Research on the Shape of Wheat Kernels Based on Fourier Describer

Wei Xiao, Qinghai Li, Longzhe Quan

Research on the Shape of Wheat Kernels Based on Fourier Describer

Wei Xiao[1], Qinghai Li [1,2], Longzhe Quan [3]*

[1] Wenzhou Vocational & Technical College.325035 Wenzhou, P.R.China

[2] Zhejiang industry&Trade Vocational College.325003 Wenzhou, P.R.China

[3] College of Engineering，Northeast Agricultural University. 150030 Harbin, P.R.China

1.68890105@qq.com，2.68890105@qq.com, 3.quanlongzhe@163.com

Abstract. The shape of wheat kernels is one of the most important criterions for quality inspection and grading. This paper has used Fourier describer to describe the three views of wheat shape accurately and has had a counter-construction operation.Also it verified this method for describing the shape, small but complex. Finally, the appropriate characteristic parameters were selected, and the BP-network was used to classify the four varieties wheat kernels. This method deserves a recognition rate of 98%~99%.

Keywords: machine vision; wheat kernel; Fourier describer; pattern recognition; BP-network

1 Introduction

Seed identification, which can keep economic order, increase farmers' income and promote economic growth, is always one important issue in the area of agriculture.They can also help us understand kinds of seeds better. There have been more studies on appearance characteristics of wheat kernels with machine vision at home and abroad, which have gained approving effect [1-6]. However, it was difficult to describe the wheat kernel shape accurately with traditional description methods because the views of wheat shape are too complex. On the other side, traditional description methods need more parameters, which would go against the pattern classification, while the Fourier describer can describe the shape of wheat kernel more precisely with fewer parameters, and set a reliable foundation for the pattern classification.So this paper will classify the four varieties of wheat kernels with the method of Fourier describer.

2 Acquisition of kernel edge coordinates

2.1 Preprocessing of the three-dimensional images of wheat kernel

By using digital image processing techniques, such as image denoising, image segmentation, image transformation and image edge detection, the edges of wheat kernel image can be detected.

Fig.1 The front view of wheat kernel

Fig.2 The side view of wheat kernel

Fig.3 The top view of wheat kernel

Fig.1, Fig.2, Fig.3 have presented respectively the color images, binary images and marginal detection images of each view of wheat kernel. Better marginal detection can set a firm foundation for the follow-up Fourier describer.

2.2 Acquisition of kernel marginal coordinates

At First, before doing Fourier describer of kernel shape, the coordinates on marginal images should be ensured, namely,determining each pixel's position in the images.

$(x\text{-}1 , y+1)$	$(x , y+1)$	$(x\text{-}1 , y+1)$
$(x\text{-}1 , y)$	(x , y)	$(x+1 , y)$
$(x\text{-}1 , y\text{-}1)$	$(x , y\text{-}1)$	$(x+1 , y\text{-}1)$

Fig.4 The relation of every pixel coordinatesin eight connected domains

According to Fig.4, any relational pixel point coordinate can be determined if center pixel coordinates (x, y) were known in eight connected domains. Similarly, nearby pixels coordinates can be identified by the edge of a known pixel coordinate. And so, each pixel coordinates can be obtained.

3 Determination of edge spread vector and phase angle

Spread vector is an indispensable condition for Fourier describer, and phase angle is the essential condition of the counter- construction of kernel shape.

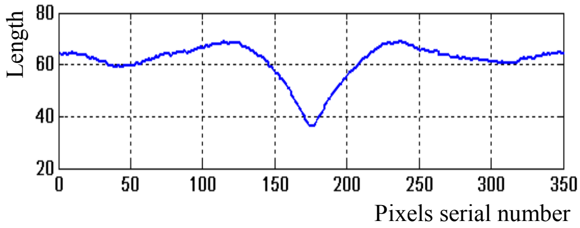

Fig.5 The edge curve of wheat kernel image

We need to calculate the distance from every edge pixel to the centroid and get a length sequence base on the centroid of wheat kernel. That is the unfolded of edge vector (as shown in Fig.5).

$$l_k = \sqrt{(x_k - x^*)^2 + (y_k - y^*)^2} \tag{1}$$

Where: l_k --The distance from the kth edge pixel to the centroid;

x_i, y_i --Every edge pixel's coordinate;

x^*, y^* --The centroid of contour curve of wheat kernel.

The edge pixel coordinates cannot be determined with only the value of l_k when making the counter-construction. The phase angle（θ_k） of every pixel's should also be identified.

$$\theta_k = \arctan(\frac{y_k - y_k^*}{x_k - x_k^*}) \tag{2}$$

4. The discrete Fourier descriptor to the vector of wheat shape

Fourier transformation is a familiar kind of linear transformation, which can simplify the dimensions of 2-D boundary data easily [7].

4.1 The Fourier transformation and countertransformation on the vector of wheat shape

N-D vector of wheat shape can be acquired with its edge, which consists of N pixels, and it is transformed in the way of discrete Fourier transformation:

$$L(\omega) = \frac{1}{N}\sum_{k=0}^{N-1} l_k \exp[-j2\pi\omega k / N] \quad \omega = 0,1,\cdots,N-1 \tag{3}$$

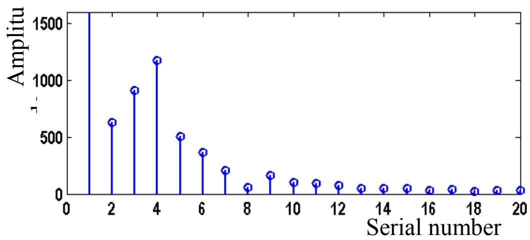

Fig.6 the Fourier transformation sequence of wheat edge curve

In the expression above, $L(\omega)$ is the Fourier transformation sequence of marginal vector. From the Fig.6, we can conclude that major information about the wheat shape was well reflected by the first few larger numbers, rather than the last smaller numbers, which were supposed to the secondary information or noise.

Counter- transformation about $L(\omega)$:

$$l_k = \sum_{\omega=0}^{N-1} L(\omega)\exp[\, j2\pi\omega k / N] \quad k = 0,1,\cdots,N-1 \tag{4}$$

Table 1 Data errors

Error	M=1	M=2	M=3	M=4	M=5	M=6
Front	4.04	2.43	2.34	1.23	0.88	0.73
Size	8.96	8.92	1.89	1.65	0.83	0.73
Top	8.68	8.67	0.95	0.74	8.68	8.67

The marginal vector can be reciprocal converted between length field and frequency domain with the expression (4) and (5). Discrete Fourier transformation is a reversible linear transformation, so there is no information wastage in this process. However, it is unprofitable to describe wheat shape with entire Fourier transformation sequences for pattern classifying. Thus, the wheat shape can be described precisely; characteristic parameters can be simplified by the first few components including larger information. A vector $\hat{l}_k$, similar with l_k, can be obtained with the help of counter- transformation on parts of Fourier transformation coefficients.

$$\hat{l}_k = \sum_{\omega=0}^{M-1} L(\omega)\exp[\, j2\pi\omega k / N]\, k = 0,1,\cdots,N-1 \tag{5}$$

Where: M−− the number of Fourier transformation values.

4.2Counter- construction of kernel shape

A group of proximate edge pixel coordinates vector can be counter –constructed through approximate vector $\hat{l}_k$ and phase angle vector θ_k [7~9].

$$\begin{cases} \hat{x}_k = x^* + \hat{l}_k \cos\theta_k \\ \hat{y}_k = y^* + \hat{l}_k \sin\theta_k \end{cases} \tag{6}$$

Where： $\hat{x}_k, \hat{y}_k$ --proximate edge pixel coordinates

By means of analyzing the level of similarity between (x_k, y_k) and $(\hat{x}_k, \hat{y}_k)$, the describing ability of each component for kernel shape can be represented which could underlie the determination of characteristic model.That can be seen from the Fig.7,Fig.8, the larger the value of M, the better the counter- construction. However, if the value of M is too large, description model will become confused(as shown in Table 1). Thus,according to the specific circumstance, it is necessary to choose the appropriate M value.

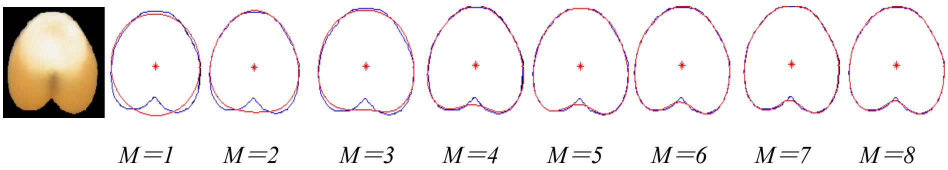

Fig.7 the counter- construction image of wheat in front view image

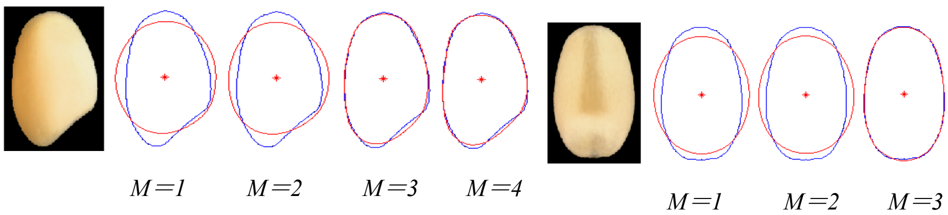

Fig.8 the counter- construction image of wheat side view and top view image

4.3Error analysis of counter- construction of kernel shape

The relationship between error of counter-construction of each M can be figured out through the Fourier describer of 300 wheat kernels' 3-D views of four varieties. According to the research, the average error between similar kernel shape and original one were less than 2 pixels that do not affect the pattern discrimination. Thus, choosing the first four of the Fourier transformation, can describe the front view of kernel shape and serve as the judgment characters. Likewise, the first three were chosen for the side view and so were the top view.

Evaluation mode of 3-D wheat kernel consists of following parts: (1) The first four (f_1, f_2, f_3, f_4) in Fourier transformation of front view image; (2) The first three (s_1, s_2, s_3) in side view image; (3) The first three (t_1, t_2, t_3) in top view image.

5 Examples of application

In this paper, four varieties of 300 wheat kernels (Dong nong99-6501(variety A), Dong97-3821(variety B), Dong97-4056(variety C), Long94-4083(variety D)) have been made pattern classification. Specifically, all varieties of wheat have been classified with the help of BP network method, and characteristic parameters of 3-D shape of wheat kernels have respectively extracted.

5.1 Data normalization

As Table 2 shown, normalized treatment should be taken among these datas, as some orders of magnitude exit in characteristic modes.

$$n_i = \frac{o_i - o_{\min}}{o_{\max} - o_{\min}} \tag{7}$$

Where: o_i — feature data; n_i — normalized data;

Table2 the mean judgment pattern values of four varieties of wheat kernel image

	f_1	f_2	f_3	f_4	s_1	s_2	s_3	t_1	t_2	t_3	out
A	2.255	0.063	0.091	0.118	0.337	0.061	0.679	4.881	0.003	0.01	1
B	2.070	0.047	0.078	0.092	4.387	0.047	0.806	5.144	0.014	0.93	2
C	1.998	0.049	0.127	0.076	4.954	0.036	1.079	5.980	0.016	1.12	3
D	2.174	0.055	0.044	0.093	4.693	0.075	0.809	5.224	0.016	0.91	4

5.2 Network design

With the neural network toolbox in MATLAB, a 3-layer neural network was designed [9]. The input includes 10 neurons and the transfer function is "pureline()". The middle layer contains 15 neurons and the transfer function is tansig(). The output consists 1 neuron and the transfer function is pureline(). The input datas was normalized which belong to each characteristic pattern, and the number 1, 2, 3, 4 are labled as the varieties of wheat kernels in the output datas.

5.3 Network simulation

Take 250 wheat kernels as the training samples, and put them in the course of neural network training, a good effect was achieved (Fig.9). The other 50 wheat kernels serve as test samples that used to test the constructed network. The recognition correct rate of nerve network is presented in the Table 3.

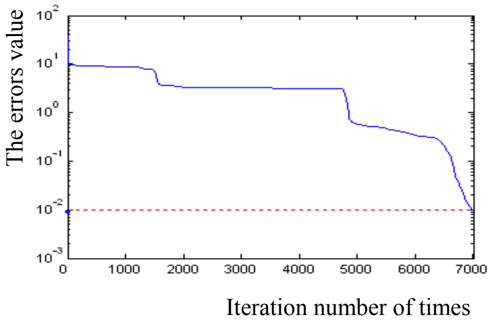

Fig.9 the error curve of BP neural network learning

Table3 The Recognition correct rate of nerve network

Classification Accuracy	A	B	C	D
Training sample	100%	100%	100%	100%
Examination sample	96%	94%	90%	92%
Overall sample	99.3%	99%	98.3%	98.7%

Conclusion

In this paper, the Fourier descriptor was used to further describe the 3-D shape of wheat kernels only with several appropriate characteristic parameters and a satisfactory result was obtained. In particular, the counter-construction of wheat shape was achieved by means of the transformation coefficients of the vector of the wheat.

A better description pattern was determined to discribe the shape of wheat kernels by use of the statistical error analysis, simultaneously, the classification of four varieties of wheat shape was come true by means of BP nerve network.

It is thus clear that, irregular shape of wheat kernels can described precisely by the Fourier describer; meanwhile, it can distinguish the delicate different shape between wheat kernels. What is more, by the use of the counter-construction method, the capacity to describe the wheat shape got a good validation. In conclusion, this method has laid the wide foundation for application in detecting and classifying of grain kinds of agricultural products.

References

1.Yang Jin-Zhong, Hao Jian-Ping, Du Tian-Qing, Cui Fu-Zhu, Sang Su-Ping, 2008. Discrimination of Numerous Maize Cultivars Based on Seed Image Process. ACTA AGRONOMICA SINICA, 34(6): 1069−1073

2. Zha Jianwen, Chen Yongyan. Recognition System for Corn Species by Exterior Parameters, 2004. Transactions of the Chinese Society for Agricultural Machinery, 35(6)：115-118．

3. Cheng F，Liu Z Y，Ying Y B,2005． Machine vision analysis of characteristics and image information base construction for hybrid rice seed． Rice Science，12(1)：13-18．

4. Dubey B P，Bhagwat S G，Shouche S P，Sainis J K，2006． Potential of artificial neural networks in varietals identification using morphometry of wheat grains． Biosyst Eng，95：61-67．

5. Yang G H，Ouyang Y Q，Li X, Luo X N，Wang C L，2006． Primary valuations in morphologic traits of foreign outstanding germplasmsn maize． Seeds，25(9)：100-102．

6. Hao Jian-ping,Yang Jin-zhong, Du Tian-qing, Cui Fu-zhu1, Sang Su-ping, 2008. A Study on Basic Morphologic Information and Classification of Maize Cultivars Based on Seed Image Process. Scientia Agricultura Sinica, 41(4)：994-1002．

7. Ying Yibin, Rao Xiuqin. Application of Machine Vision Technique to Quality Automatic Identification of Agricultural Products[J]. Fundamental and Applied Research, 2000.
8. S.O.Nelson． Dimensional and Density Data for Seeds of Cereal Grain and Other Crops[J]． Transactions of ASAE，2002, 45 (1)：165-170．
9. Wolfnann lurk， et al． Video monitorinn of pulverized coalinjection in blast furnace[J]． IEEE Transactions on Industry Applications．2002，38：571-576．