Low Cost Solution for Rice Quality Analysis using Morphological Parameters and its Comparison with Standard Measurements

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***Abstract*–Rice is a top leading food all over the world and fulfill the needs of a dominant portion of people. Rice quality is determined by different parameters including width, length, area, number of large, medium, small and broken rice. In recent years, there has been an increasing trend in automation of rice quality parameters. State of Art Software named Satake RSQI10A Grain Scanner is being used in this regard in various rice mills in Pakistan including Amir Rice Mill. The main aim of this paper is to provide a low cost software product that mimics all the features and functionalities of this state of art software. The results obtained in terms of percentage accuracy of average length and average width of rice grains are 95.04 and 95.45 respectively. Moreover, the low cost of our software make it an easy replacement for an existing state of art expensive software.**

Keywords: quantitative rice parameters; rice grain analysis; broken rice; yellow rice; rice grain length; rice grain width; rice grain area

I. INTRODUCTION AND RELATED WORK

Pakistan's economy depends heavily on rice crop because it is the 11th largest producer of the world and exporter of rice [1], [2]. Research says that 10% of the total agriculture land of Pakistan contains the rice crops [7]. The contribution of rice industry in Pakistan's economy is about 1.3% of total GDP of Pakistan. Pakistan cultivates number of nations (types) of rice including basmati, super basmati, super kernel etc.

Rice grain quality is very difficult to define precisely as tastes vary from country to country [18]. Although some of the quality characteristics desired by consumer, miller and grower may be the same, but, there exist substantial differences as well. For example, miller's definition of quality of rice is dependent on its total recovery on milling. However, consumer quality parameters include appearance, length, width, area and shape of the grain. The length to width ratio from 2.5 to 3.0 is generally acceptable as long as the length is more than 6 mm.

Some ethnic groups prefer medium long grains while some are more bent towards purchasing short bold grains. The demand for rice in Southeast Asia is for medium to medium long rice but long grains are considered to have better quality in the Indian subcontinent. In the international market, there is an increasing demand for long grain rice.

Zhao-yan et al. worked for recognition of rice seeds using neural network [19]. Pazoki et al. in 2011 identified various features including 4 shape features, 11 morphological features and 24 color features that were extracted from color images of each rice grain [20]. Efforts were made to develop convenient software tools including hardware setup for analysis and classification of rice [21]. Mahajan et al. in 2014 analyzed the quality of rice grains using Top-Hat transformation that provides promising results in improving the effects of non-uniform illumination than computer vision inspection [22]. In 2014, a technique is developed that grades and evaluates the rice grains on the basis of grain size and shape using digital image processing techniques [23]. An image analysis on broken rice was presented that categorizes the broken rice grains into 4 types including head rice, big broken, broken and small broken [24].

There exist a need to develop automated methods to measure the quality parameters of rice that will provide convenience to rice industry in terms of time and reliability. Software named Satake RSQI10A Grain Scanner1 is being used in this regard in various rice mills in Pakistan including Amir Rice Mill, Sheikhupura to measure the quality parameters of rice as shown in Fig. 1. The quality parameters of rice include length, width, area, number of small, medium, large and broken rice.

[1]SatakeRSQI10A Grain Scanner is available at http://www.satake.com.au/lab/Grain_Scanner.htm

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This paper presents a software system that mimics all the functionalities and features of Satake RSQI10A Grain Scanner. This software is attached with a scanner and it measures the morphological parameters of rice including area, width, length and number of rice (broken, medium, small). Then these automated measurements are compared with measurements taken manually. This software product will not only increase the time efficiency as compared to manual measurement but it will also be a low cost solution for the rice industry of developing countries including Pakistan, Bangladesh, Malaysia etc.,

The paper is organized as follows. Section II explains about data set, while section III gives details of methodology. Section IV is result and discussion while section V is conclusion and future work.

Fig.1. Schematic of Satake RSQI10A Grain Scanner installed in Amir Rice Mill Sheikhupura

II. DATA SET

Total of 103 rice grains were used to test the algorithms and techniques proposed in this paper as shown in Fig. 2.

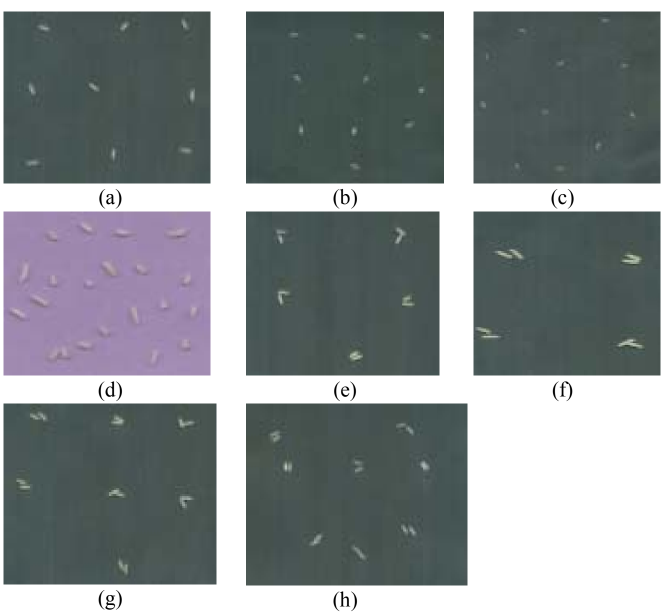


Fig.2. Rice grains a) 9 rice grains placed separately with each other (separate) b) 10 rice grains, separate c) 10 rice grains, separate d) 19 rice grains, separate e) 10 rice grains in form of cluster (cluster) f) 8 rice grains, cluster g) 14 rice grains, cluster h)16 rice grains, cluster

These rice grains were scanned using HP Scanjet G3110 scanner with a resolution of 300 dpi. Fig.1 contains total of 8 images obtained by placing the rice grains on the scanner. In Fig. 1 (a)-(c), the rice grains are placed separately i.e., each rice grain having a significant distance with other rice grains. However, rice are placed in form of small clusters in Fig. 1 (d)-(h) to check the accuracy of our algorithm over such non-trivial cases as well.

The image of Fig. 1 (a) (i.e., image 1) contains total 10 grains of rice. Out of these total rice grains, 1 is small rice grain and 9 are medium rice grains while there is no broken rice grain. Fig. 1 (b) (image 2) contains total 10 rice grains, including 1 small rice grain, 5 medium rice grains and 4 broken rice grains. Image 3 present in Fig. 1 (c) contains 9 grains including 1 small rice grain and 8 medium rice grains while there is no broken rice grain. Fig. 1 (d) (image 4) has 13 small rice grains, 3 medium rice grains and 3 broken rice grains. Image 5 of Fig. 1 (e) contains total of 8 rice grains, while Fig. 1 (f) (image 6) has 11 grains but proposed method enumerates only 10. As the length of 11th rice grain is lesser than the 20% of the average length, therefore, this rice grain is categorized as an impurity or damaged rice grain. Image 6 has 3 small, 5 medium and 2 broken rice grains. Fig. 1 (g) (image 7) has 14 medium rice grains. Fig. 1 (h) (image 8) has 16 rice grains including 13 medium rice grains, 3 broken rice grains while it has no small rice grain.

The actual measurements of width and length were taken manually of each rice grain of all the eight images for comparison with the automated measurements and then the percentage accuracy was calculated. The width and length are calculated using Euclidean distance [14] metric as given by (1):

$$D(x,y) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (1)$$

Where (x_1, y_1), (x_2, y_2) are the end points of rice grain.

III. METHODOLOGY

This section consists of the following modules

- Preprocessing
- Rice length and average length calculation
- Rice width and average width calculation
- Rice Area calculation
- Rice grains enumeration
- Small, medium and large rice grains enumeration
- Impurities and uneven particles enumeraion
- Yellow and red rice grains enumeration

A. *Preprocessing*

It is a thought-provoking task to calculate various morphological parameters of rice grains including area, width and length as rice grains has irregular or non-uniform shape. [9]. Preprocessing has a pivotal role in improving the percentage accuracy of algorithm to calculate the rice quality parameters. It has following steps:

- Binarization
- Edge detection using Canny Edge Detector

- Rice grains segmentation

A.1. Binarization

RGB image takes more processing time as it has three channels. Moreover, binary image fulfills the required objectives hence, RGB image is converted to binary image.

A.2. Edge detection using Canny Edge Detector

The sequence of steps is as follows [6]:

1. It performs noise removal from image containing rice grains.
2. Large magnitude of gradients is marked as an edge in an image as in (2) and (3).

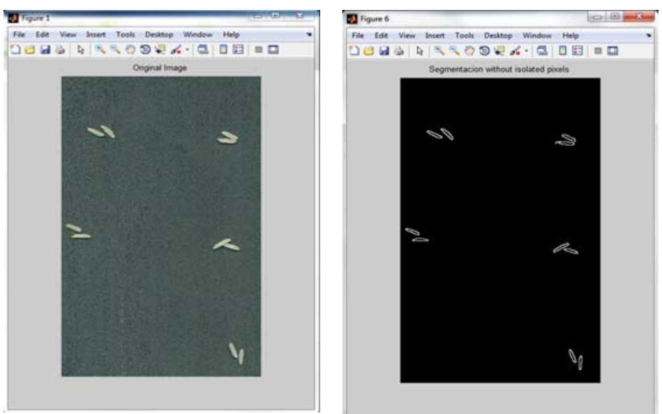
$$Edge\ Gradient(G) = \sqrt{G_x^2 + G_y^2} \quad (2)$$

$$Angle(\theta) = tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (3)$$

3. The local maxima are marked as edges to find the objects.
4. The thresholding of [0.01 0.40] is applied to obtain potential edges as shown in Fig. 3.

A.3. Segmentation of rice grains

Each rice grain is segmented using connected components with 4-neighbor connectivity.



(a) (b)

Fig. 3 . Canny Edge Detection a) Original Image b) After Canny Edge Detection is applied

B. Rice length and average length calculation

Length of rice is an important parameter to find the quality of rice. Greater length of rice ensures better quality of rice. An algorithm is proposed to calculate the length and average length of grains. The order of steps used to calculate the length of a rice grain is as follows:

1. Go over each edge point of the rice and find maximum of y-coordinate, minimum of y-coordinate, maximum of x-coordinate and minimum of x-coordinate of rice.
2. Step 1 yields four combinations of rice coordinates including (Xmax, Ymax) , (Xmax, Ymin), (Xmin, Ymax), (Xmin, Ymin)
3. The selection of two points from four points of step 2 will give the ends points of rice grain as shown in Fig. 4.
4. The length of rice grain is obtained by finding the Euclidean distance between the end points obtained from step 3.
5. Using resolution of an image, the length in pixels of each rice grain is converted to millimeters.

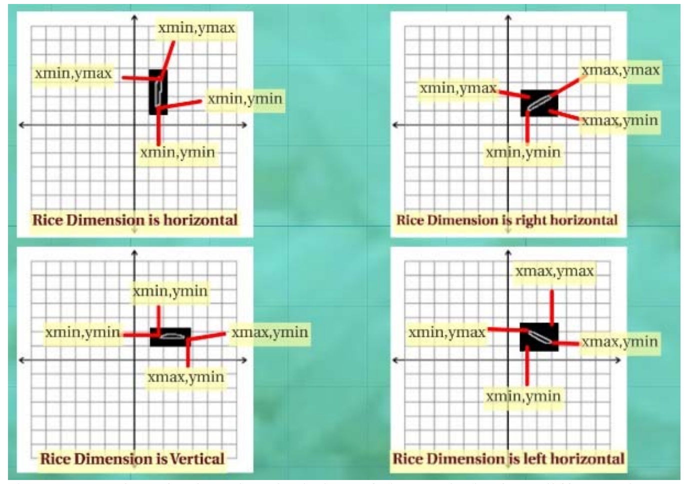


Fig. 4. Procedure for length calculation of rice grain in four different rice orientations including horizontal, right horizontal, vertical and left horizontal.

C. Width and average width calculation

One more key parameter to determine the quality of rice grain is width. The sequence of steps to calculate the width and average width of rice grains are as follows:

1. Calculate the centroid of each grain of rice
2. Find minimum distance between centroid of each rice grain and its boundary pixels as shown in Fig. 5.
3. Find second minimum distance between centroid of each rice grain and its boundary pixels.
4. Width of rice grain in terms of number of pixels is obtained by adding first minimum and second minimum distance. It will give the width of rice grain in terms number of pixels.

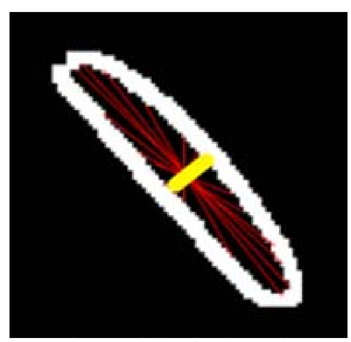


Fig. 5. Width of a rice grain

D. Area Calculation

Another important parameter to assess the rice grain quality is Area. Rice grains have non-uniform or irregular shape that makes the area calculation, a non-trivial task. An algorithm to compute the area of rice grains is proposed that is as follows [15]:

1. Subtract the background of image from the original image to get foreground object i.e., rice grains.
2. Increase the contrast of an image
3. Compute the connected component of the image. Each connected component represents one rice grain.
4. Compute number of pixels of each connected component (i.e., rice grain) to get the area of the rice grain

E. Rice Grains Enumeration

The connected components are obtained as the output of preprocessing phase [16], [18]. One connected component is denoted as one rice grain as shown in Fig. 6. The total number of connected components in an image gives total number of rice grains.

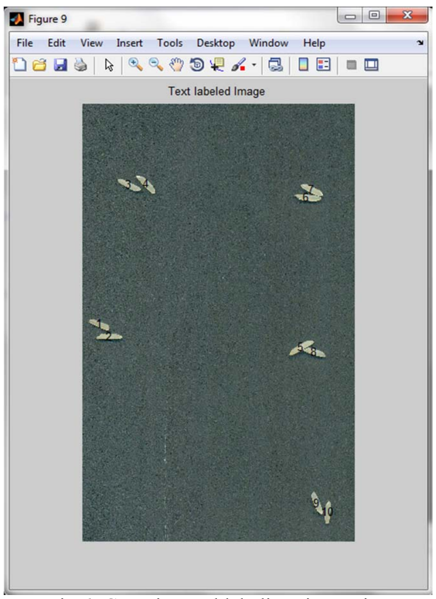


Fig.6. Counting and labeling rice grains

F. Small, medium and large rice grains enumeration

If length of the rice is less than 65% of the average length, then it is considered as small rice grain. If length is greater than equal to 65% and less than 85% then it will be treated as medium rice grain. If its length is greater than or equal to 85% then it will be named as large rice grain.

G. Impurities and uneven particles enumeration

An algorithm is proposed that categorizes a rice grain as impurity or uneven particle if the rice grain length is less than 20% of the average length of an image.

H. Yellow and red rice grains enumeration

Yellow and red rice grains are considered as impurities as it reduces rice quality. Moreover, these impurities also reduce rice grains worth in terms of price as it increase the rice weight. Other instances of impurities are broken seed, damaged kernels and chalky grains.

IV. Results And Discussion

Table 1 shows the percentage accuracies of area, width, length, number of broken, medium and small rice for Image 1 to image 8.Image 1 to image 8 corresponds to images in Fig. 2 (a) to (h) respectively. It can be concluded that percentage accuracy of length for Image 6 is the highest as compared to the rest of the images. The possible reason includes the least amount of noise present in image 6 that yielded the best results. The percentage accuracy of average width for Image 1 is highest. In case of medium and small rice, the percentage accuracy for all the images is 100%.

Table II shows average length, average width, number of medium and small rice for total of 103 rice grains (of all the 8 images) in terms of percentage accuracy. It is interesting to note that percentage accuracy of average length, average width, number of medium rice and number of small rice came out to be 95.04, 95.45 and 100 respectively.

TABLE I

Results of average length, average width, number of small and medium rice are shown in terms of percentage accuracy for each image. Image 1, Image 2…Image 8 corresponds to Fig. 2 (a)-(h) respectively

Properties	Image 1	Image 2	Image 3	Image 4	Image 5	Image 6	Image 7	Image 8
Actual Avr. Length (mm)	7.32	6.8	6.47	7.19	6.099	5.7	5.8	5.26
Experimental Avr. Length(mm)	7.76	6.68	7.12	7.12	6.736	6.61	6.7	6.31
%age Accuracy	93.95	97.77	90.05	99.05	89.55	84.25	83.1	80.01
Experimental Avr. Width(mm)	1.856	1.6	1.4	1.7	1.4	1.5	1.6	1.5
Actual Avr. Width (mm)	1.87	1.53	1.5	1.8	1.5	1.5	1.5	1.6
%age Accuracy	99.25	95.42	93.33	94.44	93.33	100.00	93.33	93.75
Experimental Avr. Area(pixels)	324.4	318.5	289.4	320.4	322.4	561.4	319.9	300.4
Total number of rice	9	10	10	19	10	8	14	16

Number of broken rice	0	4	2	3	0	0	0	0
Actual number of medium rice	8	5	5	3	9	8	14	13
Experimental no of medium rice	8	5	5	3	9	8	14	13
%age Accuracy	100	100	100	100	100	100	100	100
Actual number of small rice	1	1	3	13	1	0	0	3
Experimental no of small rice	1	1	3	13	1	0	0	3
%age Accuracy	100	100	100	100	100	100	100	100

TABLE II
Results of average length, average width, number of small and medium rice is shown in terms of percentage accuracy

Total No. of Rice Grains	103
Actual Avr. Length(mm)	7.64
Experimental Length(mm)	6.99
%age Accuracy	**93.95**
Actual Avr. Width(mm)	1.6
Experimental Width(mm)	1.5695
%age Accuracy	**95.45**
Area(pixels)	417.4
No. of Broken Rice	9
Actual No. of Medium Rice	65
Experimental No. of Medium Rice	65
%age Accuracy	100
Actual No. of Small Rice	22
Experimental No. of Small Rice	22
%age Accuracy	**100**

V. Conclusion And Future Work

Our software provides a low cost solution for rice industry by imitating the state of art Satake RSQI10A Grain Scanner that is being extensively used in rice industry of Pakistan including Amir Rice Mill Sheikhupura. The accurate results and low cost of our software add more confidence in its future use as a replacement of SatakeRSQI10A Grain Scanner. Moreover, manual methods of calculating rice quality parameters will soon become obsolete due to low cost, high accuracy and increased time efficiency of this software.

The future directions could be to apply machine learning algorithms and techniques to intelligently classify different types (nations) of rice including Basmati, Kernel and Super Kernel.

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