Cereal Grain Size measurement Based on Image Processing Technology

Yong Wu and Yi Pan

***Abstract*—In older to measure the cereal grain size rapidly and objectively, a measurement method based on digital image processing technology was proposed. Firstly, the grain images acquired by a scanner were preprocessed by using the methods of image enhancement and morphological reconstruction. Then 2D Otsu was used to segment the image. Finally, through image analysis technology the grain size parameters were measured, including grain number, area, size, roundness and size distribution etc., the experiment results show that the image measurement method has advantages of accuracy and high efficiency.**

I. INTRODUCTION

CEREAL grain size is an important evaluation index for food quality which has great significance in cereal products classifying, pricing and processing. There are many methods for grain size measurement such as the caliper method, sieving, sedimentation analysis and laser particle size analysis etc. However, these traditional measurement methods generally require larger artificial labor, additionally, they have disadvantages of being time-consuming, complex, low accuracy and may easily affected by subjective factors. Although the laser particle size analyzer can be accurate, its measuring range reach to micro-level and the measurement cost high, therefore, it is inapplicable to popularize the fast cereal grain size measurement[1].

With the development of computer image processing technology, by combining the image acquisition devices, the grain size measurement based on image processing technology is of feasibility and practicality. It has been successfully used in the fields of materials, medicine, chemical industry, construction and so on. Meanwhile, many researches on cereal grain have been made. M. Berman explains the 38 kinds of wheat flour yield deviations correctly by extracting the grain size, axial length of the maximum and minimum size, elliptical area and quality[2]; Guiping Wu et al use the image processing method to detect the broken rice rate[3],found that the result have good correlation with the manual methods which demonstrated the feasibility of the method; Peng Jia et al make a research on the grain counting methods based on Matlab image technology. It make up for the shortcoming of manual method and photoelectric method, but it is still confined to grain counting[4].At present, researches on the determination of cereal grain based on image method is still relatively scarce. This paper presents a cereal grain size measurement method based on image processing, measuring the cereal number, area, size and size distribution etc parameters so that the grain quality can be evaluated more correctly.

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II. EXPERIMENTAL METHOD AND IMAGE ACQUISITION

Cereal grain image analysis system consists of computer, scanner and monitor as shown in figure 1. General configuration of the micro-computer can meet the experiment requirements. In this paper, we adopted a BENQ 5560 scanner with resolution between 300 ~ 2400dpi. When the grain image analysis system was prepared, some samples of cereal grain were placed on the scanner's sample stage. In order to reduce the complexity of image segmentation and improve the measurement accuracy, the grain sample should not contact with each other. Computer is used to process the grain image and calculate related data, the results displayed on the monitor and can be easily stored, copied and printed.

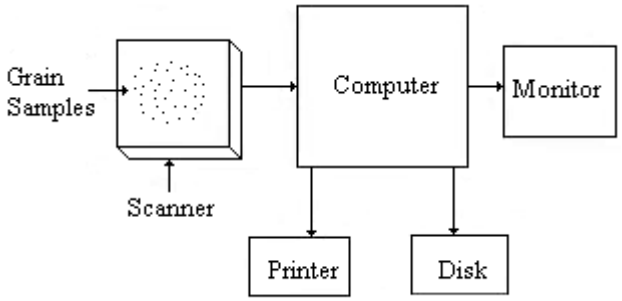


Fig. 1. Cereal grain image analysis system

The flowchart of image process is (see figure 2) : acquisition of digital images by scanner, then performing image enhancement, morphology reconstruction and image segmentation to create a binary image, next analyzing the binary image and measuring grain parameters.

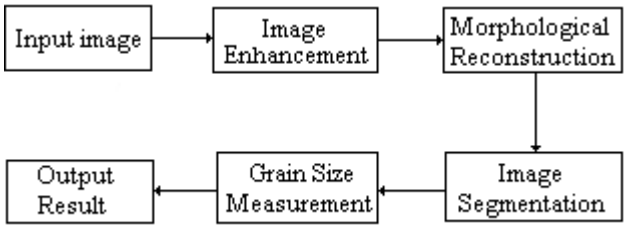


Fig. 2. Cereal grain image measurement flowchart

III. CEREAL IMAGE PROCESSING

A. Image Preprocessing

By using gray level transformation, the original scanning cereal images were transformed into gray images. However, they were still not suitable for image segmentation. On the one hand, a dirty glass surface of scanner or uneven illumination will affect the image quality; on the other hand, grain image grayscale distribution is relatively concentrated and the contrast was poor. Therefore, the image must be preprocessed.

Firstly, the image should be smoothed to eliminate the noise. Median filter has the excellent ability of noise reduction and details protection, it can be used to meet the experiment requirements.

Secondly, the grain image should be enhanced. The image smoothing processing can remove some noise, but it will blur the cereal grain contour edge at the same time which is not conducive to subsequent image segmentation. With the purpose of highlight the grain edge better, further image enhancing is necessary. This paper used the power law transformation to improve the contrast between cereal and background image. Its basic form is:

$$s=cr^{\alpha} \tag{1}$$

In the formula, r is the input gray level and s is the transformed gray level, c and α is positive constants. Adjusting the value of c can change the gray scale range while adjusting the value of α can change the contrast of interested region.

Finally, smoothing the cereal grain image with open and close reconstruction filter. Since the surface of cereal is not smooth, the differences in cereal image grayscale is obvious. Gray image morphological open-close operation can smooth the bright and dark details in grain cereal image, where, the bright detail is cereal grains and the dark detail is the background. open-close reconstruction operation has advantages of maintaining shape and characteristic of grain image, that is, it doesn't affect the grain image outline, furthermore, it has very good performance on removing noise and correcting uneven illumination.

Morphological open-close reconstruction operation is based on dilation and erosion arithmetic. Postulate a given image is f, the reference image is x, the structural element is b, $\cap$ denotes pointwise maximum and $\cup$ denotes pointwise minimum, then $\oplus$, Θ denote dilation and erosion operation respectively ; $\circ$, $\bullet$ denote opening and closing operation. Expansion reconstruction operation is defined as[5]:

$$\begin{cases} Dx^{(\mathrm{rec})}(f)=\delta_{\mathrm{x}}^{+\infty}(f) \\ \delta_x(f)=\cap(f\oplus b,x) \end{cases} \tag{2}$$

Corrosion reconstruction operation is defined as:

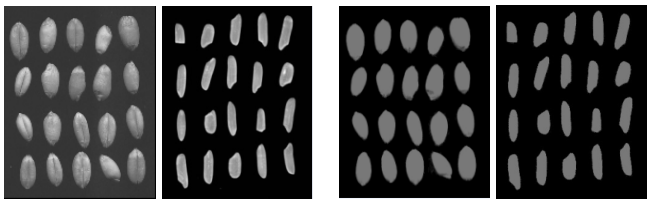
$$\begin{cases} E_x^{(rec)}(f)=\varepsilon_x^{+\infty}(f) \\ \varepsilon_x(f)=\cup(f\Theta b,x) \end{cases} \tag{3}$$

morphological open-close operation reconstruction is defined as:

$$O_x^{(rec)}(f)=D_x^{(rec)}(f\circ b,x) \tag{4}$$

$$C_x^{(rec)}(f)=E_x^{(rgc)}(f\bullet b,x) \tag{5}$$

Where $\delta_{\mathrm{x}}^{+\infty}(f)$, $\varepsilon_x^{+\infty}(f)$ denote unlimited expansion and Corrosion iterative reconstruction. Through denoising, gray-scale transformation and morphological open-close reconstruction etc. series of pretreatment, the cereal grain image is shown in figure 3.



a. Original image b.After preprocessing

Fig.3. Cereal grain image after preprocessing

B. Image Segmentation

The accuracy of cereal grain size measurement largely depends on the effect of image segmentation, the target image segmentation must accurately reflect the cereal grain size information. Threshold technique is one of the simple and effective segmentation methods, and the method of maximum between-cluster variance (Otsu) is suitable for cereal image with obvious bimodal characteristics. One-dimensional Otsu method is susceptible to noise leading to errors segmentation, this paper introduced a two-dimensional Otsu algorithm [6]–[7],the algorithm is not only make full use of the image pixel information but also consider the pixel and its spatial neighborhood relevant information, its segmentation result is better.

Postulating $M \times M$ image gray level is L, gray distribution from 0 to L-1, $f(m, n)$ is the image pixels, (m, n) is the image coordinates, M is the image size and N is a square area of the window width, neighbor average gray level $g(m, n)$ of the pixel $(m, n)$is defined as:

$$g(m,n)=\frac{1}{N\times N}\sum_{i=-(N-1)/2}^{(N-1)/2}\sum_{j=-(N-1)/2}^{(N-1)/2}f(m+i,n+j) \tag{6}$$

Obviously, $0<g(m, n)<$L.

The two-dimensional histogram was defined in the size of a $L \times L$ square region, The horizontal axis represent the image pixel gray value, the vertical axis represent pixel neighborhood average gray, $f(x, y)$ and $g(x, y)$ forming the binary group denote (i, j), n_{ij} is the frequency, the probability occurrence at any point of the histogram is P_{ij} the formula is:

$$P_{ij}=\frac{n_{ij}}{M\times M} \tag{7}$$

Where, $0\le i,j\le L$-1, $\sum_{i=0}^{L-1}\sum_{j=0}^{L-1}P_{ij}=1$.

If (s, t) is the selected threshold point, two-dimensional histogram is divided into four region which shown in figure 4. Among them, the two diagonal regions Ⅰ and Ⅱ correspond to the background and objectives, the region Ⅲ and Ⅳ away from the diagonal correspond to the edge and noise. The

segmentation algorithm of 2D Otsu method will not go into details here, readers may refer to [6].

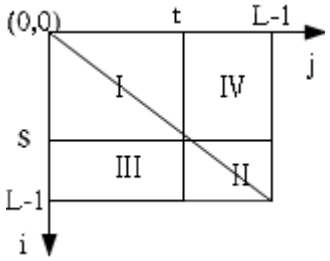
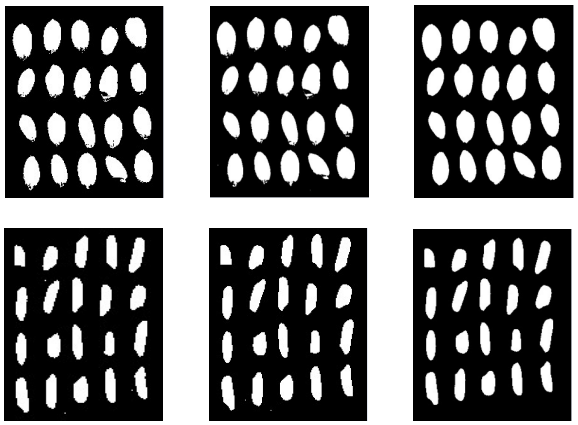


Fig.4. Two-dimensional histogram region

Using 2D Otsu method to segment the cereal grain image after preprocessing can get a better result. Comparing to the traditional Otsu and 2D Otsu method, it has lower segmentation error rate and can reflect the cereal grain size information more accurately, comparison of the results shown in figure 5.



a. Otsu algorithm b.2D Otsu algorithm c. this paper method

Fig.5. Comparison of image segmentation results

IV. Cereal Grain Size Measurement

A. Size Calibration

Digital image is consist of a certain number of same size square pixel,in this paper, grain size is calculate by pixel. Scanning the standards graduated scale with the same resolution as scanning cereal grain image, using the ratio of standard size and the image pixels to calibrate the grain image size. When the proportional coefficient is determined, we can calculate the actual size of cereal grain.

B. Grain Parameter Measurement

(I) Grain Counting: The image have turn into binary image after segmentation ,the pixel only has two values ,that is 1 and 0 which represent target and background respectively. As the pixel of cereal region is continuous, performing the feature of connectivity, Through calculating the number of connected graph to calculate the number of grain [4].

(II) Grain Area and Perimeter: Its area means the vertical projection area of grain which can be calculated through the total pixel of objectives graphics, according to which we can obtain the corresponding equivalent area circle diameter $d=\sqrt{4S/\pi}$, this paper defines it as grain size. Extracting the number of the boundary points as the perimeter, in order to reduce the specific error of the digitizing image, the pixel incline to the horizontal or vertical direction 45 °should be multiplied by $\sqrt{2}$ for calibration.

(III) Feret Diameter: the distance of outer parallel tangent of grain, its define is shown in figure 6. the maximal ferret diameter is the length of the cereal grain and the minimal ferret diameter is the width of the grain.

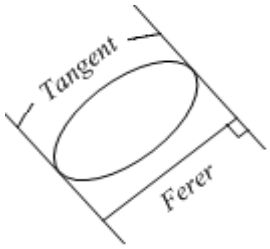


Fig.6. Feret diameter define

(IV) Roundness: That is the circular degree of the cereal grain, defined as: $m = 4\pi S/P^2$, if grain shape closer to round, its value is closer to 1,on the contrary, m is close to 0.In the formula， S and P represent the cereal grain area and perimeter respectively.

V. Grain Measurement Results and Analysis

In this paper, we took wheat and rice for example, each collecting about 98 samples to measure their relevant parameters. The image processing and grain measurement was completed by Matlab, grain size measurement statistical results are shown in table 1 and table 2.

TABLE I
GRAIN SIZE MEASUREMENT STATISTICAL TABLES OF WHEAT

Diameter Range/mm	Num-ber	Area mm^2	Perime-ter/mm	Length mm	Width mm	Round-ness
4.0~4.4	7	14.41	16.68	6.38	3.95	0.65
4.4~4.6	18	15.87	17.64	6.63	4.09	0.64
4.6~4.8	26	17.39	18.04	6.76	4.13	0.67
4.8~5.0	33	18.76	18.53	6.94	4.25	0.69
5.0~5.4	14	20.37	19.62	7.16	4.33	0.67

TABLE 2
GRAIN SIZE MEASUREMENT STATISTICAL TABLES OF RICE

Diameter Range/mm	Num-ber	Area mm^2	Perime-ter/mm	Length mm	Width mm	Round-ness
3.3~3.6	5	9.41	13.40	4.72	1.98	0.66
3.6~3.8	10	11.00	14.97	5.33	2.27	0.62
3.8~4.0	36	11.97	15.80	6.20	2.52	0.60
4.0~4.2	39	13.18	17.54	7.13	2.53	0.54
4.2~4.5	8	14.54	18.50	7.38	2.59	0.53

From the table 1 and table 2,we can know of the grain size, size distribution and morphology etc parameters clearly. The grain size distribution of wheat grain is more uniform than that of rice, the vertical projection area of wheat grain is bigger, cereal grain shape close to oval, about 79% of the wheat grain size distribution is in the range of 4.3mm ~ 5.0mm; The shape of rice is not so regular, the majority of them is long grain shape, about 86% of the rice grain size distribution in the range of 3.6mm ~ 4.2mm. grain size distribution can be more intuitive to see from the grain size distribution histogram ,it is shown in figure 7.

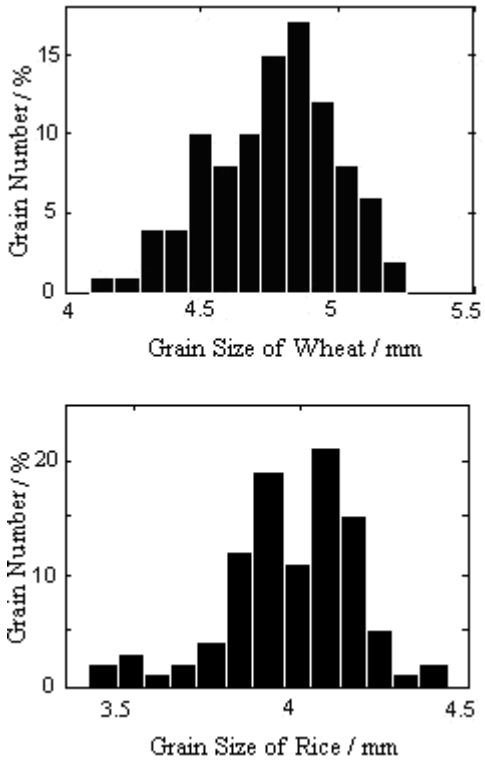


Fig.7. Grain size distribution histogram

In order to verify the feasibility of measuring grain size of image technology method , we use it and the caliper method to respectively measure the largest sample of cereal grain ferret diameter (that is grain length), linear regression analysis for measurement results are shown in figure 8.

It is show that the result of image method and the caliper method have good correlation, for the measurement of wheat grain, its fitting relation is:

$$y_w = 0.8345x_w + 1.1234 \quad (8)$$

For the measurement of rice grain, its fitting relation is:

$$y_r = 0.97x_r + 0.0652 \quad (9)$$

Where x is caliper measurement result and y is image measurement results, we can learn from the figure 8 that the correlation coefficient square (R^2) of fitting formula are 0.9406 and 0.9862, this two methods show a notable correlation, and we can calculate the relative error of the image method is less than 2%,which proved the feasible of the cereal grain size measurement of image method.

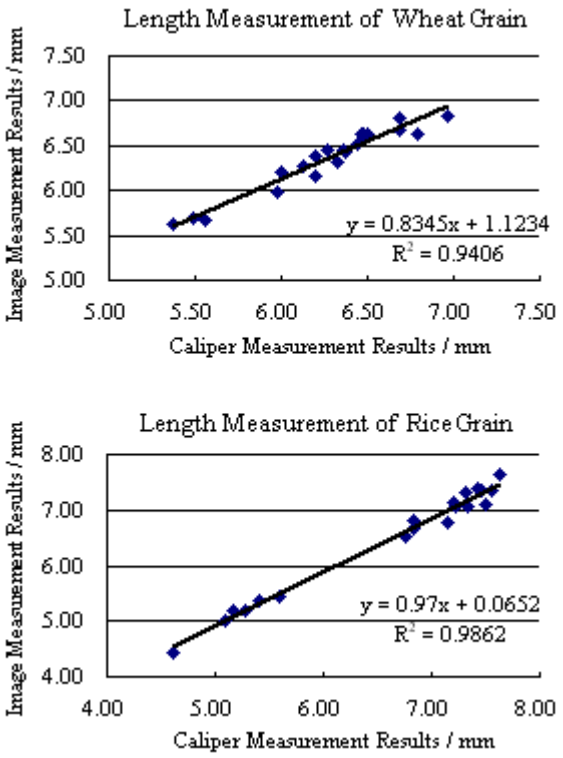


Fig.8. Image Method and Caliper Method Measurement Results

VI. CONCLUSION

Using digital image processing techniques as a means of cereal grain research make it more intuitive and easy to measure the grain size so that we can make a better accurate assessment for the cereal grain quality. This methods show a great potential, on how to reduce the measurement error of grain image and increase the degree of automation of grain size measurement technique is still need further research.

REFERENCES

[1] D. H. Wang, X. Y. Huang , Z .Liu and Z. F. Chen ,"Microphotograph granularity examination system research," *Mining and Metallurgy*,vol. 17, no.2, pp. 114–116,Jun.2008.

[2] M.Berman, M.L.Bason, F. Elison, G. Peden and C.W. Wrigley, "Image analysis of whole grains to screen for flour milling yield in wheat breading," *Cereal Chemistry*, vol.73,no.3,pp.323–327, Apr.1996.

[3] G.P.Wu,E.B.Shen and H.W.Yang, "Accuracy analysis of rice broken rate detection based on digital image method," *Journal of the Chinese Cereals and Oils Association*,vol.24,no.10,pp.94-97, Jun .2009.

[4] P.Jia,Y.K.Li and P.Zhao, "Grain counting method based on Matlab image processing," *Journal of Agricultural Mechanization Research,* no.1,pp.152-153, Jan .2009.

[5] Q. B. Shen, W. Wu , X. M. Yang and X. H. He, "Detritus image segmentation using watershed transformation," *Journal of Computer Applications*,vol.29,no.10,pp. 2859-2861,Otc.2009.

[6] X. J. Jing, A. N. Cai, J. A. Sun, "Image segmentation based on 2D maximum between-cluster variance", *Journal of China Institute of Communications*,vol.22,no.4,pp.71-76,Apr.2001.

[7] Y.S. Jiang, X.L.Song, J.J.Ren, "2D Otsu algorithm improvement based on genetic algorithm", *Application Research of Computers*, vol. 27,no.3,pp. 1189-1191, Mar.2010.

[8] Z.B.Sun, J.R.Cai and S. Jiang, "Application and research on the measurement of grain size of food using image processing," *Food Research and Development* ,vol.26,no.6,pp.164-166,Aug.2005.