Germination of Rice Seed Using Image Processing and Matlab

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Abstract **- This paper presents a machine vision application designed for rice seed germination analysis by using image processing and computer vision technology. The application is called "Rice Seed Germination Analysis (RiSGA)". RiSGA consists of five main processing modules which are 1) image acquisition,2) image preprocessing,3) feature extraction,4) quality control analysis and 5)quality results. The experiments is conducted on three variation of Indian rice (Brown Rice, White Rice, and White Rice. RiSGA extracts four main features which area) colour, b)size, c)shape, and d)texture. Then, RiSGA applies 1) Euclidean distance 2)Rule Based System and 4)Artificial Neural Network techniques in rice seed germination prediction. The precision rate is 93.06 percent, with the speed 8.31 seconds per image.**

Keywords **- Rice seed, seed germination, rice seed features, image processing, computer vision**.

INTRODUCTION

India is one of agricultural countries which produces a huge number of food products each year. Nowadays, the agricultural industry is probably more widespread in the world. One product that is highly widespread in the world especially in India is rice. White rice is a vital worldwide agricultural product. Rice is a very popular exported product in the world. In India, there are various well-known rice species. It is essential to grade the quality of commodities in order to command the better price in the market competitions. The quality of the rice is mostly based on the quality of the seeds. Paddy rice is mostly offered based on the good quality of products. To measure the seed quality assessment, many factors is considered in the germination test, for instance, seed quality additives, species purity, physical purity, insect pests and diseases, seed germination and seed vigor. However, it is very difficult to identify which kind of seeds should be

better used in seed germinations. Thus, this research is applied the image processing and computer vision technique instead of using only human vision. The traditional way to conduct the germination test is based on human abilities, it takes times and high labour to conduct the germination test in the seed quality control process. Nevertheless, it is very difficult to identify the quality of rice seeds by using only human vision because it is time-consuming and uses high labour to assess the quality control process in order to earn benefits from the rice productive. The germination test in this research was applied following the standard seed germination test in ISTA (1996) with the top of paper method for crop germination. Moreover images have been collected to predict the germination of rice seed images by using image processing techniques which can identify the quality of products. Therefore, the objective of this research is to propose the novel technique by applying the image processing and computer vision technology to assess the crop germination prediction in order to reduce times and costs. Thus, the computer software which can predict rice seed image for crop germination by using image processing techniques is developed. Due to the advance of video camera technology, people can take a digital picture or digital video stream easily in any places and any time by a camera or by a mobile phone device. It is not only very easy to use a digital camera, but also it is inexpensive. Moreover, it is easy to transform and process by using a computer system. Thus, this research employs a digital camera to capture the image. Many researches have been conducted the rice seed classification and rice seed recognition systems based on varieties, shape and size. The system of this research aimed to allow users to load an unknown whole rice seed image into RiSGA which the system attempts to predict which kind of seeds were germinated or non-germinated for crop germination. Finally, the RiSGA displays the germination results on the system's graphic user interface (GUI). Many experiments were conducted to evaluate the seed germination by using machine vision technology.

RELATED WORKS

Many researchers have applied image processing for rice germination in their studies. This is because using image processing is rapid, economic, consistent, and objective. However, there is no research conducted by using machine vision and image processing in the microscopic level which is more efficient for analyzing the information. Therefore, this research aims to implement the automatic system in the microscopic level. The Rice Seed Germination

Analysis(RiSGA) system is developed and used as the inspection tool for measuring the rice seed quality in the rice germination.

MATERIALS AND METHODS

The experiment was conducted by using the following computer hardware specifications:
1) CPU Intel(R) Core(TM) i5-2400 CPU @ 3.10GHz
2) Memory DDR3 4 GB and
3) Hard disk 500 GB.
For the computer software, Microsoft Windows 7 (Microsoft Corp.; Redmond, WA, USA) was used as the operating system. For the development tool, MATLAB R2013a (The Math Works Inc.; Natick, MA, USA) was used.
Analysis and design were described by using the system conceptual diagram and system structure chart. The details of each element are described below.

SYSTEM CONCEPTUAL DIAGRAM

First, the images of many rice seeds are taken by a digital camera. Next, the images of the rice seeds are transferred into the RiSGA for predicting rice seed image for crop germination which involves RiSGA comparing the features of testing rice seed image data sets with training rice seed image data sets by using artificial neural network technique. Finally, RiSGA displays the rice seed germinating prediction results to the user as shown in Figure 1.

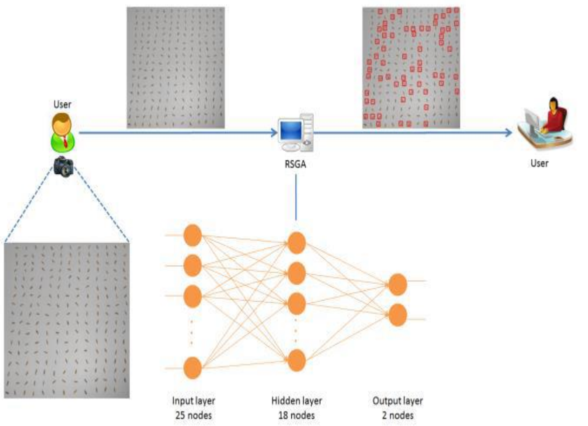

Figure 1: Rice Seed Germination Analysis System Conceptual Diagram

SYSTEM STRUCTURE CHART

The RiSGA structure chart elaborates on how each model works is shown in Figure 2. The RiSGA consists of five main process modules:
1) image acquisition,
2) image pre-processing,
3) feature extraction,
4) quality control analysis and

5) quality results.

Each process module has the following details:

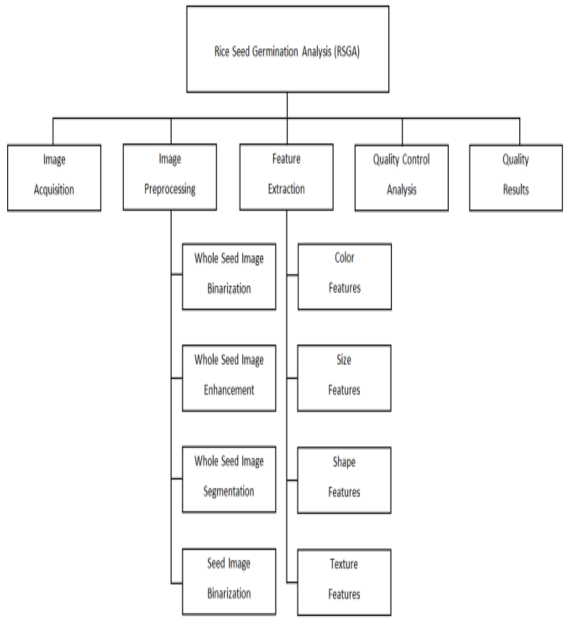

Image acquisition- In this module, it consists of three main parts which are capturing image, cropping microscopic image, and storing image. In capturing the image, the rice seed is placed on the plate and then the rice seed is taken in a bird-eyes-view angle from a digital microscope camera on a light mode or a simple camera. The rice seed image will be used as the input to the RiSGA system. In cropping the image, the size of each image captured from the microscope camera and the simple camera is very large and there is a lot of noise. Therefore, the raw microscopic image must be cropped in the same scale of 1900 x 1900 pixels at the same position. In storing image, the rice seed images from the microscope camera and the digital camera are collected and stored in the system database.

Image Pre-processing- In the second module, the image pre-processing module prepares an image before processing in the feature extraction process. This module consists of two sub-modules which are seed image segmentation and seed image binarization.

SEED IMAGE SEGMENTATION

First, the RiSGA system finds the bounding box of the rice seed microscopic input image by changing the RGB rice input microscopic image to the binarization image (Figure. 2 (a) - Figure. 2 (b)). Next, the RiSGA system will perform morphological closing to close any opening area. The RiSGA system fills holes and removes noise in order to get the enhanced binarization image. Then, the RiSGA system labels the eight connected components of the enhanced binarization image to build the rectangle which can cover and fit the size of the rice seed object in order to be the label bounding box of the rice seed microscopic image (Figure. 2 (c)). Finally, the RiSGA system uses the label bounding box of the rice seed microscopic image to segment only the rice seed object in the input image (Figure. 2 (d)).

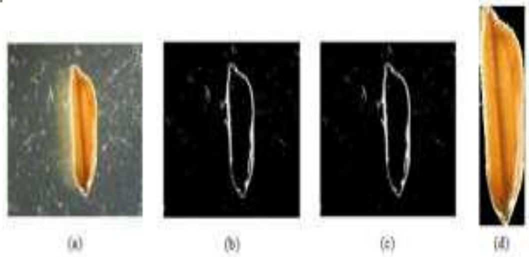

Figure. 2 The sample of rice seed microscopic image segmentation.

The sample of rice seed microscopic image segmentation is shown in Figure. 2. Figure. 2 (a) shows a rice seed microscopic image. Figure. 2 (b) shows a bounding box of rice seed microscopic image. Figure. 2 (c) shows an enhanced bounding box of rice seed microscopic image. Figure. 2 (d) shows a segmented rice seed microscopic image.

Seed Image Binarization :

RiSGA changes an RGB colour image to a gray-scale image as shown in Figure 3(a)-3(b). Then, RiSGA transforms the gray-scale image into a binary image as shown in Figure 3(c). Finally, RiSGA converts the binary image to a binarization image as shown in Figure 3(d).

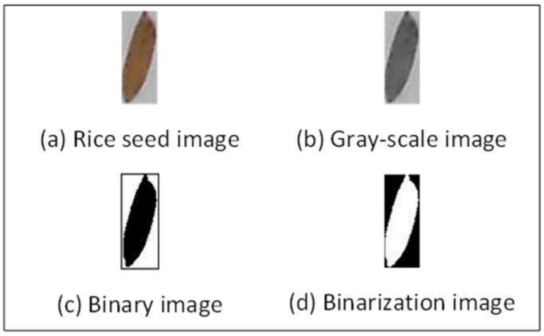

Figure 3: Sample of seed image binarization

Features extraction:

In the third module, the feature extraction module is the most important module. This is because this module contains rice images which are cropped from Module 1. Moreover, this module is used to describe the accuracy of the large set of the data. In the classification process, there are three main sub modules or seven combination optimal features as follows:

1) colour,
2) shape,
3) size, and
4) texture

To define the optimal features, the feature selection process is used to observe the most relevant features of the seed characteristics. In this research, the Wrapper Feature Selection Approach is selected to search the optimal feature subset in order to achieve the best performance. After the Wrapper Feature Selection Approach had been applied, the three main sub-modules or the seven combination optimal features occurred which were (1) Average red colour, (2) Average green colour, (3)Average blue colour (4)Aspect ratio,(5)Edge, (6)Entropy and (7) Energy.

Colour Feature

There are many colour spaces in colour features. In this research, the RGB colour space is considered as the main colour feature. The colour features consist of three features which are as follow:

1) average red colour,,
2) average green colour and
3) average blue colour.

The details of colour features calculation in Figure 5(a) is shown below.
Average red colour = 148.4075
Average green colour = 129.0601
Average blue colour = 115.8955

Size feature

The size features measure image regions based on ellipse shape-based consisting of five features which are orientation, major axis length, minor axis length, eccentricity and area. The details of size features calculation in Figure 3(d) is shown below:

Orientation = 75.8977
Major axis length = 85.7503
Minor axis length = 24.6090
Eccentricity = 0.9579
Area = 1640

Shape feature

The shape features measure seed shape. Shape feature consists of two features which are roundness and aspect ratio. Roundness used to measure the similarity of the seed to the roundness which can be calculated in equation (1). Aspect ratio was calculated from the major axis length divided by the minor axis length which can be calculated in equation (2).

$$Roundness = \frac{4\pi * area}{perimeter^2} \quad (1)$$

Where area: seed area and perimeter: the approximate length of seed boundary

$$Aspect\ Ratio = \frac{Major\ Axis\ Length}{Minor\ Axis\ Length} \quad (2)$$

The details of shape features calculation in Figure 3(d) is shown below.
Roundness = 0.4968
Aspect ratio = 85.7503/24.6090 = 3.4845

Texture feature

RSGA uses gray level co-occurrence matrices (GLCM) for measuring the seed surface texture. The GLCM in this research applied four texture features which are contrast, correlation, entropy and homogeneity. Each texture feature calculated based on equation 3-6 [2]. RSGA applied GLCM in two directions which are horizontal and vertical direction.

where,

P{i, j} = entry in a normalized gray-tone spatial-dependence matrix.
N = number of distinct gray levels in the quantized image.

Contrast texture feature

The contrast texture feature measures the local variations in the GLCM. The contrast texture can be calculated in equation 3

$$\sum_{i,j=0}^{N-1} P_{i,j}\,(i-j)^2 \qquad (3)$$

Correlation texture feature

The correlation texture feature measures the linear dependency of gray levels on those of neighbouring pixels. The correlation texture can be calculated in equation 4.

$$\sum_{i,j=0}^{N-1} P_{i,j}\,\frac{(i-\mu_i)(j-\mu_j)}{\sigma_i \sigma_j} \qquad (4)$$

Entropy texture feature

The entropy texture feature is a statistical measure of randomness that is used to characterize the texture of the input image. The entropy texture can be calculated in equation 5

$$\sum_{i,j=0}^{N-1} P_{i,j}\,\frac{(i-\mu_i)(j-\mu_j)}{\sigma_i \sigma_j} \qquad (5)$$

Homogeneity texture feature

The homogeneity texture feature measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. The homogeneity texture can be calculated in equation 6.

$$\sum_{i,j=0}^{N-1} P_{i,j}\,\frac{P_{i,j}}{1+(i-j)^2} \qquad (6)$$

The details of texture features calculation in Figure 5(b) is shown below.

Contrast horizontal = 0.2577
Correlation horizontal = 0.9177
Entropy horizontal = 1.8826
Homogeneity horizontal = 0.8856
Contrast vertical = 0.1225
Correlation vertical = 0.9610
Entropy vertical = 1.6838
Homogeneity vertical = 0.9388

Quality Control Process:

In the fourth module, the RiSGA system uses the quality control analysis to apply four techniques to predict rice seed image for rice germination: (1) Euclidean Distance, (2)Rule Based System, (3) Fuzzy Logic and (4)Artificial Neural Network. Next, the RiSGA system compares the features of the testing rice seed image data set with the training rice seed image data set in the system database.

Euclidean Distance

The Euclidean Distance is used to measure the similarity of the distance between every feature of a sample data set and every feature of each training data set in the RiSGA system .The RiSGA system applies the Euclidean Distance based on the minimum distance. The minimum Euclidean Distance determines that the sample data set and the training data set are very similar. The Euclidean Distance is calculated in equation (7):

$$ED = \sqrt{\sum_{i-1}^{n} (x_i - y_i)^2} \qquad (7)$$

Where,

ED = the Euclidean distance value between two objects which are x and y,
n = number of features, xi = the value of feature i in the system database and
yi = the value of feature i in a sample image.

Rule Based System

The rule based system is used to store and manipulate knowledge. The knowledge is stored as the rule based representation in IF-THEN structure. The fact is represented in the IF part (antecedent). The action is represented in the THEN part (consequent). The RiSGA system applies the rule based system from the area under the normal curve in the normal distribution of data set.

Fuzzy Logic

The fuzzy logic is determined as a set of mathematical principles for knowledge representation based on degree of membership function. To define the appropriate degree of membership function, the RiSGA system applies the mean and the quantity of three times the standard deviation to define the degree of membership function. The feature values in the data set are normalized to the scale of 0 and 1 which is easier to determine the degree of the membership function. The RiSGA system applies the trapezoidal function for representing the degree of the membership function. The input were between -0.3 and 1.5.

ARTIFICIAL NEURAL NETWORK

ANN is a mathematical model or computational model that is inspired by the structure and functional aspects of biological neural networks. ANN is composed of many artificial neurons that are linked together according to specific network
architecture. The patterns feed the input into the network and then the network will return the output. The objective of the neural network is to transform the input into the meaningful output. In this research, the artificial neural network (ANN) classifies the rice images by using the neural network structure of 7-6-2. The seven input nodes are equal to seven features of each seed image and the two output nodes are equal to two kinds of germinated seed and non-germinated seed in the training data set. The hidden nodes are 2/3 of average between input nodes and output nodes which is the rule of thumb. Figure. 4 shows the design of the neural network

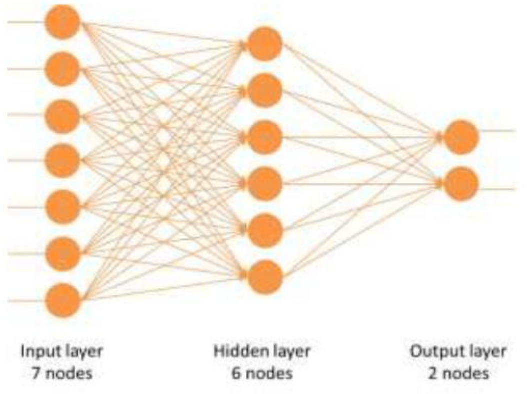

Figure. 4 The design of the neural network.

The neural network consists of input layer, hidden layer, and output layer. The input layer consists of 7 nodes. The hidden layer consists of 6 nodes. The output layer consists of 2 nodes.

Quality Result

The quality result module shows rice seed germinating prediction results. The graphic user interface (GUI) of the system is shown in Figure 5 as follows.

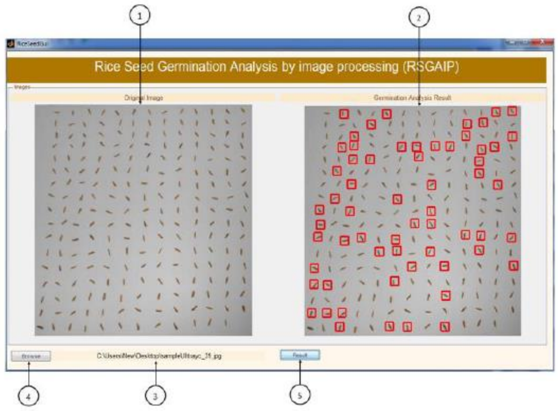

Figure 5: RiSGAIP graphic user interface

1. Image box-there are two image boxes which are the input unknown rice image (Figure 5 label number 1) and the germination analysis image box (Figure 5 label number 2). The germination analysis results contain the red mark that represents for non-germination rice seed result.
2. Text box-there are one textbox which is the browse image file location text box (Figure 5 label number 3).
3. Command button-there are two command buttons which are the browse image button (Figure 5 label number 4) and the result button (Figure 5 label number 5).

CONCLUSION

The RiSGA fulfilled the objective by extracting four main features which is based on colour, size, shape and texture features in order to predict the rice seed crop germination test by using image processing technique. Here we have used the techniques such as Euclidean distance, Rule based system, Fuzzy logic and Artificial neural network
to predict and separate the germinated and non-germinated seed through computer vision.

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