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A Novel Image Fusion Method Based on Edge Characteristics for Electrical Capacitance Tomography

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Abstract. "Soft-field" nature and ill-posed problems to influence on the accuracy of image reconstruction in electrical capacitance tomography technology (ECT), in the analysis of ECT basic principle and imaging algorithm, a novel image fusion method based on edge feature detection using the feature of different frequency domains of wavelet decomposition is presented in this paper. The LBP algorithm and Landweber algorithm are used as the base of image reconstruction in the paper, the fusion rules based on the combination of Local gradient and local signal strength and the weighted averaging operator are used to fuse the high-frequency coefficients and low-frequency coefficients of the fused image, in this way , higher accuracy imaging results can be got. The simulation results show that the image fusion accuracy is improved, and reconstruction image effect is enhanced.

Keywords: Electrical Capacitance Tomography; image reconstruction; image fusion; local gradient; signal strength

1 Introduction

The LBP algorithm, the regular method, are used ECT reconstruction algorithm, these algorithms have their own imaging characteristics, but at the same time have their own limitations [1].Image fusion is a data fusion technology whose main object of study is image. An image fusion method based on edge characteristics in electrical capacitance tomography is put forward in this paper and the LBP algorithms, Landweber iterative method are used as the reconstructed image's source.

2 Principle of Algorithm

The wavelet transform is used as the multi-resolution analytical tool, using the wavelet transform in this paper; signal can be decomposed into low-frequency approximate component and high-frequency detail component [2].

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The edges of the image has its local characteristics[3], so local image parameters can better reflect the image edge features, this article uses the local gradient and local signal strength to reflect the image edge information.

3 The Fusion Rules of All the Frequencies

3.1 High-frequency Component of The Fusion Rules

The window's size which is adopted in this paper is 3×3, on the basis of this paper, designs the fusion rule of high-frequency part based on the image edge feature is designed as follows:

In D_{j+1}^{L} and $_{j+1}^{L}$ that the high frequency components of image L and image H, the edge significant degree that D_{j+1} and $^{H}_{j+1}$ for each pixel within the window region are calculated, and then the process that the normalization of $D_{j}^{L}{}_{+1}$ and $D_{j}^{H}{}_{+1}$ is introduced as the following formula:

$$GI_D^L(m,n)=\frac{GI^L(m,n)}{GI^L(m,n)+GI^H(m,n)}$$
$$GI_D^H(m,n)=\frac{GI^H(m,n)}{GI^L(m,n)+GI^H(m,n)} \quad (1)$$

In the above formula, $GI_D(m,n)$ and $GI_D^L(m,n)$ indicate the normalized edge feature degree of each point's High-frequency components in image L and image H.

Then, for each point in the $D_i^{L}{}_{+1}$ and $D_i^{H}{}_{+1}$, if $GI_D^H(m,n)-GI_D^L(m,n)>T$ images will be fused in accordance with the maximum rule:

$$D_{F}(m,n)=\begin{cases} D^{L}_{+1}, GI_D^L(m,n)>GI_D^H(m,n) \\ (m,n)>GI^{DL}(m,n) \end{cases} \quad (2)$$

L

$(,)-$

If $GI_D(m,n)-GI_D(m,n)<T$ images will be fused in D_{j+1} accordance with the weighted average rule: 2 (3)

$(,)<$

$$(m,n)=\frac{D_i(m,)+D(m,n)}{j+1\quad H\quad (,)\quad j+1}$$

Wherein T is a threshold value, in this paper T is used as 0.3.

3.2 Low-frequency Component of The Fusion Rules

In I_L and H I that the high frequency components of image L and image H, the edge significant degrees that GI_H for each pixel within the window region

are calculated in this paper, and then the process that the normalization of GI and GI_H is introduced as the following formula:

$$GI_j^L = \frac{GI^L(m,n)}{\sum\sum GI_{j+1}^L(m,n) + \sum\sum GI^L(m,n)} \qquad GI^H = \frac{GI^H(m,n)}{\sum\sum GI_{j+1}^H(m,n) + \sum\sum GI^H(m,n)} \tag{4}$$

In the above formula, GI_{j+1}^L and GI_{j+1}^H indicate the ratio of scale factor edge features of the image L and image H. Then, using the normalized edge feature, the data fusion rules used as the following:

$$GI_F^j = GI_L^j + GI_H^j \tag{5}$$

LBP algorithm and Landweber iterative method was chosen as the ECT image reconstruction algorithm and the images obtained from the rebuilding of these algorithms are used as the source image for image fusion. The Wave Toolbox in MATLAB is selected to operate the experiment, the decomposition level is set to 5, the threshold T = 0.3. The experimental procedure is shown in the following figure 1:

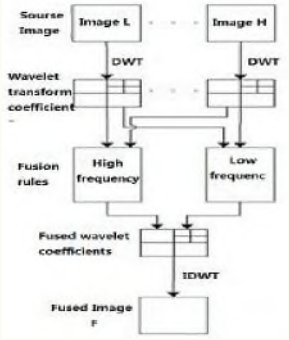


Fig. 1 Processes of image fusion algorithm

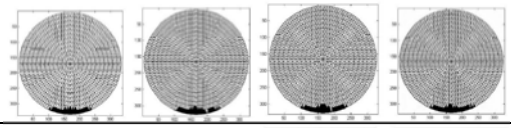
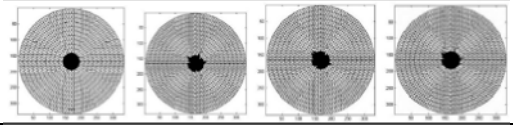
4 The Comparison of Experimental Results

The Laminar flow and core flow are chose as examples, the experimental results of validate fusion algorithm are shown in Table 1:

Table 1 Fusion Comparison

Image reconstruction algorithm

Default flow pattern LBP Landweber Fused image

Laminar flow	
core flow	

The evaluation results are shown in Table 2.

Table 2 Difference of RMSE and EP

Algorithm	Evaluation Index			
	RMSE		EP	
Laminar flow		core flow	Laminar flow	core flow
LBP	0.31	0.29	0.4138	0.4297
Landweber	0.25	0.26	0.4356	0.4389
Fused	0.22	0.24	0.4395	0.4426

From the table we can see, whether it is from the standard deviation or edge retention, and imaging results of the fusion algorithm is better than LBP algorithm and Landweber algorithm.

5 Conclusion

In this paper, ECT is combined with image fusion technology, for the ECT imaging characteristics and the characteristics that in the wavelet-based image fusion technology the data can be dealt with separately on a different frequency domain, in order to maximize the enhanced the effect of the reconstructed image, richer and accurate information can be extracted from different source images than a single source image.

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