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Improving the Accuracy of Image Segmentation and Noise Reduction Based on Artificial Intelligence and Wavelet Transformation

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Abstract

Laser imaging is interferedwith by the environment, equipment, etc, making the laser images contain noise. The current image segmentation methodshave poor robustness for noise interference, a high probability of false segmentation, and serious loss of important information. Therefore, in order to overcome these disadvantages, a laser image segmentation method based on the deep learning of artificial intelligence was put forward.First of all, the wavelet transform was used to carry out feature extraction of the laser image, and then suppress the noise interference. Later, the artificial intelligence learning algorithm was introduced to train the feature vector of the laser image, and the laser image pixels were classified according to the training results, so as to realize laser image segmentation. Finally,the laser images with and without noise were used forthe simulation test.The results indicated that the segmentation accuracy of artificial intelligence deep learning for laser images with and without noise was 91% and 95%, respectively, which was significantly higher than that of the classical laser image segmentation method, so the segmentation efficiency could meet the requirements of large-scale laser image development.

***Keywords**: Artificial Intelligence; Wavelet Transform; Light Image Segmentation; Noise Reduction*

I. Introduction

As laser image segmentation is the foundation for the subsequent processing, foreign scholars have deeply studied this problem and proposed a number of laser image segmentation methods. Currently, the research on laser image segmentationcan be roughly divided into two stages: one is the traditional stage, and the other is the artificial intelligence stage. The former mainly includes thethreshold-based laser image segmentation method, edge-based laser image segmentation method, and region-based laser image segmentation method. These methods are characterized bya simple working process and fast laser image segmentation, but they are sensitive to noise. Therefore, when the laser image contains noise, there is a poor segmentation effect. The artificial intelligence stage mainly includes laser image segmentation method of clustering analysis, laser image segmentation method of the neural network, as well as laser image segmentation method of the Hidden Markov. Among them, the laser image segmentation efficiency of the clustering analysis method is low, the laser image segmentation results of the neural network are not stable, and the laser image segmentation results of the Hidden Markovoften lose important information, so the laser image segmentation effect needs to be further improved.

The laser image segmentation method based on the deep learning of artificial intelligence was proposed to overcome the defects of current laser image segmentation methods. It used the denoising advantages of the wavelet transform and good classification performance of support vector machine (SVM), and thena contrast test was conducted between it and the classical laser image segmentation method to verify the superiority of the laser image segmentation results in this paper.

II. Laser image segmentation based on artificial intelligence deep learning

(1) Using Wavelet Transform(WT) to filter laser image noise

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Let $\psi(t)$ be an integrable function, which represents the result of Fourier transform, and then

$$C_\psi = \int_R \frac{\left|\hat{\psi}(\omega)\right|^2}{|\omega|} d\omega \tag{1}$$

$\psi(t)$will produce a wave sequence after stretching and translation, i.e

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}} \psi\left(\frac{t-b}{a}\right) \tag{2}$$

Continuous wavelet transform and inverse transform can be expressed as:

$$W_f(a,b) = \langle f, \psi_{a,b} \rangle = \frac{1}{\sqrt{|a|}} \int_R f(t) \psi\left(\overline{\frac{t-b}{a}}\right) dt \tag{3}$$

$$f(t) = \frac{1}{C_\psi} \int_{R+} \int_R \frac{1}{a^2} W_f(a,b) \psi\left(\frac{t-b}{a}\right) da db \tag{4}$$

Laser image noise filtering of wavelet transform is essentially a function approximation problem, and the specific steps are as follows

Step1: The original laser image is processed by logarithmic transformation, which can be expressed as

$$f' = \ln(f+1) \tag{5}$$

Where f and f' represent the values before and after transformation, respectively;

Step2: Multiscale decomposition of log-processed laser image is carried out by wavelet transform, so as to obtain multiple wavelet coefficients;

Step3: The hard threshold is used to process the wavelet transform coefficient to make the wavelet coefficient of the corresponding noise be 0 and the noise interference be effectively suppressed, so as to obtain the new wavelet transform coefficient;

Step4: The inverse transform of wavelet transform is used to reconstruct the new wavelet transform coefficientto obtain the laser image without noise;

Step5: The exponential transformation is used to stretch the laser image without noise, specifically as follows:

$$f' = \exp(f) - 1 \tag{6}$$

For a laser image with noise, as shown in Figure 1(a), the wavelet transform filters the noise of the laser image, and the result is shown in Figure 1(b). By comparing the original and denoised images, it can be found that the wavelet

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transform can effectively remove the noise contained in the laser image, which is conducive to the subsequent processing and analysis of the laser image.

(a) Original image *(b) Denoised image*

Fig 1: Noise row filtering effect of laser image by wave transform

(2) Extraction of laser image segmentation features

The laser image segmentation resultsare also directly related to feature extraction of laser image segmentation. As a single feature cannot describe the information of different regions of the laser image, currently, multi-feature is mainly used to achieve laser image segmentation. Texture feature and gray feature are adopted to describe the information of different regions, so as to achieve the high-precision segmentation of laser images.Wavelet transform can carry out multi-scale segmentation of laser images, while texture features correspond to the details of laser images, that is, the wavelet coefficients of high-frequency part. Therefore, texture features are extracted from the wavelet coefficients of the high-frequency part of the laser image. Suppose the size of the laser image is M*N, and s(x, y) is high-frequency sub-image, then the calculation formula of texture feature is

$$e = \frac{1}{M \times N} \sum_{x,y=0}^{M^* N-1} |s(x,y)|^2 \tag{7}$$

Gray scale is also a feature of laser image. After denoising the laser image by wavelet transform, the gray scale value of each pixel and its neighboring pixel is taken as the gray feature of laser image segmentation. The distribution of pixel points (i, j) in eight neighborhoods is shown in Figure 2.

Table 1: Distribution of pixel points (i, j) in eight neighborhoods

I(i－1，j－1)	I(i－1，j)	I(i－1，j+1)
I(i，j－1)	I(i，j)	I(i，j+1)
I(i+1，j－1)	I(j+1，j)	I(i+1，j+1)

As gray feature and texture feature have different units, the values may varygreatly. Therefore, the laser image segmentation features are processed as follows to make their value region between [-1, 1].

$$g(x) = 2 \times \frac{\max - x}{\max - \min} - 1 \tag{8}$$

(3) Artificial intelligence deep learning

Artificial intelligence deep learning is an algorithm based on modern statistical learning theory. For a dichotomous problem, it is assumed that all samples can be completely separated by a hyperplane, and the hyperplane with the maximum distance from the two types of samples is the optimal hyperplane, as shown in Figure 2.

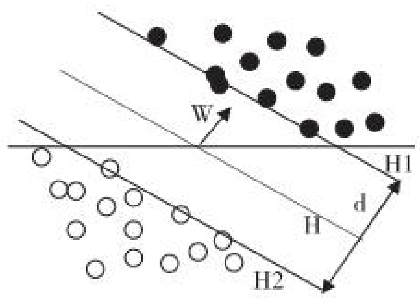

Fig 2: Working principle diagram of artificial intelligence deep learning

Let the sample set be(x_i, y_i), i=1, 2, …, m, $y_i \in \{-1,1\}$ meets the following conditions

$$y_i\left[\left(w\cdot x_i\right)-b\right]-1\geq 0 \tag{9}$$

Then Lagrange multiplier (a_i) is used to transform (9) into its dual problem, i.e

$$Q\left(a\right)=\sum_{i=1}^{n}a_i-\frac{1}{2}\sum_{i,j=1}^{n}a_ia_jy_iy_j\left(x_i,x_j\right) \tag{10}$$

Equation (10) should meet the following conditions

$$\sum_{i=1}^{n}a_iy_i=0,a_i\geq 0,i=1,2,3,\cdots n \tag{11}$$

By solving Equation (11), w* and b * of the optimal plane can be obtained, and the optimal classification function can be obtained, as follows:

$$D\left(x\right)=\text{sgn}\left(\left(w^*\cdot x\right)-b^*\right)=\text{sgn}\left(\sum_{i,j=1}^{n}a_i^*y_i\left(x_i\cdot x\right)-b^*\right) \tag{12}$$

According to the Density Functional Theory, the inner product is replaced by the kernel function and x is replaced by $\varphi(x)$, and then Equation (12) can be transformed as follows:

$$Q\left(a\right)=\frac{1}{2}\sum_{i,j=1}^{n}a_ia_jy_iy_j\varphi\left(x_i\right)\varphi\left(x_j\right) \tag{13}$$

Finally, the classification function is transformed as follows:

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$$f\left(x\right)=\operatorname{sgn}\left(\sum_{i=1}^{n}a_i^{*}y_ik\left(x_i\cdot x\right)-b^{*}\right) \tag{14}$$

(4) Laser image segmentation steps of artificial intelligence deep learning

Step1: Set the initial values of parameters related to artificial deep learning;

Step2: Collect the laser image, and adopt wavelet transform to filter the noise of the laser imageto eliminate the interference of noise to the laser image results;

Step3: Use wavelet transform to extract gray and texture features of the laser image, and carry out naturalization operation for different types of characteristic values according to Equation (8);

Step4: Use artificial intelligence deep learning algorithm to fit the connections between features and different regions of the laser image, and establish a classifier for laser image segmentation;

Step5: Use the laser image to be segmented to test the performance of the established classifier, and output the laser imagesegmentation results.

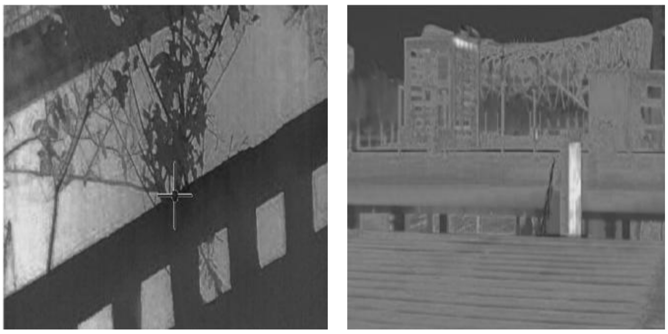
III. Case study of laser image segmentation

(1) Test environment and laser image to be segmented

To analyze the performance of artificial intelligence deep learning in laser image segmentation, the test environment of laser image segmentation is shown in Figure 1. The laser images to be segmented are divided into 4 categories, each of which contains laser images with and without noise. The image without noise is shown in Figure 3. To test the superiority of artificial intelligence deep learning method in laser image segmentation, the classical laser image segmentation methods in Literature and Literature are selected for comparison test in the same test environment.

Table 2: Test environment of laser image segmentation

Environmental parameters	Specific settings
Processor	AMD 3. 0 GHZ
Internal storage	16 G DDＲ 400
Operating system	Win 2000
Programming tool	Java



(a) *(b)*

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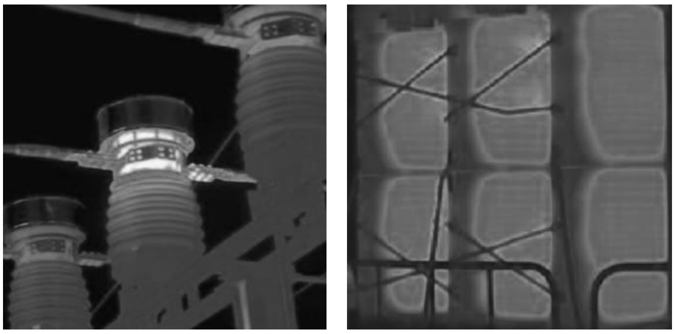

(c) *(d)*

Fig 3: Tested laser image

(2) Subjective visual effect analysis of laser image segmentation

The noise-free and noisy samples of four types of laser images are segmented by using three methods, and the segmentation accuracy is shown in Table 2. The segmentation accuracy of all methods for the noise-free laser image is better than that of noisy laser images, indicating that noise interferes with the segmentation accuracy of laser images to a certain extent. Compared with the laser image segmentation methods in Literature and Literature, the average accuracy of artificial intelligence deep learning increased by about 5%, indicating that artificial intelligence deep learning can retain more important information of laser images and prevent mis-segmentation.

Table 3: Comparison of segmentation accuracy of laser images

Series number of image	Noise-free			Noisy		
	Artificial intelligence deep learning	Literature ［16］	Literature ［17］	Artificial intelligence deep learning	Literature ［16］	Literature ［17］
A	95. 17	91. 99	90. 02	90. 82	86. 28	85. 20
B	95. 89	91. 04	90. 31	91. 57	85. 68	85. 32
D	95. 29	90. 17	91. 36	91. 31	85. 45	85. 64
d	95. 70	90. 56	91. 57	91. 23	86. 84	85. 83
Mean value	95. 51	90. 94	90. 82	91. 23	86. 06	85. 50

(3) Comparison of laser image segmentation time

The segmentation time of laser images containing noise is calculated, as shown in Figure 4. It shows that the laser image segmentation time of artificial intelligence deep learning is less than 35 ms, while the laser image segmentation time of Literature [16] and Literature [17] is more than 60ms. Therefore, artificial intelligence deep learning improves the efficiency of laser image segmentation.

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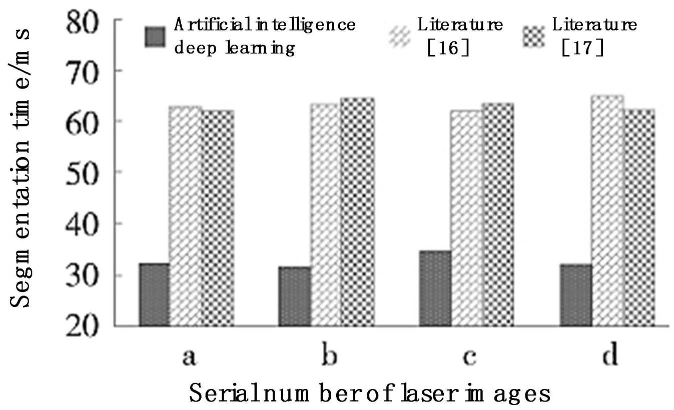

Fig 4: Comparison of laser image segmentation time

IV. Conclusion

The laser image segmentation method of artificial intelligence deep learning was proposed by combining with the imaging characteristics of laser images, in order to overcome the defects of current laser image segmentation methods.It takes the laser image segmentation problem as a classification problem, namely, the laser image is divided into multiple regions, and the artificial intelligence deep learning algorithm is adopted to fit the edge of various regions, thus realizing laser image segmentation. The simulation experimental results indicate that, compared with the current classical laser image segmentation methods, the artificial intelligence deep learning method can obtain more ideal laser image segmentation results. Meanwhile, it can resist all kinds of noise interference, with a larger laser image segmentation speed, so it can be applied to laser images of different fields.

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