The Appropriate Algorithms of Image analysis for Rice Kernel Quality Evalution

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Abstract

A computer vision system is developed for evaluating the quality of rice kernels. The image processing algorithms are developed and used to extract features for touching kernels. The touching kernel features consist of two forms of touching: point and line touching kernels. The shrinkage operation can separate touching features in image without loosing the integrity of a single feature. Object recognitions are applied to the line touching feature. Area, perimeter, circularity and shape compactness are used as criterions for classifying the broken rice and long grain rice. In addition, the method of Fuzzy logic is used to organize and classify the class of each kernel. The experiments give that correct results in evaluating the quality of rice kernels are obtained in 90% cases compared with human inspection.

Keywords: Computer vision, Rice kernel quality evaluation, Rice variety

1. Introduction

Rice is an important staple food in the world. Samples of rice are generally inspected before a rice mill or rice banks buy paddy from farmers in order to decide the quality of rice. Some key factors deciding the quality of rice is the percentage of broken rice and adulteration with contamination. Currently, the quality of rice has been determined subjectively and manually through a visual inspection by human. The results, sometimes, may not be reliable due to human errors or inexperienced technicians. Moreover this manual inspection is complicated and time consuming. Therefore a quick and more reliable rice quality evaluation system is need. There have been many studies on use of image processing techniques for grain quality inspection. For example, the quality factors evaluation of corns and soybeans,[1], the measuring degree of rice milling[2], shapes analyzed of brown rice and polished rice[3],the qualification of fifteen Indian wheat varieties[4], the developing of an automated kernel-positioning device[5].

Recently, an automatic kernel handling system is developed for singularize grain kernels to present to the image-processing unit [6].

From the analysis of previous research it can be found that almost of researchers studied and worked on separated kernel. There need to design machine for singularized kernels to be placed in certain direction and position. Therefore, we would like to propose an automatic vision based algorithm to segment the touching kernels and to calculate the features of the segmented rice grain kernels

2. Rice Samples

Thai Jasmine rice (Pathumthani1) which has to have slender kernels, translucent, clear kernels and natural fragrant aroma characteristic, jasmine rice is classified as long kernel rice which have average length 5-7 mm. is selected for analysis in this research.

3. Image Acquisition System for Rice Kernel Classification

A three chip charge couple device (CCD) color camera (TK C1484 BEG, JVC) is used for image acquisition, providing image resolution of 752×582 pixels, Each colorimetric component is quantized into 256 levels. A zoom lens (TG 3Z3510, Computar) of 3.5 to 10.5 mm is fitted to the camera. The iris is selected for white balancing before each image session. The video signals (RGB) from the camera are converted to color digital image by a frame grabber board (DT 3120, Data Translation Inc.) The camera is mounted at the top of the illumination chamber. Working distance from the lens to the rice kernels is set to 500 mm. Images are converted to square pixel with 0.1876 mm./pixel (0.0352 mm^2/pixel). The camera captures images of objects in the illumination chamber. The back light source consists of two 50 W quartz halogen lamps with 6mm. thick piece of frosted glass to diffuse the light. A variable rheostat is used to vary the light intensity. All the vision algorithms are implemented using Microsoft Visual C++ 6.0 Language.

Image analysis is carried out on a Pentium 4 personal computer

2.2 Image Processing

Image processing algorithms consist of the following five steps as shown in Figure1. Rice kernels are randomly placed on the black background in one layer for image acquisition. Images are acquired and stored for further analysis. In the first pre-processing step image registration and noise removal is carried out. In second step we run Shrinkage algorithm for segmenting touching rice kernels. In the third step we perform edge detection. In the forth step rice grain feature vectors are calculated and in the fifth step rice classification is performed using fuzzy rules.

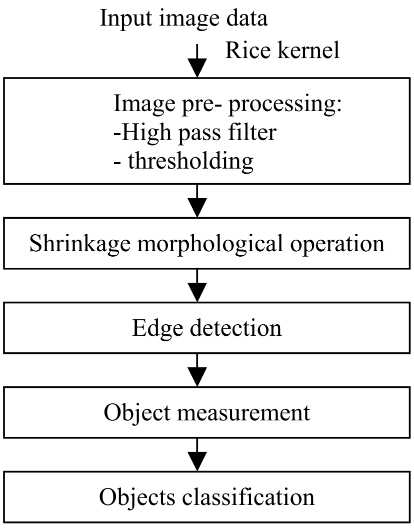


Figure 1. Flow diagram of image processing algorithms

4.1 Image Pre-Processing

We capture color images and save in the three dimensional RGB (red, green, blue) color space (pixel resolution of images are 270,400). High pass filter is applied to reduce noise from uneven illumination during image acquisition. High pass filter sharpens image by using convolution. We use a 3×3 mask for high pass filter as shown in equation (1)

$$\text{Mask of high pass filter}=\begin{bmatrix} 0 & -1 & 5 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix} \qquad (1)$$

Threshold algorithm is used to segment the grain kernels from the black background. We select threshold level through segmentation of kernel from background. For this research the suitable threshold level is found to be 120(in 0-255 scale).

4.2 Shrinkage Operation Algorithm

We randomly place and spread the kernels in one layer. It can be see that kernels are not pointing in specific directions. Moreover some of kernels are touching each other. We can classify the amount of touching into two types: point touching (Figure2) and line touching (Figure3).

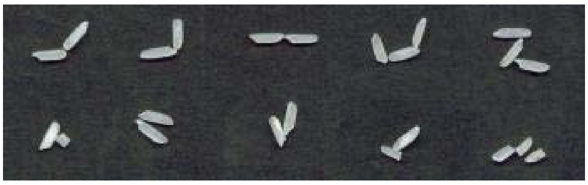


Figure2. Point touching in the different forms

Figure3. Line touching in the different forms

The propose image of analysis algorithm, which is used to separate connected object, is based on shrinkage operator. Shrinkage operation consists of a combination on erosion and dilation. Erosion is applied to separate touching features without loosing the integrity of the single features. Erosion is done two times because of rice kernels are small object so that the peeling off a layer of pixels from the perimeter of the feature is done by a small amount. The dilation operation follows erosion. The goal of dilation is grow the eroded features to their original shapes without re-joining the separate segments. The erosion and dilation operations are illustrated in equation below.

$$\textit{Erosion}: \quad B(i,j)=\min\{A(i-1,j-1),A(i-1,j),A(i-1,j+1), A(i,j-1),A(i,j),A(i,j+1), A(i+1,j-1),A(i+1,j),A(i+1,j+1)\} \qquad (2)$$

$$\textit{Dilation}: \quad B(i,j)=\max\{A(i-1,j-1),A(i-1,j),A(i-1,j+1), A(i,j-1),A(i,j),A(i,j+1), A(i+1,j-1),A(i+1,j),A(i+1,j+1)\} \qquad (3)$$

Where

$B(i,j)$ is the intensity of the output image.

$A(i,j)$ is the intensity of the input image.

There are many types of touching which are possible to occur in the image. Table 1shows the possible forms of touching and results from application shrinkage operation are also given.

4.3 Rice Kernel Edge Detection

After we separate the kernel using shrinkage algorithm. We perform edge detection to find region boundaries. The representation for 4 neighborhood and 8 neighborhood region identification can be written in eqaution (4), (5) and (6). Equation (7) is the rules used to identify region of kernel.

Pixel connectivity using 4 neighborhood technique for a pixel p with the coordinate(i,j) is given by

$$N_{41}(A) = \{(i-1, j-1), (i-1, j+1), (i+1, j-1), (i+1, j+1)\} \quad (4)$$

$$N_{42}(A) = \{(i-1, j), (i, j-1), (i, j+1), (i+1, j)\} \quad (5)$$

Pixel connectivity using 4 neighborhood technique is given by

$$N_8 = \begin{Bmatrix} (i-1, j), (i, j-1), (i, j+1), (i+1, j), \\ (i-1, j-1), (i-1, j+1), (i+1, j-1), (i+1, j+1) \end{Bmatrix} \quad (6)$$

Where

$N_{41}(A)$ is 4 neighbors of $A(i,j)$ in diagonal line

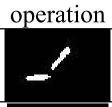
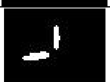
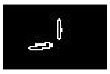
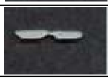
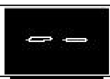
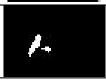
$N_{42}(A)$ is 4 neighbors of $A(i,j)$ in perpendicular line

$N_8(A)$ is 8 neighbors of $A(i,j)$

Rules for identification region are:

$$\begin{aligned} & for\ A(i,j) \neq 0 \\ & if\ N_{41}(A) \neq 0\ then\ A(i,j) = 0 \\ & elseif\ \ N_{42}(A) \neq 0\ then\ \ A(i,j) = 0 \\ & elseif\ \ N_8(A) \neq 0\ then\ \ A(i,j) = 0 \\ & elseif\ \ N_8(A) = 0\ then\ \ A(i,j) = A(i,j) \end{aligned} \quad (7)$$

Table1. Results from shrinkage algorithm

Touching feature	Results from shrinkage operation	Results from edge detection
		
		
		
		
		

4.3 Rice Grain Feature Vector Calculation.

Perimeter, area, shape descriptors(kernel circularity and shape compactness) are selected as feature vector to classify group of kernels which are placed in random direction. The shape descriptors are given by equations(8)

$$Circularity = \frac{Perimeter^2}{Area} \qquad Compactness = \frac{4\pi . Area}{Perimeter^2} \quad (8)$$

The size and area of rice kernels are calculated by using Chain code algorithm. Chain code algorithm is suitable method for data that can be arranged as a sequence of symbols. Chain code correspond to the neighborhood of primitive. In order to reduce processing time, path of chain code is broken in two ways: clockwise and counter clockwise direction. Eqaution (9),(10),(11),(12) present the chain code algorithm. (Milan Sonka,1999)

For edge image $A(i,j)$;

$$\text{Given} \quad L = \bigcup_{i=1}^{m} (g,h) \quad (9)$$

$$i = \min \bigcup_{i=1}^{m} g, \quad j = \min \bigcup_{i=1}^{m} h \quad (10)$$

$$\begin{aligned} & the\ \ first\ pass: clockwise\ direction \\ & \overrightarrow{PM(i,j)} = 2 \cup (i = i-1, j = j) && if\ \ A(i-1,j) \neq 0 \\ & \overrightarrow{PM(i,j)} = 1 \cup (i = i-1, j = j+1) && if\ \ A(i-1,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 0 \cup (i = i, j = j+1) && if\ \ A(i,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 7 \cup (i = i+1, j = j+1) && if\ \ A(i+1,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 6 \cup (i = i+1, j = j) && if\ \ A(i+1,j) \neq 0 \\ & \overrightarrow{PM(i,j)} = 5 \cup (i = i+1, j = j-1) && if\ \ A(i+1,j-1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 4 \cup (i = i, j = j-1) && if\ \ A(i,j-1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 3 \cup (i = i-1, j = j-1) && if\ \ A(i-1,j-1) \neq 0 \end{aligned} \quad (11)$$

$$\begin{aligned} & the\ \sec ond\ pass: counterclockwise\ direction \\ & \overrightarrow{PM(i,j)} = 6 \wedge (i = i+1, j = j) && if\ \ A(i+1,j) \neq 0 \\ & \overrightarrow{PM(i,j)} = 7 \wedge (i = i+1, j = j+1) && if\ \ A(i+1,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 0 \wedge (i = i, j = j+1) && if\ \ A(i,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 1 \wedge (i = i-1, j = j+1) && if\ \ A(i-1,j+1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 2 \wedge (i = i-1, j = j) && if\ \ A(i-1,j) \neq 0 \\ & \overrightarrow{PM(i,j)} = 3 \wedge (i = i-1, j = j-1) && if\ \ A(i-1,j-1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 4 \wedge (i = i, j = j-1) && if\ \ A(i,j-1) \neq 0 \\ & \overrightarrow{PM(i,j)} = 5 \wedge (i = i+1, j = j-1) && if\ \ A(i+1,j-1) \neq 0 \end{aligned} \quad (12)$$

where L is set of position index when $A(i,j) \neq 0$

g is row index

h is column index

$\overrightarrow{PM}$ is perimeter vector which consists of perimeter code value and direction of code.

The image is scan in the increasing order of rows, starting from top-left corner until the non zero intensity pixel is found. Conditions in both equation(11) and (12) are checked at the same time. Each equation provides the next position of pixel in the clockwise direction and counterclockwise direction. Codes are stored in space L and perimeters are calculated.

In this research,the possible forms of individual and line touching kernels are evaluated, for example full grain kernel is clsely touching with the ¾ of full kernel, ½ of full kernel touching with the ¼ of broken kernel, etc...

Table 2 presents size and shape parameters of individual and possibe form of touching kernels

Table 2. Size and shape parameters of individual and possibe forms of touching kernels

Touching kernel features	Average Area (mm.)	Average Perimeter (mm.)	Average Circularity	Average Compactness	Amount of kernel
Individual full kernel	14.82±1.3058	5.44±0.4412	1.9971±0.1479	6.2923±1.2023	1
Individual ¾ of full kernel	6.3784±0.4235	3.3768±0.2238	1.7877±0.1183	7.0293±0.9856	1
Individual ½ of full kernel	3.1892±0.5121	2.2512±0.3214	1.5891±0.2017	7.9079±0.9581	1
Individual ¼ of full kernel	2.6264±0.4822	1.8760±0.3653	1.3402±0.1556	9.3779±1.0058	1
Full kernel touching with full kernel	26.8268±4.0056	6.9412±0.3425	1.7960±0.1465	6.9970±0.5412	2
Full kernel touching with ¾ of full kernel	22.8872±1.0635	6.0032±0.2478	1.5746±0.1217	7.9806±0.1565	2
Full kernel touching with ½ of full kernel	17.2452±3.6225	5.8156±0.2132	1.9596±0.2413	6.4127±0.2468	2
Full kernel touching with ¼ of full kernel	12.0064±0.4823	3.9396±0.2314	1.2927±0.1312	9.7212±0.3478	2
¾of full kernel touching with ¾ of full kernel	20.8236±2.0031	2.5228±0.3647	1.3250±0.1546	9.4838±0.5136	2
¾of full kernel touching with ½ of full kernel	13.5072±1.2256	3.9396±0.1212	1.1490±0.1241	10.9363±0.6621	2
¾of full kernel touching with ¼ of full kernel	11.6312±0.3449	3.7520±0.2132	1.1203±0.2149	10.3827±0.7210	2
½of full kernel touching with ½ of full kernel	9.5676±2.1354	3.1852±0.3985	1.0631±0.2057	11.8209±0.2364	2
½of full kernel touching with ¼ of full kernel	6.7536±0.4435	2.8104±0.1418	1.1725±0.1654	10.7176±0.3212	2
¼of full kernel touching with ¼ of full kernel	0.9380±5.2346	1.1250±0.2011	1.3507±0.1387	9.3035±0.6814	2
3 full grain touching	32.21±7.0125	8.34±0.5650	1.0586±0.2263	10.2951±0.5269	3

4.3 Rice Grain Classification

Classifiaction uses all measured and calclated results. Fuzzy fuzzification method is chosen for classification of individual sample into classes. The results of this classification are used to calculate the percentage of broken rice. There are 4 inputs in the fuzzy system : AR (area) , PM(perimeter) , CL (circularity) , CP(compactness).Their mambership degree to a fuzzy set must be determined by using appropriate membership functions. In the application, values of universe of discourse of all inputs are [0 1]. The membership functions used for the inputs are triangle type. Five memberships funcions are used to represent the linguistic terms [SS, very small; S,small; M,medium; L, large; LL, very large]. In this case, the output of fuzzy logic classifier is an index between o and15. The example stages of development are represented by following linguistic terms, FK, full kernel; TK, ¾ of full kernel; MK, ½ of full kernel; QK, ¼ of full kernels. The examples of set of rules defining the system are:

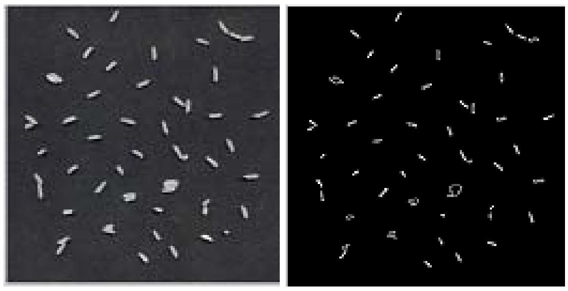
1. IF (AR=very small) and (PM=very small) and (CL=very small)and (CP=very small) then(kernel=QK)
2. IF (AR= small) and (PM=y small) and (CL= small)and (CP= small) then(kernel=MK)
3. IF (AR=medium) and (PM= medium) and (CL= medium)and (CP= medium) then(kernel=TK)

The implication is applied for each rule using the method of minimun.The outputs of each rule are obtained and converted to the numerical values.

5. Results and Discussion

The image analysis algorithms are tested by work with the image in which kernels are randomly placed and spread in one layer. From the results of operation, we can observe that the shrinkage operation works efficienly for separating the connecting part from point touching kernels. Meanwhile this shrinkage algorithm cannot separate the conection part of the line touching kernels. In addition, the faults of shrinkage algorithm may occur during the second erosion. There is the tiny kernel, which is smaller than ¼ of full kernel, is eroded. Thus the result may contain errors. Another fault is size and area of each kernel will be different from the original kernels by the peeling of outer perimeter. The application of 4 and 8 neighborhoods can be expeditiously used to detect the kernel edge. Based on chain code algorithm, size and shape features are determined for the recognition and classification. Fuzzy classification is used to classify kernels because of the degree of membership functions can provide more information about the confidence of class assignment.

The precision of image analysis procedures is checked by comparison with manual counts. Image in Figure4 is an example of testing using image analysis. From manual count; there are 53 full kernels and 12broken kernels in the image whereas the image analysis gives 51 full kernels and 12 broken kernels. The system counts 16900 mm.^{2}. The processing time requires about 1 min. whereas a manual counting takes about 3 minutes for a sample with 53 kernels. Thus the time required by automated counting and measuring compared to manual counting and measuring is currently 70% less. From the other experiments, we found that the algorithms perform satisfactorily in evaluating the percentage of broken rice with overall accuracy of 92%.



(4a) (4b)

Figure4. Image for testing the image analysis algorithms: (a) original image, (b) result of edge detection

6. Conclusion

In this study, the image analysis algorithms are developed segment and identify kernels. From the obtained results, it can be concluded that the five steps of the image analysis algorithm is an efficient method to analyze rice kernels both in the point and line touching positions. The main benefit of the image analysis is to reduce time and give 92% accuracy compared with manual results.

7. References

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