perform better in most test results than the one layer fusion algorithm.

（3） Comparing the first layer fusion using the one layer fusion algorithm of the same fusion algorithm with the two layer fusion algorithm the two layer fusion algorithm of the second layer fusion Conducting with CT perform poorer in most test results than the one layer fusion algorithm.

（4） In the case of all layers use the Wavelet transform algorithm, comparing three-layer fusion algorithm with the one layer fusion algorithm, the three layer fusion algorithm perform better in most test results than the two layer fusion algorithm.

（5） In the case of all layers use the Wavelet transform algorithm, comparing the two layer fusion algorithm of the second layer fusion Conducting with MRI with the three layer fusion algorithm, the two layer fusion algorithm perform better in most test results than the three layer fusion algorithm.

In summary, the advantage of the multi-image fusion method compared to traditional fusion is better, the advantage of two-layer image fusion method is more obvious. Therefore, the multi-image fusion method has its advantages, but it is uncertain that the more the image fusion level, the more obvious advantages are.

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