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Research Paper

An Improvement of Fruit fly optimization Optimization Algorithm and Its Application in Multithreshold Segmentation of Ultrasonic Images

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ABSTRACT:*Ultrasound image segmentation is of great significance in medical clinical application, but it is often faced with unclear image segmentation boundary, slow segmentation speed, inaccurate threshold selection and so on, which leads to the loss of the significance of clinical automatic diagnosis. In this paper, a multi threshold image segmentation method based on fruit fly optimization algorithm (FOA) is proposed. Combined with the multi threshold segmentation method of random forest feature selection and ceemd energy entropy, the optimal segmentation threshold can be found accurately through the optimization and iteration of fly optimization algorithm. The experimental results show that the improved fly optimization optimized multi threshold segmentation algorithm (WFOA) has better optimization accuracy and real-time performance compared with several similar optimized image segmentation algorithms, and takes a very good practical effect in Ultrasound image segmentation.*

KEYWORDS: *fruit fly optimization algorithm, ultrasonic image, multi-threshold segmentation, clinical diagnosis*

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I. INTRODUCTION

Over the past decade, the rapid development of ultrasound imaging technology has led to a massive [1-2] in the non-invasive aspects of fetal cardiac evaluation. In particular, the recent emergence of some handheld portable ultrasound devices more facilitates the detection of [3-5] on fetal ultrasound imaging. Evaluation of fetal heart function using fetal heart ultrasound imaging technology brings very good technical support to prenatal and postnatal care and [6]. The precise assessment of cardiac function by fetal heart ultrasound, such as the stenosis of the left and right ventricles, and ultrasound may help to confirm the diagnosis of congenital heart disease. Heart and placental disease [7-10] can be further investigated by using computer imaging diagnosis and other AIDS such as EED signals, including monitoring vascular blood flow, blood oxygen saturation and hematocrit.

This paper starts from the original fetal ultrasound image, by improving the fly optimization algorithm [11-13] and applied in ultrasonic image segmentation, through the fly optimization algorithm optimization and iteration accurate segmentation of fetal heart function, at the same time by combining the two-dimensional maximum entropy [14-15], in terms of multi-threshold image segmentation, experimental experiments, achieve good results. By comparing several other similar algorithms, it achieves good results in optimal accuracy and real-time performance..

II. THE BASIC FRUIT FLY OPTIMIZATION OPTIMIZATION ALGORITHM

The fly optimization algorithm (FOA) simulates the process of flies hunting with a keen sense of smell and vision, along with other optimization algorithms such as firefly and cuckoo algorithms. It is a global optimization algorithm that realizes the group iterative search of the solution space. FOA principle is easy to understand, easy to operate, according to the characteristics of flies seeking food, has a good sensitivity, and the algorithm oil is strong local search ability.

Implementation steps of the basic fruit fly algorithm:

(1) Initialization. Initial position setting of Fruit fly optimization population.

(2) Formula for defining fruit fly movement direction and distance:

$$X_{(i)} = X_{axis} + Rand()$$
$$Y_{(i)} = Y_{axis} + Rand() \quad (1)$$

(3) Distance determination formula:

$$D(i) = \sqrt{X(i)^2 + Y(i)^2}$$
$$S(i) = 1/D(i) \quad (2)$$

$D_{(i)}$ as the coordinates of the individual fly, is the judgment value of the fly taste $S_{(i)}$.

(4) Concentrated flavor values $S_{(i)}$ were obtained by substituting the fitness function for the flavor determination values.

$$Nsmell(i) = Function(S_{(i)}) \quad (3)$$

(5) Look for the optimal concentration of individuals (maximum or minimum) in all groups

$$Bestsmell = \min(Nsmell(i)) \quad (4)$$

(6) All individuals were clustered towards the best individual

(7) Iterate to find excellence

Repeat steps (2) - (5) to determine the optimal value.

III. IMPROVED FRUIT FLY SEGMENTATION ALGORITHM

3.1 Optimization and improvement of the initial test position

The basic Fruit fly optimization optimization algorithm, in each iteration of learning, will specify the optimal individual as the center, lose the diversity of the group, and be easy to fall into the local optima and fail to converge. Therefore, this paper adopts the random forest-based feature selection and the CEEMD energy entropy constraint criterion. The entire process includes the first step of the initial population optimization using a random forest. The second step is to select features from the CEEMD energy entropy to reduce data redundancy. Then, the optimal parameters are trained using optimal combinations and features to obtain more accurate and unbiased experimental results. CEEMD is an adaptive time-frequency signal analysis method developed based on EEMD that can effectively extract fault frequency features. According to previous studies, CEEMD performs better [16] than EEMD on signal decomposition.

3.2 Energy entropy threshold

The feature extraction method based on CEEMD energy entropy is as follows: Step 1: CEEMD decomposes the signal to obtain multiple IMF:

$$x(t) = \sum_{j=1}^{n} c_j(t) + r(t) \quad (5)$$

Step 2: Calculate the amplitude energy for each component: $E_1, E_2, \ldots, E_n$

In Equation (2), N is the number of sampling points in the j th component.

Step 3: Assuming that r (t) is negligible, the total signal energy is

$$E_{sum} = \sum_{j=1}^{n} E_j = \sum_{j=1}^{n} \sum_{k=1}^{N} |c_j(k)|^2 \quad (6)$$

Step 4: In order to avoid the IMF component controlling the relatively weak IMF in the partial amplitude energy concentration, the amplitude energy of each IMF order is normalized:

$$p_j = \frac{E_j}{E_{sum}} \quad (7)$$

Therefore, the corresponding CEEMD energy tendency (en) can be expressed as n

$$H_{EN} = -\sum_{j=1}^{n} p_j \log p_j \quad (8)$$

In equation (5), p is the proportion of the j-th IMF amplitude component in the total energy.

Improved Fruit fly optimization-optimized segmentation algorithm flow Random Forest is a multi-classifier integration algorithm that achieves higher classification accuracy[17] in a short time with fewer training samples. For multi-time domain feature sets, a random forest classifier can reduce the dimensionality of

features and reduce overfitting. The algorithm flow is as follows:
Step 1: input the energy entropy features of the sample data into the random forest, calculate the feature importance, and rank the features in descending order of feature importance
Step 2: Delete from a feature set and build a new feature set according to a certain deletion rate
Step 3: Enter a new feature set into a new random forest, calculate the importance of each feature, then sort in descending order, and repeat steps 2 and 3 until the specified number of features is left
Step 4: Each feature set corresponds to a random forest; the corresponding bag exit error rate is calculated, and the feature set with the lowest bag exit error rate is taken as the last selected feature set.

IV. EXPERIMENTAL VERIFICATION

4.1 Database set

This study collected real ultrasound pictures of fetal heart, a total of four age types of fetuses, each type of fetal heart pictures is divided into normal and abnormal two types of classification pictures.

4.2 Experimental Analysis

In this paper, the input ultrasound images were converted to a gray scale level of 256, and the random forest method was used to set the iteration initial number and population size, and the search obtained a two-dimensional optimal threshold.The test functions used are shown in Table 1.

Table 1 Test Functions

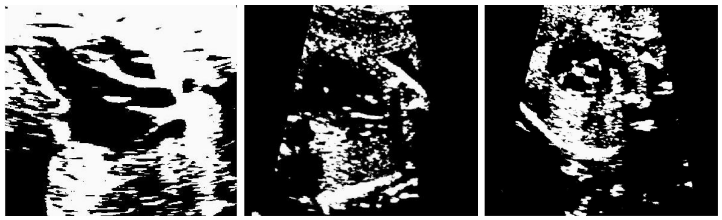
Test function	Range	Optimal	Target precision	Peak
$f(x)=20+e-20\exp(-0.2\sum_{i=1}^{n}x_i^2/n)-\exp(\sum_{i=1}^{n}(\cos 2\pi x_i)/n)$	[-30, +30]	0	10^{-10}	multiple
$f(x)=\sum_{i=1}^{n}x_i^2/n$	[-30, +30]	0	10^{-10}	Single
$f(x)=\sum_{i=1}^{n\text{-}1}\left[3(\cos(2x_i)+\sin(2x_{i+1}))+\exp(-0.2)\sqrt{x_i^2+x_{i+1}^2}\right]$	[-30, +30]	0	10^{-10}	multiple
$f(x)=1+\sum_{i=1}^{n}x_i^2/400+\prod_{i=1}^{n}\cos(x_i/\sqrt{i})$	[-600, +600]	0	10^{-10}	Single
$f(x)=-\sum_{i=1}^{n}x_i\sin\sqrt{\lvert x_i\rvert}$	[-500, +500]	0	10^{-10}	Single
$f(x)=\sum_{i=1}^{n}\lfloor x_i+0.5\rfloor^2$	[-100, +100]	0	10^{-10}	Single

4.3 Analysis of multiple thresholding-threshold segmentation experiments

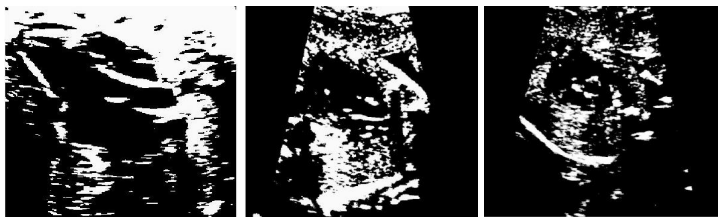
Threshold optimization was performed with the traditional Fruit fly optimization algorithm, WFOA, GA and WGA, 30 times each, and the average threshold fitness function values and variance of the Ozu method were statistical optimized, as shown in Table 4.From the optimization results, WFOA achieves the largest optimal threshold adaptation value, which shows that WFOA can achieve better results than other algorithms in optimizing the threshold.In terms of variance, WFOA is more stable than all the other algorithms, considering both global and local, and thus improving the diversity of the population.

(a)

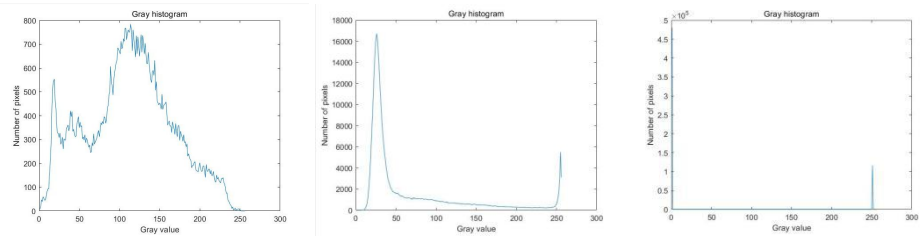
(b)



(c)



(d)



(e)

Figure 1: Image segmentation results. (a) original image,(b)WFOA method,(c)GA method,(d)FOA method,(e)Gray histogram

As can be seen from Figure 1 that the traditional fruit fly algorithm is blurred and the segmentation effect is not obvious.GA and WGA algorithms can segment the general outline in the image, but the segmentation effect in small parts is not good, and there is noise.The improved algorithm in this paper outperformed the other three algorithms both in denoising ability and segmentation effect.

V. CONCLUSION

The rapid and accurate segmentation of ultrasound images has very realistic clinical significance.Starting with the research point of interest of fetal heart ultrasound image segmentation, we combine the study of the traditional fruit fly optimization algorithm and the two-dimensional maximum entropy method.Through experimental verification, the proposed method also has a great performance improvement compared with other traditional methods.It can be further promoted and applied in clinical practice.

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