Apple grading based on IGWO optimized support Vector Machine

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Abstract

In order to improve the accuracy of apple external quality classification based on support vector machine, an improved grey wolf optimization algorithm IGWO was proposed by adding Logistic chaos mapping, nonlinear convergence factor and Cauchy variation to the grey wolf optimization algorithm. Firstly, different benchmark functions are used to test the improved IGWO algorithm. The test results show that the IGWO algorithm has improved the convergence speed and accuracy. Secondly, the image processing method is used to extract apple's external features as the data set. The improved grey wolf algorithm was used to optimize the penalty parameters and kernel parameters in support vector machine, and the optimal IGWO-SVM classification model was obtained. Finally, compared with the classification results of SVM and GMO-SVM, the results show that IGWO-SVM has the highest classification accuracy.

Keywords: Apple external quality rating; Improved Grey wolf optimization algorithm IGWO; Support vector machine; Reference function; IGWO-SVM.

1. Introduction

At present, apple classification mainly relies on manual sorting to detect, but this method has strong subjectivity and low classification efficiency, resulting in low accuracy of apple classification. Therefore, it has important research significance and value to use effective science and technology for apple classification.

With the rapid development of image processing technology and machine vision, it has been widely used in the agricultural field.

Li Xianfeng et al. [1] proposed a decision-level multi-feature fusion apple classification method based on D-S evidence theory, and the accuracy rate of apple classification reached 92.5%. Li et al. [2] used image processing technology to extract apple features and BP neural network for classification, and the classification result could reach 92.5%.Xia Qing et al. [3] used the least square support vector machine based on the improved algorithm of particle swarm optimization to classify apples, and the experimental results showed that the accuracy of apple classification was above 96%. Li Xuejun et al.[4] proposed an apple classification algorithm based on the combination of discriminant tree and improved support vector machine decision making. The results showed that the method was feasible and its classification accuracy was above 98%, which could be effectively used for apple classification.

2. Improved grey wolf optimization algorithm

2.1. *Logistic chaos map*

Using Logistic chaotic mapping [5] to substitute random initialization in grey wolf algorithm can improve the uniform distribution of initial population and global search ability of the algorithm. The expression of Logistic chaos mapping is as Eq. (1):

$$X_{n+1} = X_n \times \mu \times (1 - X_n), \mu \in [0,4], X \in [0,1] \quad (1)$$

2.2. *Improvement of nonlinear convergence factor*

In the improved grey wolf algorithm, in order to improve the search ability of the algorithm, the nonlinear convergence factor such as Eq. (2) is used. The improved convergence factor [6] decreases linearly with the number of iterations from 0 to 2.As shown in Fig.1, at the beginning of iteration, the convergence rate of the improved convergence factor is reduced compared with that of the original algorithm. At the end of iteration, the speed of convergence factor increases, which makes the search for local optimal solution [7] more accurate.

$$a = 2 - 2\left(\frac{1}{e-1} \times \left(e^{\frac{t}{t_{\max}}} - 1\right)\right) \quad (2)$$

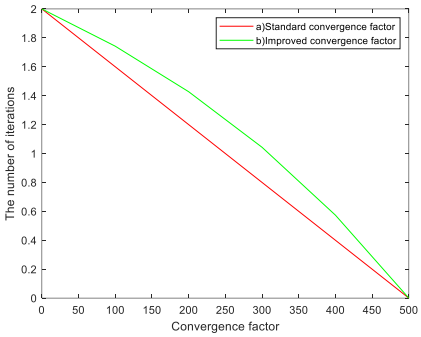


Fig. 1 Nonlinear convergence factor

2.3. *Cauchy variation is introduced*

In order to avoid the algorithm falling into local optimum, Cauchy variation [8] is added to the improved grey wolf algorithm,the variation formula is shown in Eq. (3) :

$$X(\varphi + 1) = X_{\text{best}}(\varphi) + C(0,1) \oplus X_{\text{best}}(\varphi) \quad (3)$$

2.4. *Improved grey Wolf algorithm test*

Tab.1 lists information about standard test functions. Where, F1 and F2 are unimodal functions; F3 and F4 are multimodal functions. Experimental hardware conditions: Intel(R) Core(TM) i5-8300H CPU @ 2.30ghz processor, 16G running memory, software Matlab2018b.

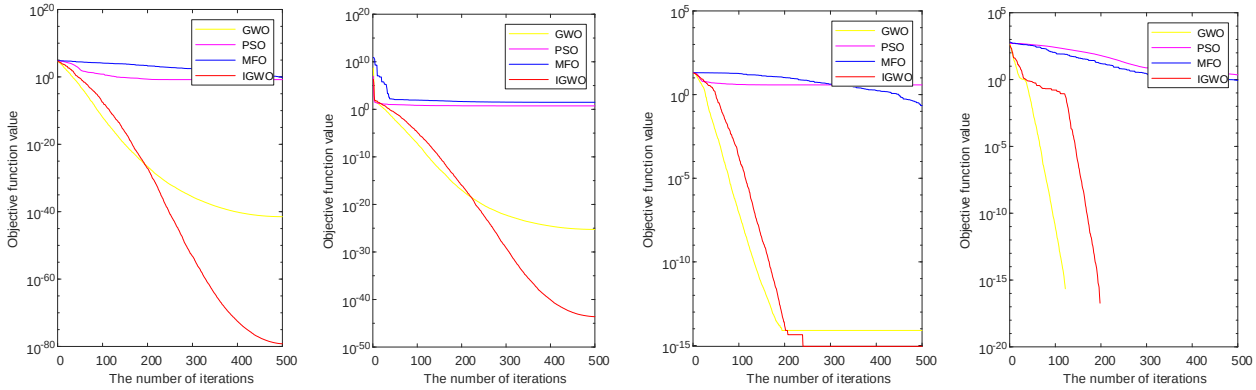
Tab.1 Benchmark function

Function name	Function formula	Dim.	Scope
Sphere	$f_1(x) = \sum_{i=1}^{n} X_i^2$	30	[-100,100]
Schwefel2.22	$f_2(x) = \sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$	30	[-10,10]
Ackley	$f_9(x) = -20\exp(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}) - \exp(\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi x_i) + 20 + 30$	30	[-32,32]
Griewank	$f_{10}(x) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n}\cos\frac{x_i}{\sqrt{i}} + 1$	30	[-600,600]

The experimental results are shown in Tab.2 and the convergence curve is shown in Fig.2. For both single-peak functions F1 and F2 and multi-peak functions F3 and F4, the performance of the improved gray wolf algorithm IGWO is better than that of PSO[9],MFO[10] and GWO.[11]

Tab.2 Comparison of results of different algorithms

Function	PSO		MFO		GWO		IGWO	
	AVE	STD	AVE	STD	AVE	STD	AVE	STD
F1	3.14e-2	9.44e-2	3.57e-3	2.31e-3	4.19e-23	1.02e-22	8.21e-41	2.28e-41
F2	2.00e-3	2.67e-3	1.88e-3	6.85e-3	3.12e-28	2.34e-27	7.85e-47	8.72e-46
F3	2.23e-1	3.02e-2	3.69e-3	5.43e-3	1.74e-16	1.02e-15	4.63e-17	2.53e-16
F4	2.72e+0	1.68e+0	6.18e-2	1.58e-2	2.94e+1	1.12e+0	1.39e-10	7.51e-10



(a) Sphere (b) Schwefel2.22 (c) Ackley (d) Griewank

Fig. 2 Convergence curves of GWO,PSO,MFO and IGWO on test functions

3. Results and Analysis

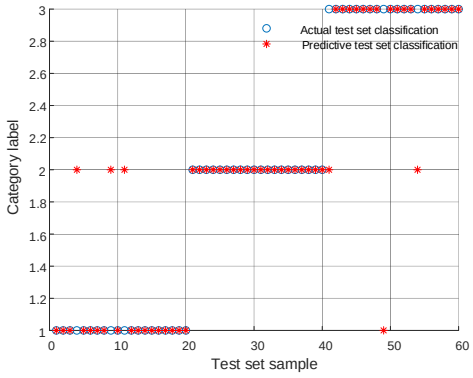


Fig.3 Results of grading using GMO-SVM

In order to verify the classification effect of IGWO proposed in this paper, SVM, [12] GMO-SVM and IGWO-SVM algorithms are successively used for classification experiments. The number of correct classification of SVM algorithm without optimization is 49, and the classification accuracy is 81.66%. As shown in Fig.3, the classification accuracy of the test set has reached 90%, with the classification accuracy of first-class fruit reaching 85%, first-class fruit reaching 100% and second-class fruit reaching 85%. The accuracy of support vector machine optimization using the improved Grey Wolf algorithm reached 98.33%, as shown in Fig.4, which achieved the expected effect of Apple classification.

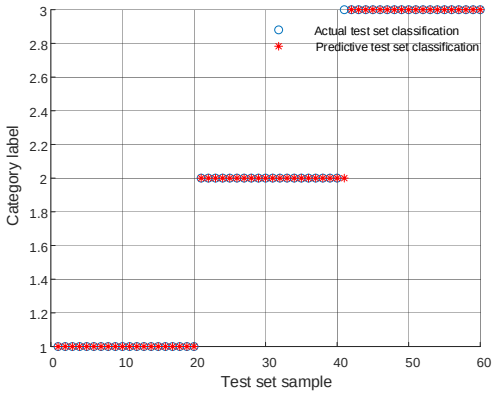


Fig.4 Results of IGWO-SVM classification

4. Conclusion

This paper proposes an improved grey wolf algorithm, namely IGWO algorithm, on the basis of the grey wolf algorithm, adding logistic chaos mapping, nonlinear convergence factor and Cauchy variation. Through the simulation experiments on four standard test functions and compared with PSO,MFO and GWO algorithms, the experimental results show that IGWO algorithm achieves higher optimization accuracy on test functions, and greatly improves the optimization performance in terms of robustness and fast jumping out of local optimum. Secondly, IGWO algorithm is used to optimize the penalty parameters and kernel parameters in support vector machine, and the optimized support vector machine is used to classify apple. The experimental results show that the accuracy rate of IGWO-SVM reaches 98.3%.

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