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Research paper

Designing A Neural Network Model in Grading Malaysian Rice

[1*]Noraziah ChePa, [2]Nooraini Yusoff, [3]Norhayati Ahmad

[1, 2] Human-Centered Computing Research Lab, Computational Intelligence Research Group, School of Computing, Universiti Utara Malaysia, Malaysia
[3]Jabatan Kejuruteraan Awam, Politeknik Tuanku Sultanah Bahiyah Kulim, Kedah
**Corresponding Author Email: aziah@uum.edu.my*

Abstract

Un-uniformity of rice grading practices in Malaysia resulted many approaches used by zones which actively producing rice in Malaysia. Realizing the importance of rice grading process in ensuring rice quality can be controlled, it is crucial to have a standard rice grading approach for the mentioned purpose. To achieve this, there are two important aspects that need to be considered in designing rice grading model; grading technique and factors to be used for grading (usually referred as rice attributes). This article proposes a Neural Network (NN) model for grading Malaysian rice. To apply the model, twenty one rice features are proposed to be used. Combination of extensive literature review and series of interview were used in determining the features. To evaluate the model, expert review was conducted involving domain experts and expertise of NN. The proposed model is believed to be beneficial not only for BERNAS but also to other researchers in the same domain. BERNAS can use the NN model to facilitate their inspection for rice quality. The model can be used as guidance or reference for similar grading works.

Keywords: *Neural Network, rice grading, Malaysian rice*

1. Introduction

Due to un-uniformity of rice grading practices in Malaysia, zones which actively producing rice in Malaysia are using their own way of grading rice. Realizing the importance of rice grading process in ensuring rice quality can be controlled, it is crucial to have a standard rice grading approach for the mentioned purpose. Rice or scientifically known as Oryza Sativa is a staple food for Asian population including Malaysian. Rice belongs to the Poaceae or Gramineae family. Oryza Sativa is divided into three species namely, Indica, Japonica and Javanica. The main type of rice grown in the tropic and subtropics is the Indica species [1].
Rice quality is crucial and important in rice production. The quality of rice is not only seen in features of varieties of rice but must also be seen in many other aspects such as the crop environment, harvesting, processing, production and others [2]. Rice quality usually represented by its physical and chemical characteristics [3].

In Malaysia, Padiberas Nasional Berhad (BERNAS) is the main body in the rice industry and the domestic rice production. It is also involved in the procurement and processing of rice including the process of grading. Currently BERNAS controls about 45% of the local rice demand and 24% of the paddy market [2].

Many related works are found on rice grading, but none of them is focusing on rice grading in Malaysian context. Therefore, the main objective of this article is to design a model that can be used to grade Malaysian rice by using Neural Network (NN) approach. Since grades and prices of rice in Malaysia are controlled by zones in Peninsular Malaysia, this article will only cover rice grading practices in the northern region of Kedah, Malaysia. Thus, discussion will be focused on the types of rice which are available in the mentioned zone.

This study is focusing on the analysis of the rice grading criteria by doing a comparison of the existing rice grading models and the current practice of rice grading in Northern Malaysia. These identified criteria then will be used to design a new rice grading model using Neural Network (NN).

This article is organized as follows; Section two discusses two important aspects in rice grading; technique and features. Discussion also covers previous techniques used by early researchers and the current practice of rice grading in Northern Malaysia. Section three discussed how NN has successfully been applied in rice grading works. Methodology of constructing the proposed model is covered in Section four. Section five covers concluding remarks of this article.

2. How rice can be graded?

There are two important aspects that need to be considered in determining rice grades; grading technique and factors to be used for

grading (usually referred as rice attributes). Rice grading can be defined as a process of sorting and assign rice into its classes or grade. The grading of rice is an important method applied in the rice production industry. It plays an important role in the determination of rice quality and its subsequent price in the market. The grading of rice is a standard procedure and method in deciding the quality of rice. The purpose of rice grading is to ensure that the rice that produced for the market meets the quality requirements of consumer. Rice grading is essential in determining rice quality. Rice quality usually indicated by the grades which will determine the price.

Many approaches and techniques have been used in the determination of the features of rice for grading purpose. These are the image processing together with NN, Wavelet Packet and Support Vector Machine, Contacting Angle Analysis method (separating contacting rice grain), Multi-threshold method based on maximum entropy (chalkiness), Minimum rectangle (MER)(length and width), image processing and the Adaptive Network Based Fuzzy Inference System (ANFIS), image processing, image processing and NN with support from computer vision systems and machine vision systems. Most of the researchers such as [8], [9], [10], [11], [12] have used image processing and NN method in their works. Image processing have been used to extract the features in rice and based on these features extracted, chosen rice is classified or graded using the NN method.

Other works such as by [13], uses the image processing method in their works because they just wanted to study the chalk feature which itself is one of the number of important features for rice classification and grading. [14] used the Wavelet packet and support vector machine to differentiate individual infected and qualified rice kernels. While [15] used several methods in their studies that are contacting angle analysis method to separate contacting rice grain, Multi-threshold method based on maximum entropy for chalkiness features, Minimum enclosing rectangle (MER) for determination of length and width. [16] used image processing and ANFIS for degree milling. [17], used the Computer Vision for capturing image and Principle component analysis (PCA) and regression Analysis is used to detect head rice, while [18] used Neural Networks with trained Multilayer Perceptron (MLP) Zernike moment and feature extractor used by Line sensor for Capturing Image. Table 1 shows criteria used for grading rice by previous researchers.

Table 1: Criteria used for rice grading

Researcher	Year	Criteria
Pabamalie , L.A.I. &Premaratne, H.L	2010	Texture
Seyed Jalaleddin Mousavi Rad, Fardin Akhlaghian Tab,and Kaveh Mollazade	2011	
Pabamalie ,L.A.I. &Premaratne, H.L	2010	Color
Seyed Jalaleddin Mousavi Rad,	2011	
Fardin Akhlaghian Tab, and Kaveh Mollazade		
Deden. M.F. Shiddiq, Yul Y.Nazaruddin, Farida I. Muchtadi and Sapta Raharja	2011	
Weifeng Zhong, Chengji Liu,Yanli Zhang and Liguo Wu	2011	Dead
Weifeng Zhong, Chengji Liu,Yanli Zhang and Liguo Wu	2011	Chalky
Qing Yao, Jianhua Chen, Zexin Guan, Chengxiao Sun and Zhiwei Zhu	2009 2010	
Mingyin Yao,Muhua Liu,Huadong Zheng	2011	
Liu Guangrong Bhunpinder Verma	2010	
Weifeng Zhong, Chengji Liu, Yanli Zhang and Liguo Wu	2011	Cracked
Mingyin Yao, Muhua Liu,Huadong Zheng	2010	
Bhunpinder Verma	2010	
Weifeng Zhong, Chengji Liu, Yanli Zhang and Liguo Wu	2011	Immature
Qing Yao, Jianhua Chen, Zexin Guan, Chengxiao Sun and Zhiwei Zhu	2009	Shape (length & width)
Jose D Guzman & Engelbert K.Peralta	2008	
Mingyin Yao,Muhua Liu,Huadong Zheng	2010	Head rice
Oliver C.Agustin,Byung-Joo Oh	2008	
Oliver C.Agustin, Byung-Joo Oh	2008	Broken kernel
Bhunpinder Verma	2010	
Chong Yaw Wee,P.Raveendran, Fumiaki Takeda	2007	
Oliver C.Agustin,Byung-Joo Oh	2008	Brewers
Jose D Guzman & Engelbert K.Peralta	2008	Size
Jose D Guzman & Engelbert K.Peralta	2008	Varietal types

In Malaysia, enforcement in rice grading and determination of rice grading are done as legislated in Padi and Rice Control Act 1994. The criteria used for grading and determining the quality of rice grain is based on its length and whiteness. The content of head rice, length of grain, content of broken rice, and milling degree are the main criteria for grading of rice (BERNAS, 2011). Rice is graded according to eight categories namely, *Super Special Tempatan 5*, *Super Special Tempatan 10*, *Super(Local)*, *Premium*, *Standard*, *Rebus*, *Pulut and Hancur*. The grading is based on 11 characteristics or grading factors [5]. BERNAS is not only responsible for local rice but also imported rice. Mustafa in his interview [6], says imported rice is from Thai, Vietnam, Pakistan, Myanmar, USA, Australia, Japan and India. In Malaysia, the fragrant rice, Basmati, parboiled and glutinous rice is a part of imported rice [7].

Based on early interviews with BERNAS [Alief] and [Mursyidah], most of the rice mills handled by BERNAS in the northern area produce rice of the grade *Super (local)* or known as *Super Special Tempatan 15%* but the production the *Super Special Tempatan 5 and Super Special Tempatan 10* is handled by another branch of BERNAS in Bukit Raya, Pendang. Rice mills in Bukit Raya are not engaged in the manufacture of rice but they receive the processed rice from other mills which includes the *Super Special Tempatan 15%* and is then repackaged to *Super Special Tempatan 5 and* Super Special Tempatan 10.

Main factors used in the current rice grading method by BERNAS are based on the grain composition, milling quality, defectives and moisture. The purpose of grain composition analysis is to determine the percentage of kernel, head rice, big broken, small broken and brewer or chip. Milling quality consists of the whiteness, translucency and the milling degree. According to [6] and [4], defectives means irregularity in the appearance of the rice grain and this causes the rice to be downgraded. The main factors are defectives in rice such as chalk, damage, color, immature, foreign matter, other seed, paddy etc. While the moisture in the rice grain is to determine the amount of water contained in the rice grain [23].

3. Neural network for rice grading

Neural Networks or neural net (NN) or known as Artificial Neural Networks (ANN) is a technique that represents the human brain or inspired by the way biological nervous system works to simulate the

learning process. Another definition for NN is a processor of information consisting of simple processing elements connected together [20]. [21] stated that NN model represents a human brain. Nodes in NN represent the neurons and a link represents a synapse. Technically, NN is configured for a specific application such as clustering, grading or pattern recognition, prediction system and function approximation through a learning process.

The application of Neural Network in agricultural products is not new. Sidnal and his team from India [26] has successfully applied NN in grading and quality testing of food grains. Their NN managed to produce high accuracy of grain grading (above 80%) and managed to identify 100% of the grains. Another successful work of NN was conducted by Effendi and his team [27] in grading Grading *Jatropha curcas* Fruits in order to determine the fruit maturity. Their backpropagation NN performed well by producing 95% accuracy. Table 2 shows accuracy of NN together with other methods in grading rice.

Table 2: NN accuracy

Method	Accuracy
Image Processing & Neural Networks	94% - Premium 93% - Grade 1 71% - Grade 2 68% - Grade 3
	Grading accuracy 96.67% 90% - mahli 92.34% - Neda 100% - Gerda 100% - Fajr 100% - Hashemi
	90%-95% (sound, cracked, chalky, broken & damaged)
	100% - short 97.27 % - medium 99.13% - long 98.30 % - very long [size] 97.73% long and slender 94.27% intermediate 100% round [shape]
Wavelet packet (preprocessed) Support Vector Machine	95.75% - dead 91.6% - chalky 99.8% - cracked 96.8% - immature 100% - sound 98.6% - overall
Computer Vision (for image)	96.41%-crackle rate 94.79% - chalky 96.20%-head rice rate
Image Processing	23.3% - Chalky degree 57.1% - Chalky grain rate

Previous works on rice grading reported that NN is the most popular method used [18],[11],[9]. They used the same method to classify rice with the combination of other approach for capturing the rice image. The difference between the researchers is the design that they used for classifying rice and the features or characteristics for rice grading.

NN has proven to be a promising paradigm for intelligent systems. It has been trained to perform complex functions in various fields of application including pattern recognition, identification and classification (Johnson and Picton, 1995). Hence, NN is proposed in this article based on its strength.

4. Designing the proposed model

Four main phases involved in designing the proposed NN model; theoretical study, requirement gathering, model design, and model evaluation.

4.1. Theoretical study

This phase is about identifying and defining the gap of the discussed topic and the importance of conducting the study. Eleven major models of rice grading involving the application of NN in rice grading have been identified and thoroughly reviewed.

4.2. Requirement gathering

This phase involved combination of systematic literature review, content analysis and series of interview with domain experts from BERNAS. Underlying theories and existing rice grading methods and features used from literature were thoroughly reviewed to identify classifier used previously. There are fourteen attributes of rice have been extracted from literature review

According to personal communication with BERNAS particularly with staff from Quality Management Division, current implementation of determining rice quality and rice grading are based on Act 54, Rice (Grade and Price Control) 1992 Amendment 2008. Based on the Act, there are seventeen attributes used at the moment.

Features and attributes to be used in the proposed model are obtained from combination of attributes used in the existing models and method used by BERNAS. Comparison and analysis have been made between attributes from these two resources. These attributes were compared. Redundancies were removed to get the final twenty one attributes to be used in the proposed model. Table 3 and Table 4 depicted the attributes identified for input and output layer respectively.

Table 3: List of attributes for input layer

No	Input unit	Attributes	Formal representation
1	X_1	Kernel	*Kn*
2	X_2	Head rice	*Hr*
3	X_3	Big broken	*Bb*
4	X_4	Small broken	*Sb*
5	X_5	Brewer	*Bw*
6	X_6	Whiteness	*Wh*
7	X_7	Translucency	*Tr*
8	X_8	Milling degree	*Md*
9	X_9	Chalky	*Ch*
10	X_{10}	Immature	*Im*
11	X_{11}	Damage	*Da*
12	X_{12}	Red streak kernel	*RSK*
13	X_{13}	Colour	*Co*
14	X_{14}	Foreign matter	*Fm*
15	X_{15}	Average length	*Avgl*
16	X_{16}	Paddy grain	*Pg*
17	X_{17}	Moisture content	*Mc*
18	X_{18}	Size	*Sz*
19	X_{19}	Shape	*Sh*
20	X_{20}	Width	*Wi*
21	X_{21}	Texture	*Tx*

Table 4: List of attributes for output layer

No	Input unit	Attributes	Formal representation
1	Y_1	Super Special Tempatan 5%	*SST5*
2	Y_2	Super Special Tempatan 10%	*SST10*
3	Y_3	Super (local)	*Sp*
4	Y_4	Premium	*Pm*
5	Y_5	Standard	*St*
6	Y_6	Rebus	*Re*
7	Y_7	Pulut	*Pu*
8	Y_8	Hancur	*Ha*

Attributes to be used in the input layer are features of rice that will be considered for grading purpose. While attributes to be used in the output layer are rice category used by BERNAS.

4.3. Model design

NN model is designed based on the identified attributes. Multilayer Perceptron (MLP) is chosen to be used in this study due to its strength and the ability to do classification task. There are 21 features which representing factors used for rice grading are used in designing the input layer of the proposed NN model. While for output layer, there are eight features used which representing rice categories in Malaysia. Architecture for hidden layer will be determined through experiment. Figure 1 shows the design of NN model.

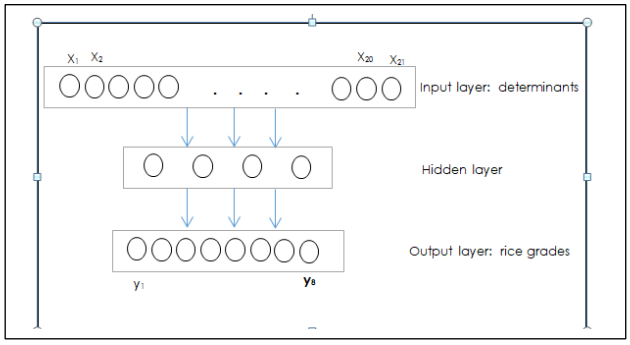

Figure 1: The proposed NN model

Based on the proposed model, eight units in the output layer represent grades of rice. In this study there are eight grades available, hence the eight nodes are used to represent the mentioned grades. Eight types of rice grades are; *Super Special Tempatan 5*, *Super Special Tempatan 10*, *Super (Local)*, *Premium*, *Standard*, *Rebus*, *Pulut* and *Hancur*.

Super Special Tempatan 5 referring to any rice obtained from paddy planted in Malaysia containing not exceeding five percent of broken rice but does not contain any percent of Super (import) rice. *Super Special Tempatan 10* means any rice obtained from paddy planted in Malaysia containing not exceeding ten percent of broken rice but does not contain any percentage of Super (import) rice [5]. *Super (local)* means the broken rice containing not exceeding 15%. The percentage that allowed is 13%. In rice production by BERNAS most of the rice mills produce super local. If percentage of broken is more than 45% the rice is downgraded to *Premium and Standard* grade and it also refers to grade rice recovery (GRR). Usually in rice production, KBB produce *Super (local)*, while the *Super 5 and super 10 while is* produced at another rice mill in Bukit Raya Pendang.

Rebus is rice in which the starch in the kernel has been gelatinized by soaking, steaming and drying the rice and consists of 100% parboiled grains and contains not less than 80% parboiled head rice. *Pulut* consists of 80% pulut grains and shall contain not less than 60% pulut head rice. The last category is *Hancur* which means big brokens or brokens or mixture of both big brokens and brokens [5].

4.4. Model evaluation

Expert review used to evaluate the designed model. The purpose of model evaluation is to get the consent from expert regarding the designed model. Three main aspects used in evaluation are; suitability of the features for grading, suitability of the grades, and the architecture of the proposed model.

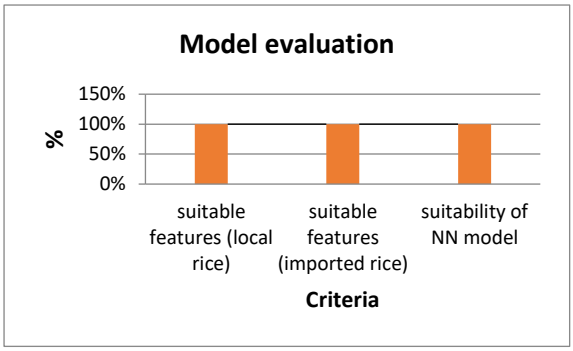

Figure 2: Results of model evaluation

Experts involved were domain experts from BERNAS and experts from computing, particularly the experts of NN. Evaluation results show that the respondents agreed that the features are suitable to be used in the proposed rice grading model. The same features are also suitable to be used for grading the imported rice. Domain experts have suggested the brewer word to be changed with chip, and adding varietal type as one of the features. However, varietal type is not included in this study because the varietal type can be measured or can be identified by length, size and shape.

There are also some suggestions from domain experts regarding the designed NN model. Domain experts from BERNAS suggested this NN model to be integrated with a mechanical system that can grade the sample based on value (weight) in certain time. They were also recommended to apply the proposed NN model for paddy samples in future works. The NN experts suggested to revise the number of the hidden layer units used and the need to justify the number of hidden layer units and the need to train and test data using Back propagation NN (BPNN) in the development of the model. These suggestions will be done in the experimental part.

5. Conclusion

Rice grading is important as it relates significantly with the rice quality. High quality rice will be assigned to high grades while low quality rice will be assigned to low grades. Rice quality affects the price and demand for rice in market. Hence rice grading is required to control rice quality.

This study identified twenty one features that can be used to grade Malaysian rice. These features were identified through combination of extensive literature review, content analysis and series of interview with the domain experts from BERNAS. With the identified features, an NN model has been proposed for grading Malaysian rice.

The proposed model is believed to be beneficial not only for BERNAS but also to other researchers in the same domain. BERNAS can use the NN model to facilitate their inspection for rice quality. The model can be used as guidance or reference for similar grading works. Although the proposed model is technically accepted by the experts, there are some rooms for improvement as discussed in Section four.

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