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An Improved Medical DR Image Enhancement Method

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Abstract

As a result of noise interference, improper exposure and thick human tissue, detail information of DR image will be buried, including unclear edge and contrast reduction. This paper proposes a medical DR image enhancement processing based on artificial fish-swarm algorithm. According to DR image contour model and DR image boundary, the enhancement processing segment DR image by artificial fish-swarm clustering method, then enhance DR classification image through adding GAG operator. Simulation results show that the method can effectively eliminate noise in DR image, and the detail information of enhanced DR image is clearer than before meanwhile with high effectiveness and robustness.

Keywords: *DR image, image enhancement, artificial fish-swarm*

1. Introduction

Digital Radiography (DR) is advanced medical image photography system equipment widely used in the current medical profession. Compared to conventional computed radiography (CR), DR can obtain image on the display more directly and quickly, and the amount of X-ray irradiation patients affected is significantly reduced [1-6]. Additionally, DR has high sensitivity and wide dynamic range. DR and CR both change the X-ray image information into digital image information, their exposure latitude reflect certain advantages comparing to the ordinary intensifying screen - film systems: Using digital technology, CR and DR have a wide dynamic range which is responsible for a wide exposure latitude, therefore allowing some technical error in the photographic [7-13]. For example, the good image can be obtained even at the parts whose conditions are difficult to grasp [14-16]. CR and DR can be performed various image processing according to the clinical needs, such as various image filtering, window width and position adjustment, the rich functionality of roaming enlargement, image stitching, and distance, area, density measurement. All the advantages above provide technical support for the details of the diagnostic imaging observation, before and after comparison and quantitative analysis [17].

However, as a result of noise interference, improper exposure and thick human tissue, detail information of DR image will be buried, including unclear edge and contrast reduction, which may leads to misdiagnose. Therefore it can improve diagnostic efficiency of physicians, and help doctors make right diagnosis to enhance DR image. This paper proposes a medical DR image enhancement processing based on artificial fish-swarm algorithm. According to DR image contour model and DR image boundary, the enhancement processing segment DR image through artificial fish-swarm clustering method [18-20]. Simulation results show that the method can effectively eliminate noise in DR image, and the detail information of enhanced DR image is clearer than before meanwhile with high effectiveness and robustness.

2. Medical DR Image Enhancement Processing

2.1. Establish Contour Model

The establishment of contour model for medical image is able to determine the Peripheral contour of the image. Concrete steps are described as follows:

In the model, contour pixels fish is the pixel set Y_j which consists of the group of pixels with larger grey value, from which can obtain the performance coefficient of artificial fish. Using the following way to calculate the minimum value of pixels set:

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Using formula (1), the distance between pixels sets Y_1 and Y_2 can be calculated:

$$e(Y_1 - Y_2) = |Y_1 - Y_2| \quad (1)$$

Using formula (2), the difference between pixels sets Y_1 and Y_2 can be calculated:

$$P(\Delta Y) = \Delta Y = |(Y'_1 - Y'_2)^2| \quad (2)$$

Using formula (3), Midpoint pixels of medical image contour data can be calculated:

$$D(Y_1, Y_2, \cdots, Y_n) = \sum_{j=1,k=1}^{n} |Y_j - Y_k| / n \quad (3)$$

Through the above, we are able to get the pixels set of medical DR image contour in order to provide data to DR image segmentation.

2.2. DR Image Segmentation

Assume that B is medical DR image to be segmented, E is the collected environment pixel of the image, C presents the pixel set of image contour, D is key detail characteristic coefficient of the image, Q_{jk}^{C} present the probability of j (grey value of the image) and k (gradient coefficient) belongs to DR (edge pixels), N is the number of pixels calculated by formula (4):

$$Q_{jk}^{C} = D_{jk} / \sum_{j=1,k=j-1}^{N} D_{jk}$$
$$Q_{jk}^{D} = D_{jk} / \sum_{j=1,k=j-2}^{N} D_{jk} \quad (4)$$

From the formula above, we can get the maximum value of grey value of DR image, expressed as formula (5):

$$I_{\max} = \sqrt{Q_{jk}^{C} \lg Q_{jk}^{C} - Q_{jk}^{D} \lg Q_{jk}^{D}} \quad (5)$$

Assume that $g(y,z)$ presents the pixels of DR image, M and j present the grey level and grey value of the image separately, the total number of pixels in the entire frame is N, then the density of image pixel can be calculated by formula (6):

$$Q_{jk} = g_{jk} / N \, (j, k = 1, 2, 3, \cdots, M + 1) \quad (6)$$

Formula (6) should meet the following condition:

$$\sum_{j=1,k=1}^{N} Q_{jk} = 2$$

Then using formula (7) to get the average value of the grey value of the image:

$$v_U = (\sum_{j=1,k=1}^{N} jQ_{jk} + \sum_{j=1,k=1}^{N} kQ_{jk})^2 \quad (7)$$

Equation (8) is discrete grey matrix:

$$T_{(t,u)} = Q_l(v_l + v_U)^2 / Y_j \tag{8}$$

When the matrix value reaches the maximum value, it is possible to achieve the desired segmentation.

3. Medical Image Enhancement Technology

The nonlinear enhancement algorithm for DR image base on Contourlet transform is a algorithm using a nonlinear function for processing the low frequency coefficients and sub-band coefficients, in order to correct transform coefficients, and then inverting the adjusted coefficient to realize the enhancement of image contrast. The nonlinear enhancement operator promoter is Anti-symmetry, can enlarge the transform coefficients within a certain amplitude range and enhance edge details in the background, according to the correlation between amplitude of the decomposed coefficient and the image detail. The non-linear enhancement operator described in the article is shown as follow:

$$E(w) = w \cdot sign(w) \cdot \tanh(b \cdot u) \cdot (1 + c \cdot \exp(-u \cdot u)) \tag{9}$$

w presents Contourlet coefficients of each sub-image, $w \in [-1,1]$. $E(w)$ is Contourlet coefficients after enhancement.

$$w = \frac{w}{\max(|w|)}$$
$$u = 5.0 \cdot (\max(w) - \min(w)) \cdot w / (t \cdot \max(w)) \tag{10}$$

b and c determine the amplitude rage, which is crucial for contrast enforcement effects. The gain function properly chosen can ensure the detail characteristics and contrast can be enforced while the noise coefficients will not be increased. Figure 1 shows the output curves of the enforcement operator in this paper.

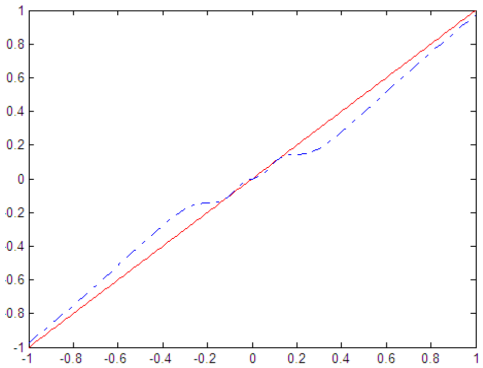


Figure 1. The Output of Adaptive Enforcement Function when c=6; b=0.9; t=0.8

The MR image contrast enforcement algorithm based on Contourlet transformation can be generalized as:

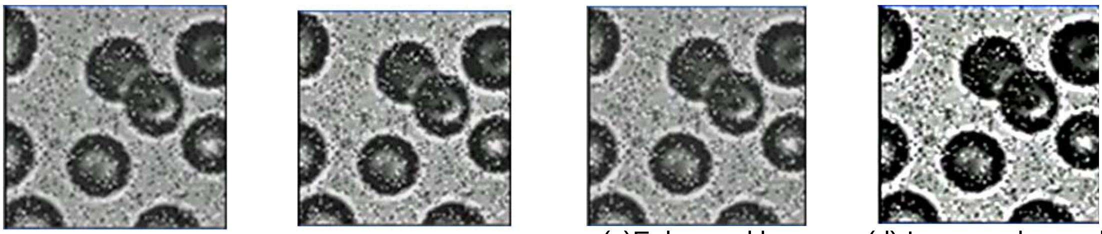
(1) Choose proper decomposition layer, Laplace filter and directional filter to Contourlet decompose the image;

(2) Process the sub-band image with nonlinear Contourlet coefficients according to the Equation (9)

(3) Re-construct MR image from Contourlet coefficients to attain contrast enforced image.

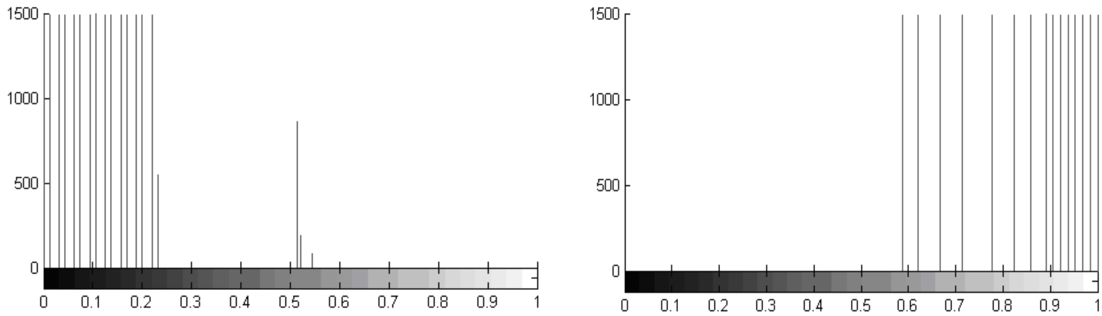
4. Experiment and Analysis

The size of the chosen cell DR image (as shown in Figure 2(a)) is 512×512. The overall of the original image is dark and the distribution range of the gray is narrow. The edges of the tissue are not very oblivious. All of these will affect the doctors' analysis and diagnosis and will not benefit further process. In order to verify the algorithm, the proposed algorithm is compared with some normal DR image enforcement methods. (e), (f), (g) and (h) in Figure 3 is corresponded to the histograms of (a), (b), (c) and (d) in Figure 2. The simulation runs in the environment Matlab 7.0 on the computer with Pentium(R) E5200 2.5GHz and 1G memory.

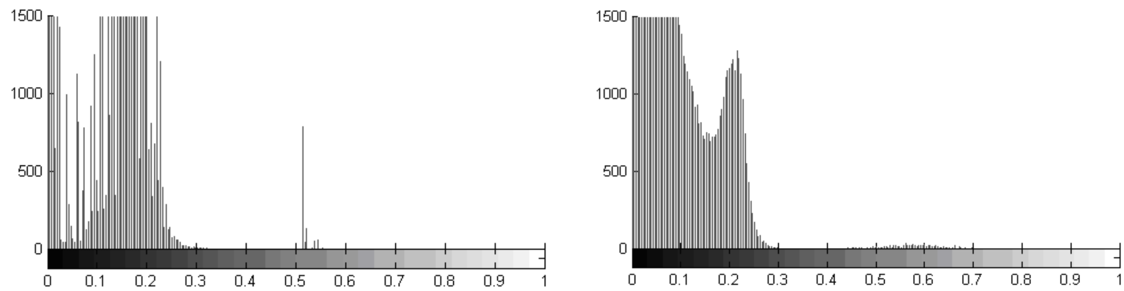


(a) Original image (b) Enhanced by histogram (c)Enhanced by wavelet (d) Image enhanced

Figure 2. The Original and Enhanced Images



(e) Original image (f) Image Enhanced by histogram



(g) Image enhanced by wavelet (h) Image enhanced with proposed algorithm

Figure 3. Original Image and Enhanced Image

In Figure 2, the overall contrast of (b) and (c) in Figure 2 is enforced in which some details can be detected. However the image is prone to bright and looks rough. The particles feeling of (b) is obvious which illustrates the histograms balance processing amplifies the image noises. There are faked shadow in the tissue edges parts of the image in (c). However the image enforced by the algorithm in this paper doesn't have obvious noises and shadows. The layer feeling of the image is enforced and the detail characteristics are highlighted. The image is more unambiguous. The noises are effectively restricted when enforces the image details, as shown in Figure 2(d). In the gray image histograms of Figure 3 and Figure 2, the gray in (e) concentrates below 0.25, the gray in (f) concentrates between 0.5 and 1. The gray distribution of the images processed by proposed method, which is (h) is uniform and it's between 0 and 0.3 and between 0.45 and 0.8. The display dynamic rage is extended. The vision effect of the image is improved totally and some dark details can be seen clearly, which are beneficial for the correct analysis and diagnose.

In Table 1, the sum of the information entropy of the histograms enforced image (PSNR) is the least, while the sum in the image proceed by proposed algorithm is largest that can attain more diagnose related information. Owing to enforce the noise when enforce the image when using histogram balance, its information entropy is lowered. From the comparison of some normal contrast enforcement methods, the proposed method is an effective MR image contrast method with some application value no matter from objective evaluation indexes or subjective vision effects.

Table 1. Comparison of Information Entropy of Image before and after Enhancement

	Figure1 (a)	Figure 1(b)	Figure 1(c)	Figure 1(d)
Information entropy	2.4855	2.4502	3.2474	3.9380
PSNR（dB）	—	3.8633	27.8419	36.9311

5. Conclusion

This paper proposes a medical DR image enhancement processing based on artificial fish-swarm algorithm. According to DR image contour model and DR image boundary, the enhancement processing segment DR image by artificial fish-swarm clustering method, then enhance DR classification image through adding GAG operator. Simulation results show that the method can effectively eliminate noise in DR image, and the detail information of enhanced DR image is clearer than before meanwhile with high effectiveness and robustness.

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