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Research of Maize Seeds Classification Recognition Based on the Image Processing

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Abstract

The maize seeds recognition is an important aspect of the seed quality testing and breeding. With the development of computer technology, it is an inevitable tendency to recognize seeds varieties and inspect quality using machine vision instead of human vision. For the characteristics of maize seeds and their images, seeds varieties recognition technology and algorithm was studied and explored in depth and their shape and color feature parameters were extracted. Based on 4 species including Nongda 108, Zhengdan 958, Ludan 981 and Jingdan 28, the classifier was designed using BP neural network to do varieties recognition testing. Research showed the average recognition accuracy was more than 94.5%, and that recognition and detection of maize seeds varieties based on the image technology is feasible.

Keywords: *Maize, Image processing, Feature extraction, BP neural network*

1. Introduction

Maize is not only food and feed, but also economical crop. The global annual consumption of maize, according to statistics, has been maintained above 8 tons and sustained a healthy trend of growth since 2010 [1], so it has a good market prospect. The finest maize seeds are the guarantee for improving the output, efficiency and quality in agricultural and industrial production process. Therefore, it is important to improve the quality of maize actively and obtain the principles and methods of quick quality detection, recognition, classification and optimization for further development food industry and commercial trade market, and it is also the key factor for the reproduction of the agriculture [2].

In practice, there are the following seeds recognition methods: field planting recognition, protein electrophoresis, fluorescence analysis and seeds morphology detection method [3]. Field planting detection is accuracy, but it requires a lot of hard work and time; cycle is long and the detection site is in the field, greatly influenced by environment and business level of testers, so the accuracy of detection results is affected to a certain extent. Protein electrophoresis and fluorescence analysis method is of high accuracy, but the testing time is long and equipment is expensive. Seed morphology detection method is manual measurement and subjective judgment using calipers and balances, affected badly by testers' technical operation level and experience, so this method is simple, economic and fast, but the

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accuracy and scope of application has the very big limitation, which makes it difficult to spread [4]. With the rapid development of information technology and automation technology, using image recognition technology to replace manual recognition of seeds varieties is a new topic [5].

Maize seeds automatic detection system based on image technology has following process: firstly, preprocessed image of seeds collected and extracted seeds features on the above image; and then these features were input classifiers to detect and recognize. Features extraction is a critical problem in the detection and recognition of maize seeds, which directly affects the design and performance of classifiers [6]. Based on image processing technology, maize seeds were regarded as the research object, and the typical characteristics extraction method was studied and applied to the actual variety recognition system.

2. Image Acquisition and Feature Extraction System of Maize Seeds

2.1. Image Acquisition

The hardware system of acquiring maize seeds image included a camera, light source, lens hood and loading platform, as shown in Figure 1.

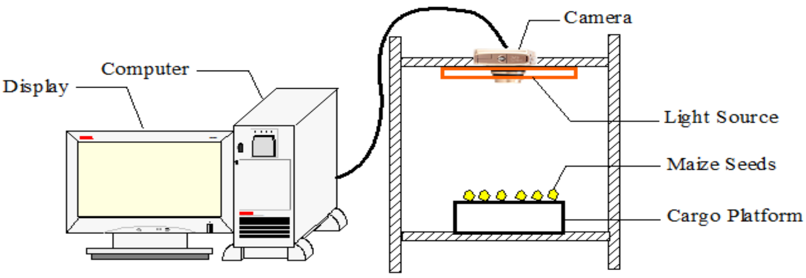

Figure 1. The Hardware System

Figure 2. The Original Color Image of Maize Seeds

The system acquired images by Canon IXUS140 digital camera whose resolution was 1024×768, aperture was F3.2 and ISO was 100; the light source was provided by Opple T5 ring lamp whose power was 22W, outer diameter was 185mm, and the color temperature was 6500K; Cargo platform was made by black rubber to improve the contrast and reduce the reflection.

The image of seeds acquired was shown in Figure 2.

2.2. Feature Extraction System

In the process of seeds recognition, the related technologies include: to preprocess the image and acquire the outlines of maize grains; to extract the feature parameters defined and derive the feature data. The flowchart was shown as Figure 3.

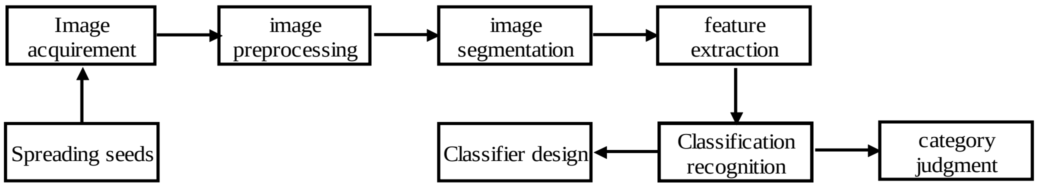

Figure 3. The System Flow Chart

3. Image Processing

3.1. Median Filtering

Considering noise that could be produced in the process of image acquisition and transmission as shown in Figure 4, the system selected median filtering algorithm whose template size was 3×3 to enhance the image. Median filtering that was nonlinear filtering could effectively eliminate the noise on maintaining image details. The image filtered was shown in Figure 5.

Figure 4. Noise Image

Figure 5. Median Filtering Image

3.2. Graying

Changing the color image into gray image was called graying, which was vital in the image processing; and it was the basis for subsequent processing. The system used the weighted average method to convert the color image into gray image; that was, in accordance with the visual characteristics suitable for human [7], theories and experiments indicated that a group of weights (Red was 0.299, Green was 0.587 and Blue was 0.144) was suitable [8]. The transformation equation for:

$$Gray = 0.299 \times R + 0.587 \times G + 0.114 \times B \qquad (1)$$

Gray image was shown as Figure 6.

Figure 6. Gray Image

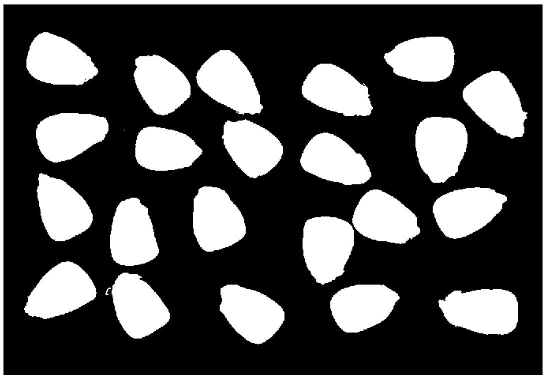

Figure 7. Binary Image Binarization

The OTSU adaptive threshold segmentation method was used in binary gray image processing. For an image, when a segmentation threshold of the foreground and background colors was t, the foreground proportion was w_0 and mean was u_0, and the background proportion was w_1, the mean was u_1. The mean of whole image for:

$$u = w_0 \times u_0 + w_1 \times u_1 \tag{2}$$

The objective function could be built:

$$g(t) = w_0 \times (u_0 - u)^2 + w_1 \times (u_1 - u)^2 \tag{3}$$

When the segmentation threshold was t, $g(t)$ was on-class variance expression [9]. While OTSU algorithm made $g(t)$ reach the maximum, the corresponding t was called the best threshold [10], so OTSU algorithm was also known as the maximum on-class variance method. The processing results as shown in Figure 7.

3.3. Morphological Processing

Morphological processing included corrosion and expansion, which could remove the burrs and empty [11].

The operator of corrosion was“ $\otimes$ ”, and using B to corrode A was denoted by $A \otimes B$, which was defined as

$$A \otimes B = \{x | (B)_x \subseteq A\} \tag{4}$$

The operator of expansion was “ $\oplus$ ”, and using structural elements B to expand image collection A was denoted $A \oplus B$, which was defined as

$$A \oplus B = \{x | [(\hat{B})_x \cap A] \neq \phi\} \tag{5}$$

The image corroded and expanded using 3×3 window was shown in Figure 8, the edges of which were extracted by using the canny operator. Its effect was shown in Figure 9.

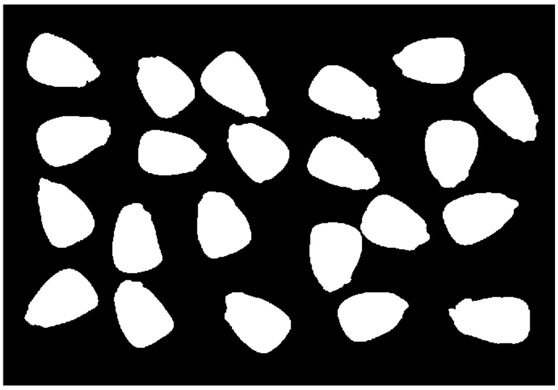

Figure 8. Corrosion and Expansion

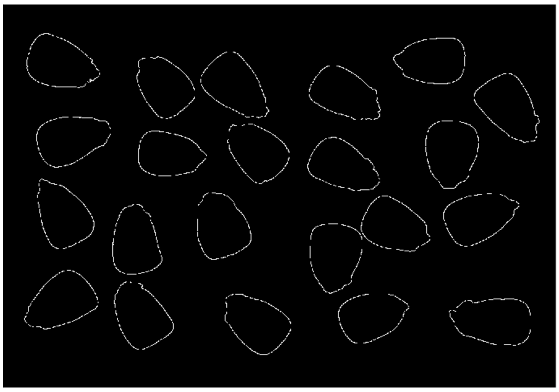

Figure 9. Boundary Extraction

4. Feature Extraction

4.1. Parameters of Shape Feature Extraction

The processed image of maize seeds was extracted multiple characteristic parameters using a connected region labeling method and multi object contour extraction algorithm (as shown in Figure 10). Each seed was extracted 8 parameters of shape feature, which were defined as follows:

(1) Area was the size in outline of maize seed, denoted by “A”.

(2) Perimeter was outline length of seed region, denoted by “P”.

(3) Long axis was the long direction of minimum external rectangle, denoted by “L”.

(4) Short axis was the short side of minimum external rectangle, denoted by “S”.

(5) Equivalent diameter was diameter of circle whose area was equivalent to seed’s, with “D”. The calculation formula was as follows

$$D = 2\sqrt{A/\pi} \quad (6)$$

(6) Rectangular degree referred to the ratio of long axis to short axis, with “R”. The calculation formula was as follows

$$R = \frac{L}{S} \quad (7)$$

(7) The compaction was the ratio of equivalent diameter to long axis, with “C”. The calculation formula was as follows

$$C = \frac{D}{L} \tag{8}$$

(8) Roundness was gained through calculation of seed's area and perimeter, denoted by "R". The calculation formula was as follows

$$R = \frac{4\pi \times A}{P^2} \tag{9}$$

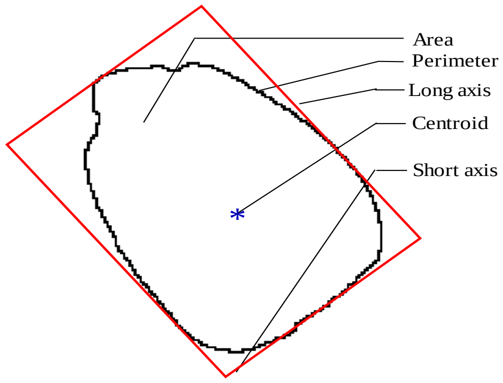

Figure 10. Diagram of the Shape Parameters

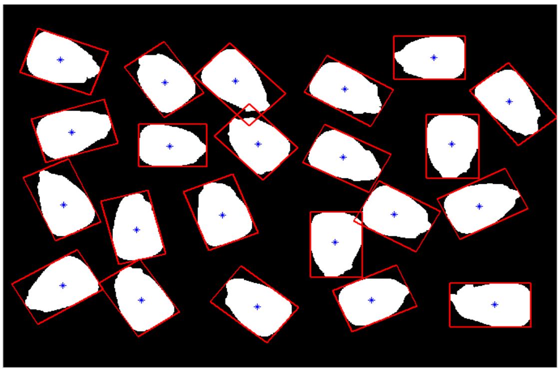

Figure 11. Extraction Effect of Shape Parameters

The data extracted was shown in Table 1, and the actual effect of extraction was shown in Figure 11.

Table 1. Shape Feature Parameters

Code	Area	Perimeter	Long axis	Short axis	Equivalent diameter	Rectangular degree	Compaction	Roundness
1	10249	405	140.6288	94.8387	114.2062	1.4802	0.8127	0.7841
2	10139	4063	138.9278	95.7397	113.709	1.4535	0.8189	0.779
3	10046	398	139.6957	92.8557	113.069	1.5031	0.8082	0.7939
4	9743	400	141.7667	93.0204	111.3728	1.5308	0.7835	0.7648
5	9600	392	133.5870	89.4703	110.5639	1.4959	0.8261	0.7805
……	……	……	……	……	……	……	……	……
18	9391	380	132.0000	88.0000	109.3713	1.5000	0.8281	0.8156
19	10261	392	131.0000	98.0000	114.2564	1.3367	0.8721	0.8366
20	10047	399	140.8723	92.1260	113.0859	1.5291	0.8029	0.7882
21	10989	432	151.0000	89.0000	118.2216	1.6854	0.7886	0.7346
22	10326	416	144.3046	91.9863	114.6957	1.5661	0.7947	0.7486

4.2. Color Feature Extraction

The system adopted RGB and HSI model to describe color information of maize seeds, involving 6 kinds of color feature parameters. Region growing method was used to extract full part of seeds Figure 12, that is, the color features were extracted in the yellow fields; the extracted data was shown in Table 2.

Figure 12. The Full Part Image of Seeds

Table 2. Color Feature Extraction

Code	R-mean	G-mean	B-mean	H-mean	S-mean	I-mean
1	210.24	175.54	140.62	0.41	0.67	160.24
2	212.85	172.61	135.74	0.38	0.64	164.34
3	201.42	179.52	142.38	0.42	0.58	159.87
4	199.87	178.55	137.56	0.37	0.61	159.46
5	213.83	176.98	143.84	0.39	0.66	162.24
……	……	……	……	……	……	……
18	219.28	172.32	142.27	0.40	0.65	160.55
19	205.44	180.17	139.22	0.41	0.62	158.64
20	217.65	179.64	135.79	0.39	0.63	159.29
21	201.42	174.88	138.17	0.37	0.67	165.37
22	204.67	175.94	140.46	0.42	0.64	162.38

5. Classification and Recognition Testing

The experiments chose 4 varieties: Nongda 108, Zhengdan 958, Ludan 981 and Jingdan 28, each 200 maize seeds as feature extraction objects. 14 features of shape and color were extracted by above methods and normalized to create BP neural network, which recognized varieties.

5.1. The Design and Training of BP Neural Network

BP neural network used to classify was divided into three layers: input layer, hidden layer and output layer, the structure of which was shown in Figure 13, [12].

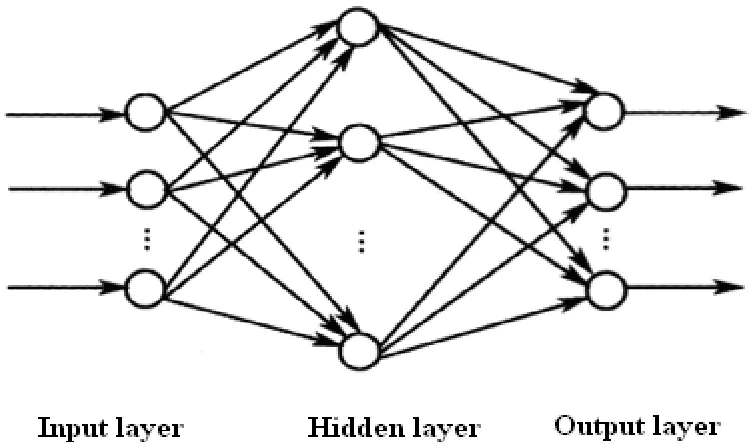

Figure 13. 3-Layer BP Neural Network Structure

There were 14 sets of feature data in input layer and 4 groups of seed type data in output layer, so the initial structure of network was $14 \times n \times 4$; meanwhile, the hidden layers, the node number of hidden layer, activation function, error function and learning velocity considered, finally the structure $14 \times 20 \times 4$ was determined.

5.2. Maize Seeds Classification Testing

Based on above test results, maize seeds recognition test was made using BP neural network created whose training error was 0.05. The test objects were newly-selected 4 species, each 50 maize seeds. It must be pointed out that the test data should be inconsistent with the sample data used for training; otherwise, the testing results were always satisfied.

The testing results were shown as Table 3.

Table 3. The Recognition Results of 4 Maize Species with BP Neural Network

Maize species	Total number	Correct recognition number	Error recognition number	Correct recognition rate (%)	Error recognition rate (%)
Nongda 108	50	46	4	92.0	8.0
Zhengdan 958	50	48	2	96.0	4.0
Ludan 981	50	49	1	98.0	2.0
Jingdan 28	50	46	4	92.0	8.0
Sum	200	189	11	94.5	5.5

Table 3, showed different maize species had different recognition accuracy, the lowest of which was 92.0%, the highest was 98.0% and the average was 94.5%.

5.3. Discussion

1) The characteristic parameters defined in this paper are not in complete accord with those in references, such as the minimum external rectangle, but experiment shows the characteristic parameters defined are effective for recognition of maize seeds.

2) Most of Ludan 981 seeds are generally characterized by high saturation and prominent color features, so the accurate recognition rate is higher; however, the morphology and structure of Nongda 108 seeds is similar to Jingdan 28 seeds', so the recognition rate is the lowest. The average recognition rate of the experiment is similar to the results of previous studies, but there are differences in individual species [13-14], which should be due to different varieties. In addition, different spreading locations of maize seeds result in the difference of image information collected, which has a certain impact on the identification of maize. It is the same with some literatures' conclusion [1, 15]. Above all, recognition rate in the experiment is high.

3) The structure of BP neural network (the number of hidden layer neurons) has great influence on recognition rate. Using the different neural network for training, the recognition rate is different, so in order to obtain higher recognition rate, it is necessary to do different attempts. To overcome this shortcoming, SVM [16] and K-means clustering analysis [5] are used for classification and recognition in some studies, and experiment shows the recognition rate of SVM is higher than that of BP neural network in the case of too few samples.

4) The selection of feature parameters is not perfect. Searching for other suitable parameters should be the target of further study; meanwhile, the principal component analysis (PCA, principal component analysis) method will be used to transmit from multiple indexes to a few comprehensive indexes [12-14]; principal components original variable will be used to reduce dimensionality and improve the execution rate in order to handle dynamic scenes.

From the experiment, the study has found a more effective method to identify the maize, which is worth further studying.

6. Conclusion

1) A set of relatively complete maize seeds recognition system has been designed.

2) Based on the characteristics of maize seeds and image, the algorithm that could effectively extract features of multi-objects has been proposed. It could effectively extract shape feature and color feature parameters

3) Based on BP neural network, maize species recognition system has been created, in the static condition which could recognize4 species including Nongda 108, Zheng Dan 958, Ludan 981 and Jingdan 28, and the average recognition accuracy was 94.5%.

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