STUDY ON IDENTIFICATION SYSTEM OF MAIZE SEEDS VARIETIES BASED ON MACHINE VISION

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Abstract: This paper systematically studies maize seeds varieties identification technology and algorithms using advanced machine vision technology. A multi-object contour extraction algorithm adapting to maize seeds varieties identification was proposed. Geometric features and color features parameters of maize seeds were defined and analyzed, and a multi-object geometric features and color features extraction algorithm is realized. Maize seeds image processing strategies and varieties identification algorithms, which is based on the machine vision, is optimized. The precision and speed of maize seeds varieties identification is improved. Through maize seeds varieties identification test on four species including Nongda 108, Ludan 981 and Zhengdan 958, identification accuracy is more than 95%.

Key words: machine vision, multi-object, feature extraction, maize seeds, variety identification

1. INTRODUCTION

Artificial identification has great limitations because it is affected by various factors. Variety identification and quality inspection of corn and other cereal seeds using machine vision instead of the human vision is an inevitable trend of achieving detecting agricultural products automatically and intelligently because it has the merits such as real-time, efficiency, objective, accuracy and without injury (Cheng et al.,2001; Wang et al.,2003). It can guarantee the seed quality, increase the economic benefits of planting and promote the development of corn planting with high-quality, high yielding and stable yielding. It said regarding the China this kind of large agricultural nation that, has extremely important significance.

In the field of corn kernel detection and identification, Liao K .etc.(Liao K et al.,1994) applied real-time feature extraction algorithms to online testing of maize quality in 1995. Ni B. etc.(Ni B et al.,1997)graded corn kernel according to its size in 1998. H. ENg. etc.(Ng et al.,1998) identified damaged kernel and moldy kernel of maize kernel in 1998. Zhou Yiming and Wang Fengyuan.etc.(Wang et al.,1995) measured and verified the basic shape of corn seeds in 1995. Song Tao and Zeng Dechao(Song et al.,1996) identified integrity and damage of maize kernel by BP network in 1996. Ning Jifeng and He Dongjian.etc.(Ning et al.,2004) identified the tip cap and germ surface of corn kernel in 2002.

The paper puts forward a method of maize seeds varieties identification based on multi-object feature extraction and identification algorithm, and explores a new method of identification and detection for corn seeds based on machine vision.

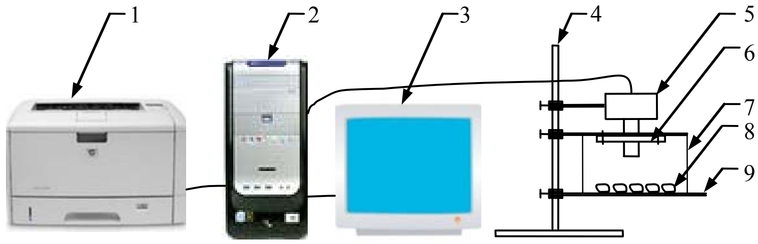
2. MAIZE IDENTIFICATION SYSTEM AND MAIZE VARIETY

2.1 Maize identification system

Maize seeds varieties identification system is mainly composed of hardware system and software system. The hardware system shown by figure 1 is composed of the image acquisition equipment, computer information processing equipment, image information storage devices, image information and results output devices and so on. The software system is developed using VC++ 6.0.

2.2 Maize varieties

Four varieties of maize seeds including Nongda 108, Ludan 981, Zhengdan 958 and Wuyue 18, which are provided by Taian Wuyue Mount Tai Co. Ltd, are selected as test samples in this study. We remove the corn seeds of the two ends of the corn ear and select seeds of morphological characteristics relative standard for research.



1.Printer 2.Computer 3. Monitor 4. Acquisition shelf

5.Camera 6.Lighting source with ring shape 7.Hood 8.Sample 9.Object stage

Fig.1 The diagram of hardware system composition

3. MULTI-OBJECT CONTOUR EXTRACTION

3.1 Image preprocessing

The images of corn seeds acquired are pretreated before varieties identification to get the target images up to the requirements. Image pretreatment process is shown in figure 2. Firstly, JPG images acquired are transformed into BMP images. Then these BMP images are preprocessed including gray scale transformation, median filtering, binary processing, and morphological transformation. Finally, the necessary images are successfully obtained.

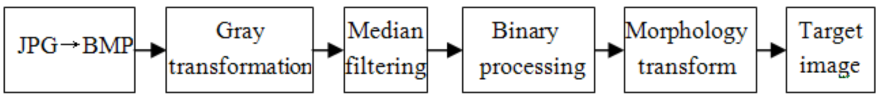


Fig.2 Maize seeds image preprocessing

3.2 Multi-object contour extraction

The traditional contour extraction of images is generally single-object contour extraction and only the single-object contour is tagged and extracted. However, contour extraction and marking of multiple seeds must be simultaneously resolved in this maize seeds varieties identification system, namely multi-object contour extraction.

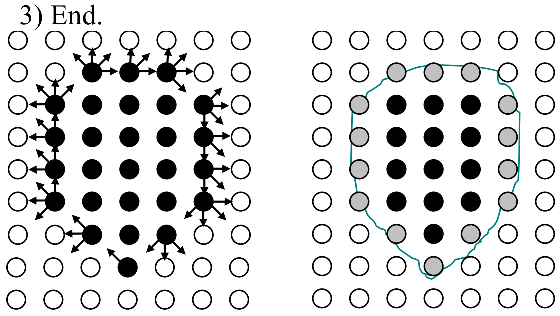
The key problem of multi-object contour extraction is contour decision of objects. That is, multi-object contour extraction.

The basic idea of multi-object contour extraction is:

1) Traversing image. Enter contour tracking if a target point is found, which is shown in figure 3, and then transfer to step 2) after the contour tracking is completed; If the images traversing complete and does not find target point, then transfer to Step 3);

2) The contour tracked completely is vector tagged. Then transfer to Step 1);

3) End.



(a) (b)

Fig.3 Diagram of contour following algorithm

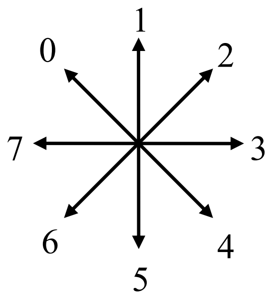


Fig.4 8-connected chain code

In order to convenient for marking the contour, we define 8-connected chain code shown in Figure 4 and establish the xy coordinate deviation of center point and bordering points according to 8-connected chain code in this paper, as shown in table 1.

Table.1 The coordinate deviation of center point and bordering points

Chain code value	0	1	2	3	4	5	6	7
X coordinate deviation	-1	0	1	1	1	0	- 1	- 1
Y coordinate deviation	1	1	1	0	- 1	- 1	- 1	0

To complex contour, it's difficult to accurately determine the region within their borders only using the value of chain code. We solve the problem using the algorithms of vector tagging in this study. The direction of the vector used is from left to right in horizontal direction. We transform the value of chain code of border points according to this direction. Method of conversion is:

If the boundary point is intermediate point of the vector, its value is 0.

If the boundary point is left endpoint of the vector, its value is 1.

If the boundary point is right endpoint of the vector, its value is 2.

If the boundary point is singular point of the vector, its value is 3.

For the contour of figure 5 (a), if it is represented as 00111233455566 beginning from the low-end clockwise using chain code, only the borders of the target region rather than the region within the borders can be expressed and marked. If it is represented as 31111110222222 beginning from the low-end clockwise using the algorithm of vector tagging from left to right, the target area can be represented with seven vector line segments. The target border and the target region within the border which is illustrated in figure 5(b) can be accurately determined. When this method applied to complex contours, the target border and the target region within the border can also be accurately and quickly determined, as shown in figure 5(b).

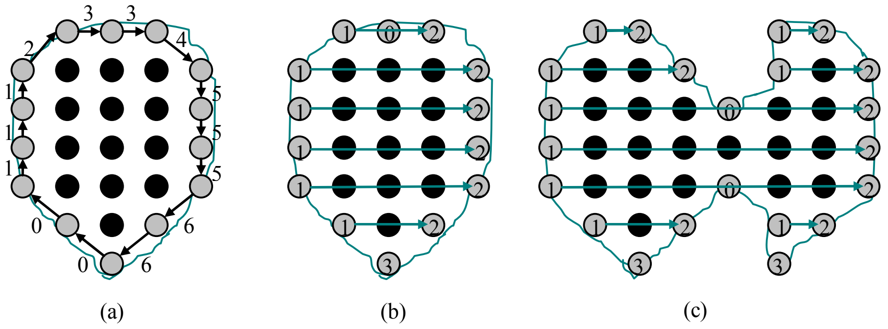


Fig.5 Description of regional contour

For the realization of multi-object contour extraction, a maize seed data linked list is built in this system. The data of each maize seed is stored in the seed data linked list including contour serial number, contour points, coordinate and serial number of each point, coordinates of starting point, adjacent 8-connected chain code, geometric parameters and color parameters of the contour. Multi-object contour extraction is better realized and the implementation of procedures is improved more efficiently by using this data structure. It makes preparation to multi-object feature extraction algorithms.

4. MULTI-OBJECT FEATURE EXTRACTION

4.1 Geometric features extraction

This paper puts forward an algorithm of multi-object feature extraction on the basis of multi-object contour extraction. This algorithm can accomplish feature extraction of many maize seeds on the image by one time without segmenting a group of seeds into many single seeds and improve the speed and efficiency of feature extraction of maize seeds.

Table 2 shows parts of the geometric feature parameters of two varieties maize seeds Nongda 108 and Zhengdan 958.

Table.2 Geometric feature parameters of maize seeds

Geometrical feature	Nongda 108 mean value	Nongda 108 mean-variance	Zhengdan 958 mean value	Zhengdan 958 mean-variance
Contour point number	469.5	21.9	573.2	25.3
Circumference	540.1244	23.57045	664.3753	28.65179
Area	19307.53	1570.919	28368.15	2527.147
The length of long-axis	170.8197	10.97938	226.2442	12.68391
The length of minor-axis	149.7795	11.73738	160.4947	11.31505
Maximum inscribed circle radius	70.28177	3.791605	80.40652	4.961622
Minimum circumscribed circle radius	87.96963	4.807754	115.2072	6.192502
Largest span	173.4634	10.37519	228.6176	12.27242
Equivalent diameter	156.6637	6.324111	189.8631	8.496643
Shape parameter	1.204634	0.039336	1.24148	0.04112
Roundness	1.254113	0.080681	1.436738	0.098116
Elongation	1.148843	0.131217	1.41609	0.122134
Compact ratio	0.91934	0.045075	0.840439	0.035888

4.2 Color feature extraction

The color of maize seeds is an important index to reflect the development and variety of maize seeds, meanwhile, the specific gravity difference of maize seed color components can provide references for maize seed identification and detection. In order to extract and describe the color information in the maize seed images more precisely, this paper also studies H (Hue), S (Saturation), I (Intensity) and other information in the HSI color space.

In order to quantitatively describe the color information of maize seeds, the paper defined 18 color features namely ΣR (Red), R-mean, R-standard deviation, ΣG (Green), G-mean, G-standard deviation, ΣB (Blue), B-mean, B-standard deviation, ΣH (Hue), H-mean, H-standard deviation, ΣS (Saturation), S-mean, S-standard deviation, ΣI (Intensity), I-mean and I-standard deviation. Based on many data analysis, the paper chooses the color features of the most stable part in the maize seed. Shown in figure 6, the areas which are extracted color features are filled with white. Table 3 shows the color feature parameters of Nongda 108, Zhengdan 958 and Ludan 981.

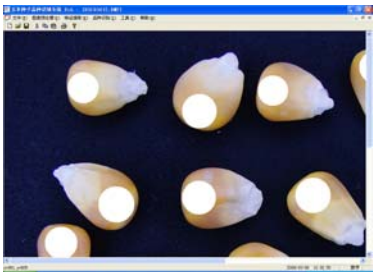


Fig.6 The color feature extraction of Zhengdan 958

Table.3 Color features of maize seeds

Color feature	Nongda 108 mean value	Nongda 108 variance	Zhengdan 958 mean value	Zhengdan 958 variance	Ludan 981 mean value	Ludan 981 variance
$\sum R$	785766.67	120701.33	1394376.45	187810.48	887345.55	130202.78
$\overline{R}$	223.46	7.277	216.88	10.143	209.42	6.717
S_R	5.771	2.762	7.176	3.845	6.324	2.132
$\sum G$	677409.62	104040.56	1145201.25	159049.50	756739.1	108232.05
$\overline{G}$	192.82	11.890	178.06	9.720	178.67	8.543
S_G	7.979	3.368	10.213	4.096	8.756	2.710
$\sum B$	448421.55	118367.10	841963.54	162325.84	556435.08	117621.73
$\overline{B}$	128.03	30.943	130.84	20.136	131.42	22.444
S_B	32.928	10.874	23.344	8.468	23.702	6.353
$\sum H$	2874.57	1534.86	4174.06	1874.997	3252.41	1965.24
$\overline{H}$	0.830	0.493	0.658	0.328	0.782	0.534
S_H	0.393	0.634	0.362	0.586	0.529	0.727
$\sum S$	1111.05	476.21	1685.89	542.443	1066.48	397.29
$\overline{S}$	0.315	0.123	0.263	0.080	0.252	0.088
S_s	0.138	0.0880	0.0357	0.0316	0.0633	0.0878
$\sum I$	636033.77	100661.19	1125079.91	157328.54	732112.75	109220.28
$\bar{I}$	181.605	14.069	175.432	10.981	173.323	10.270
S_I	14.393	12.573	11.978	4.9998	4.985	3.132

5. VARIETIES IDENTIFICATION

As the individual differences of corn seeds and the complexity of its own form, there are certain cross-cutting issues in the demographic characteristics of the different species of seeds. it is difficult to use conventional mathematical model or method to describe the relationship of characteristics and parameters between different species. Therefore, in order to identify varieties of corn seed, the weighted processing needs to be made to the different characteristics of various seeds, and then the contributions of the different characteristics to different varieties of seeds need counting and analyzing. Finally, the characteristics data and statistical data of various corn seeds will be saved to the feature library. After analysis of test, the species identification classifier of maize seed is established, to identify seed through the classifier, as shown in Figure 7.

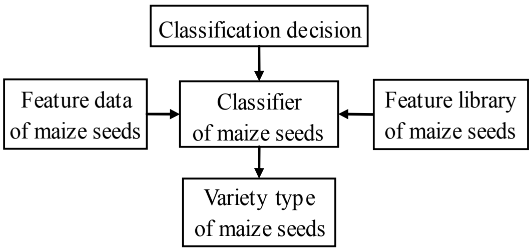


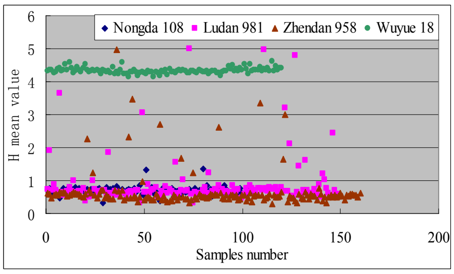
Fig.7 Diagram of maize seeds varieties identification

(1) Normalization processing is done to the various feature parameters of maize seeds. That is, the ratio of various parameters and the average of maize seeds.

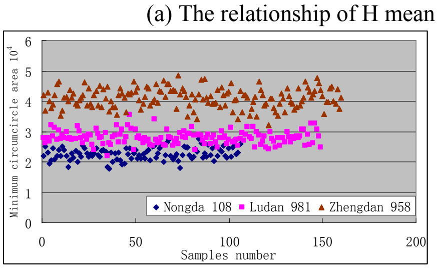
(2) After analyzing the test, the weights of various feature parameters are determined. We identify varieties of maize seeds with the following formula:

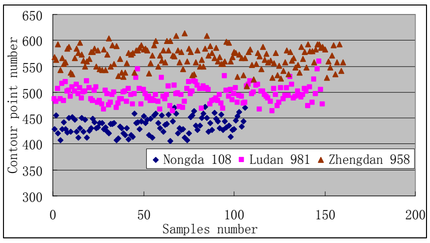
$$K= k_1Cp^* + k_2P^* + k_3A^* + \ldots + k_{32}\Sigma I^* + k_{33}\bar{I}^* + k_{34}SI^* \qquad (1)$$

Cp^*, P^*, A^*, …, ΣI^*, $\bar{I}^*$, SI^* are the normalized parameters of a certain maize seed , k_1 , k_2 , k_3 ,…, k_{33} , k_{34} are the weights of corresponding parameters, and $\Sigma k_i = 1$. When meeting $K \geqslant 0.8$ and meeting the analysis of figure 8, it is the maize seed of this variety.



(a) The relationship of H mean value of four varieties maize seeds





(b) The relationship of the minimum circumcircle area of three varieties maize seeds

(c) The relationship of contour point number of three varieties maize seeds

Fig.8 Classification foundation of four kinds of maize seeds

Using the varieties identification classifier, the test of single variety identification and mixed varieties identification are done to four varieties maize seeds including 106 tablets of Nongda108, 150 tablets of Ludan981, 160 tablets of Zhengdan958 and 120 tablets of Wuyue18, the identification accuracy are 96.23%, 95.33%, 98.13% and 100% separately, as shown in table 4.

Table.4 Results of varieties identification of 4 varieties maize seeds

Samples	Nongda 108	Ludan 981	Zhengdan 958	Wuyue 18
Sample sizes (grain)	106	150	160	120
Classification features	Contour point number	Minimum circumscribed circle area		H mean value
Threshold values	462	340000		4.00~4.76
Correct identification (grain)	102	148	159	120
Error identification (grain)	4	2	1	0
Recognition accuracy (%)	96.23	98.67	99.38	100
Comprehensive correct identification (grain)	102	143	157	120
Comprehensive Error identification (grain)	4	7	3	0
Comprehensive Recognition accuracy (%)	96.23	95.33	98.13	100

6. CONCLUSION

The results show that, the proposed multi-object contour extraction algorithm and multi-object feature extraction algorithm of maize seeds based on machine vision are very effective in identifying maize seeds varieties. It is feasible to identify and detect maize seeds varieties using machine vision, meanwhile, the method can be extended to other granular agricultural products in the fields of online identification and testing.

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