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Wheat Hardness Prediction Research Based on NIR Hyperspectral Analysis Combined with Ant Colony Optimization Algorithm

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Abstract

This paper presents a new and improved method that ant colony optimization (ACO) algorithm is combined with the support vector regression for band selection. The method is applied to the prediction research of wheat grain hardness, and tries to detect the feasibility of the forecasting ability. The optimized selection of characteristic wave band is the key link of the near infrared (NIR) hyperspectral analysis technology of wheat hardness. Experimental results showed that eleven characteristic wave band sub-intervals were selected from thirty spectral intervals by the algorithm, including 86 wave points. The selected wave band sub-interval were respectively 902.1 to 931.8nm, 968.7 to 1027.5nm, 1119.0 to 1143.4nm, 1174.1 to 1275.5nm, 1174.1 to 1275.5nm, 1626.0 to 1647.6nm and 1626.0 to 1647.6nm. After using the optimized parameter in the spectral information forecasts and analyzes by the support vector regression. Prediction performances of regression models are assessed by calculating the estimated root mean square errors of cross-validation $(RMSECV)$, the root mean square errors of prediction $(RMSEP)$ and the correlation coefficient (R). The results showed that the estimated $RMSECV$ and R_{cv} values were respectively 0.0382, and 0.9810 for the training set, the estimated $RMSEP$ and R_P values were respectively 0.0590, and 0.9544 for the validation set. Compared with the full spectrum of partial least squares (PLS), interval partial least squares (IPLS) algorithm, it simultaneously reduces the number of certain variables used in the model and increases in the prediction ability and the precision, and it can better reflect optimization model of the wave band. It is confirmed that the ACO method applied to the prediction research of the grain kernels is feasible.

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Keywords: the near infrared (NIR) hyperspectral; Ant Colony Optimization(ACO); the optimized selection of wave band; hardness prediction

1. Introduction

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Grain kernels hardness is one of the important basis of the market classification and pricing at home and abroad, it is important basis to determine the grain kernels milling technology, equipment distribution and process parameters [1]. The measurement on the raw material grain kernels hardness in advance not only can adjust the coal pulverizing process and the corresponding technical parameters, but also has important technical guiding significance for keeping the balance and stability of the materials. Besides, it can improve the production efficiency. However, the optimized selection of characteristic wave band of the spectrum plays an important role in the NIR hyperspectral analysis technology [2].

In the process of the NIR hyperspectral analysis of wheat hardness, due to multi-band and enormous information of the hyperspectrum, full-wave band modeling increases the amount of calculation, but the prediction accuracy on account of the collinearity between spectral information may also be influenced impacted. Therefore, choosing to represent the optimal characteristics of wheat hardness information is not only beneficial to reduce the computational complexity, and can improve the prediction ability of wheat grain hardness [3]. In recent years, many scholars at home and abroad have researched many methods on characteristics wave band selection of the near infrared hyperspectral, such as the method of eliminating no information variables, IPLS, genetic algorithm, etc. [4]. But these methods more or less have some disadvantages [5,6]. In view of the present commonly used spectral selection method, this method was only modeled in a single interval without considering the disadvantages of multiple interval combination. The final optimization of sub-interval not well represented the characteristics of the spectral information, and also lost some effective related information within other ranges. Genetic algorithm had nothing to do with the global search ability of the problem domain, and easy to fall into local optimal problems. This article uses the ant colony optimization algorithm which was put forward by Marco Dorigo and others in the early 1990s. It is the new development of artificial intelligence or group intelligence with the characteristics of distribution calculation, the information positive feedback and heuristic search. It has well solved the traveling salesman, communication, network routing and quantitative structure-activity relationship combinatorial optimization problems et al. At present, there exist some scholars who use the ACO algorithm to select the spectral variables [7]. It also has a variety of methods for the choice of evaluation function in this module. This paper tries to get the predictive value of hardness of wheat samples based on the support vector regression method, and in order to obtain the root mean square error as the performance evaluation criteria of the feature subset of the evaluation. ACO algorithm combined with the support vector regression applies in wheat hardness by the optimized selection of characteristics wave band of the NIR hyperspectral analysis, which can realize global search of spectral variables and set up the multivariate calibration model with the characteristics of high precision and strong stability [8,9].

2. Experimental Part

2.1. Data Acquisition

NIR hyperspectral images of wheat hardness were acquired adopting Gu Jia Shen near infrared camera [10]. In front of the NIR hyperspectral imaging data acquisition, predetermined the exposure time of near infrared camera and the speed of displacement in order to ensure the clearness of the image and avoid the distortion of images size and the spatial resolution [11]. Tests showed that when the exposure time was 3000 microsecond and the displacement movement speed reached 0.59 millimeters per second, the acquired images are clear. In fact, the spectrum with a wavelength range collected in the experiment is 871.6 to 1766.3nm, sampling interval was 3.5nm, the spatial resolution of the direction of perpendicular to the displacement was 62.5pm. During the database acquisition process, firstly wheat samples were scanned a line at one time, it could be a size of $320 \times n \times 256$ hyperspectral image data cubes after scanning n lines, the size of n was determined by the number of wheat samples.

During the experiments, 22 samples in different varieties of wheat kernels are provided. They were purchased from the agribusinesses Xintiandi in the pingyuan new district of Xinxiang, which was bought in different counties and cities in Henan province, including the soft wheat, mixed wheat and hard wheat. Using wheat hardness index instrument JYDB100(40) to measure the hardness index of wheat kernels samples [12]. The front 40 of each sample were used to learn and the other 30 of each sample were used to recognize in the test, it could be divided into training set and validation set, respectively including 880, 660 samples, the total number of wheat samples was 1540.