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Neural network-based quality evaluation of germinated Hang rice

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Abstract

Germinated Hang rice is found widely in the northeast of Thailand. It is produced by the traditional folklore wisdom and high nutritional value to the human body. Hence, its quality is very crucial. Traditionally, quality of rice grains has been assessed manually. Apparently, this method is very time consuming and it highly relies on human skills and experience. Thus, the purpose of this research is to develop an image processing algorithm incorporated with a neural network classifier that can detect the following defects of geminated Hang rice grains: broken grains, discolored grains, un-husked paddy grains, deformed grains and withered grains. These defects do not exist in general milled rice grains. Thus, twenty-four features composed of nine grain color components, five grain shape parameters, and ten grain textural features are extracted from images. Then, these features are fed into the neural network classifier. As shown in the results, percent accuracy of our proposed method was 98.0%.

Keywords: Geminated Hang rice, Image processing, Quality evaluation, Neural networks

1. Introduction

Germinated Hang rice draws much attention to researchers since it can generate gamma amino butyric acid (GABA) that truly benefits to the human body, including the ability to help improve memory and revitalize the internal system. Hence, its quality is very important. Traditionally, quality of rice grains has been assessed manually. Apparently, this method is very time consuming and it highly relies on human skills and experience. Thus, an image processing technique, one of the most advanced technological fields, is being used to replace human. For example, Visen et al. [1] developed and optimized a technique extracting the morphological, texture, and color features using images of single grains for discriminating various types of grains. Zhao et al. [2] proposed a method of identification based on the neural network to classify rice variety using color and shape features. Sanjivani et al. [3] identified food grains and evaluated their quality using pattern classification. Courtois et al. [4] proposed a method of assessing breakage and cracks of parboiled rice grains by an image analysis technique. Although there have been several image processing techniques used for evaluating quality of rice grains, there is no effective method that can evaluate quality of geminated Hang rice grains because of their specific characteristics that do not exist in general milled rice grains. Thus, the purpose of this research is to develop an image processing algorithm method that can detect defects of geminated Hang rice grains (see Figure 1) based on the agricultural commodity and food standard [5]. Our proposed method extracts twenty-four features of rice grains and then feed them into the neural network (NN) classifier to identify the defective grains.
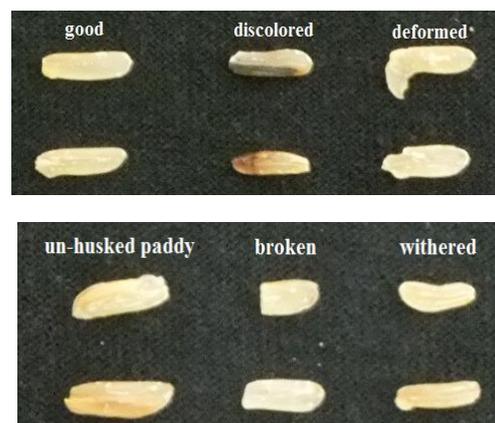

Figure 1 Good rice grains compared to defective rice grains

2. Materials and methods

To produce germinated Hang rice, the paddy rice is first soaked in water to induce nutrients. When water seeps into the rice grains, the root sprouts. Then, the paddy is steamed to achieve partial gelatinization. Next, paddy is dried and husked to remove paddy husk from paddy grains. Then rice grains are sorted based on their quality. Thus, our long-term goal is to develop an automated sorting machine for

germinated Hang rice. It will consist of a grain feeder, a belt conveyor, a quality inspection module and a sorting mechanism. In this work, the quality inspection module has been addressed. Our proposed method shown in Figure 2 is applied to identify defective rice grains. An image of rice grains is obtained by a digital camera. It is segmented by thresholding. Then, twenty-four features are extracted from segmented images. Finally, these features are fed to an NN classifier.
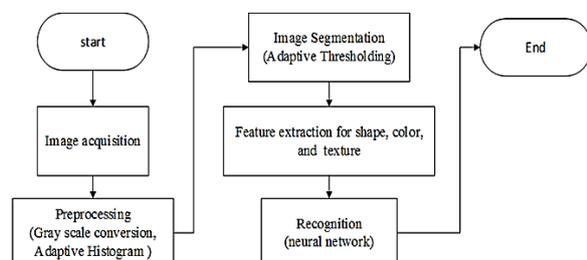

Figure 2 The procedure for detection of defective germinated Hang rice grains

2.1. Image acquisition and prepossessing

An image of germinated Hang rice grains is acquired by a digital camera (Fujifilm camera Model HS20 EXR) with a light source (see Figure 3). The grains are arranged without overlapping and lie on the black background. The color image shown in Figure 4(a) is in the form of the RGB color components. This image is then converted into the gray-scale image. After that contrast limited adaptive histogram equalization (CLAHE) [6] is applied as shown in Figure 4(b).
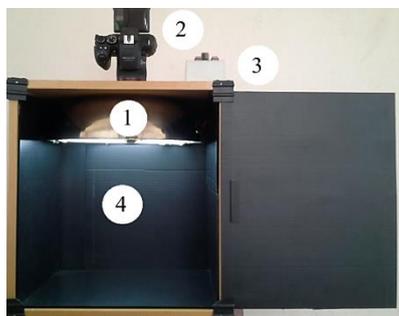

Figure 3 The color imaging system (1) light source (2) digital camera (3) adjustable light circuit (4) image-acquisition stage with black velvet background where samples sit on

2.2 Image segmentation

Segmentation attained by adaptive thresholding [7] is shown in Figure 4(c). After that, two basic morphological operations are applied to the segmented image as shown in Figure 4(d).

2.3 Feature extraction

Feature extraction involves reducing the amount of resources required to describe a large set of data. In this work, the following twenty-four features are extracted from the image of rice grains.
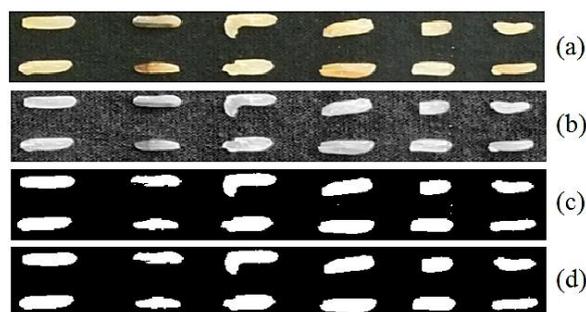

Figure 4 The resulting images after being performed by each image processing technique. (a) acquired images (b) CLAHE images (c) adaptive thresholding images (d) enhanced images

2.3.1 Color model components

Different color models can represent a different practical and theoretical point of view. Thus, in this work, there are three color models: RGB (red, green and blue), HSV (hue, saturation, and value) and L*a*b*, used to analyze the color of rice grains. The last two color models are based on the color of human feeling way, which is very intuitive and easy to understand to analyzing the color of objects.

2.3.2 Shape parameters

Shape is one of the main criteria that can be used to identify the defective rice grains. In this work, five shape parameters extracted from the image are area, major axis length, minor axis length, perimeter, and eccentricity.

2.3.3 Texture

Gray Level Co-Occurrence Matrix (GLCM) [8] has proved to be a popular statistical method of extracting textural features from images. Thus, ten textural features extracted are entropy (x, y), correlation (x, y), sum entropy (x, y), difference entropy (x, y), and contrast (x, y).

2.4 Neural network classifier

In this study, a three-layered feedforward back-propagation with 24 input neurons, 23 hidden neurons, and 2 output neurons is created. Tangent sigmoid is used as transfer function in hidden layer and linear function is used for output layer. The training function is based on the resilient backpropagation algorithm.

3. Results and discussion

To use the NN classifier, 400 rice grains consisting of 205 good grains and 195 defective grains were applied as a training set, while 100 rice grains consisting of 65 good grains and 35 defective grains were used as a test set. Table 1 shows an example of extracted information of ten rice grains that was fed into the NN classifier. After the training set was applied, the accuracy was found 99.5%, while for the test set, the accuracy was 98.0%. Figure 5 shows an example of a test set that contained 60 rice grains. Defective grains were marked with squares.

Table 1 An example of 24 features extracted from the image of geminated Hang rice grains

Feature Extraction	Grains Number									
	1	2	3	4	5	6	7	8	9	10
Entropy x	4.28907	4.29593	4.26668	4.30843	4.29744	4.27343	4.34124	4.27310	4.21478	4.14959
Entropy y	4.31147	4.31986	4.29227	4.33148	4.32376	4.29831	4.36209	4.30158	4.23109	4.16845
Correlation x	0.00423	0.00444	0.00439	0.00439	0.00445	0.00455	0.00454	0.00509	0.00354	0.00339
Correlation y	0.00172	0.00165	0.00136	0.00174	0.00148	0.00161	0.00220	0.00174	0.00162	0.00121
Sum Entropy x	3.12905	3.22868	2.90725	3.36143	3.21555	2.99568	3.67100	2.96458	2.44326	1.63985
Sum Entropy y	3.37614	3.50256	3.18459	3.63040	3.50530	3.25864	3.88852	3.27197	2.63136	1.83287
Difference Entropy x	1.08935	1.09121	1.08316	1.09512	1.09160	1.08662	1.10453	1.08544	1.06694	1.04854
Difference Entropy y	1.09614	1.09858	1.09089	1.10233	1.09954	1.09411	1.11073	1.09422	1.07204	1.05412
Contrast x	0.86309	0.86000	0.85371	0.86816	0.85701	0.85932	0.87333	0.83529	0.85495	0.81322
Contrast y	0.95500	0.95715	0.96524	0.95987	0.96123	0.96389	0.94557	0.95702	0.94555	0.94761
Color-avg-R	0.48640	0.49834	0.45953	0.51481	0.50314	0.49025	0.57457	0.50412	0.36173	0.28880
Color-avg-G	0.46238	0.47798	0.43728	0.49377	0.48397	0.45326	0.53895	0.44754	0.34817	0.26350
Color-avg-B	0.35980	0.37803	0.33765	0.39148	0.38396	0.34095	0.40551	0.33134	0.28795	0.19697
Color-avg-L	0.20324	0.20694	0.19253	0.21472	0.21000	0.20255	0.23535	0.20134	0.14914	0.12030
Color-avg-a	-0.0051	-0.0054	-0.0052	-0.0055	-0.0056	-0.0037	-0.0058	-0.0008	-0.0030	-0.0018
Color-avg-b	0.02804	0.02653	0.02750	0.02732	0.02666	0.03272	0.03661	0.03471	0.01580	0.01950
Color-avg-H	0.00030	0.00031	0.00029	0.00032	0.00032	0.00028	0.00033	0.00025	0.00022	0.00016
Color-avg-S	0.00058	0.00054	0.00056	0.00056	0.00054	0.00069	0.00075	0.00075	0.00033	0.00042
Color-avg-V	0.00191	0.00195	0.00180	0.00202	0.00197	0.00192	0.00225	0.00198	0.00142	0.00113
Major	47.8165	48.7414	48.4254	48.4580	50.9070	49.6609	51.6854	53.7575	35.7545	38.7957
Minor	15.9158	15.5996	14.6550	16.2828	15.3202	15.1322	17.6220	14.0348	15.1127	11.7002
Area	578.000	583.000	549.000	607.000	593.000	581.000	665.000	576.000	417.000	349.000
Perimeter	107.698	107.113	105.456	110.527	110.870	109.941	121.255	123.598	85.456	84.870
Eccentricity	0.94298	0.94740	0.95311	0.94186	0.95364	0.95244	0.94008	0.96532	0.90628	0.95344
Status	good	good	good	good	good	defect	defect	defect	defect	defect
Picture										

Figure 5 Grain identification results: defective grains were marked with squares

4. Conclusions

The purpose of this paper was to develop a method that can detect defects of geminated Hang rice grains which will be a part of our automated sorting machine currently developed. The proposed method was based on an image processing algorithm and an NN classifer. Twenty-four features were extracted from each rice grain and fed into the NN classifier. The experimnetal results show that the accuracy of our proposed method was 98.0%.

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