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Feature Based Qualitative Classification of Rice Varieties: A Review

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Abstract: **Rice is regarded as main staple food for around 80% of the Southeast Asia population alone. As most nations achieving self-competency in rice production, better quality rice is of utmost priority of consumer. It is very tedious work for consumers to analyze the good quality and rice grading in the market. Rice grains' quality determination is judged visually by human inspectors following manual process which is neither objective in nature nor effective due to non-reliability of results occurring as a result of inexperienced inspectors or human errors. So need for an automatic rice quality grading system arises which can eliminate the inadequacies of manual quality grading process. In this paper, Different techniques of machine learning, deep learning and image processing considering morphological, color, shape, textural as well as other features of rice are analyzed to review the current research scenario in automatic quality grading process. Various procedures and methods are considered for the review purpose to analyze the quality of rice grains on the basis of different features of rice.**

Index Terms: **machine vision, digital image processing, morphological features, back propagation network, multilayer artificial neural network**

I. INTRODUCTION

Rice is the most developing crop in numerous areas of India. India stands second driving producer of rice at worldwide level just after China. Rice is a vital ingredient of nourishment for around 80% of the Southeast Asia population alone. The botanical name of Asian rice is Oryza Sativa. As most nations achieving success in reducing dependency on other nations in production of rice, consumer is progressively worried for better quality of rice. The conventional rice quality inspection systems are commonly used. Quality assessment of rice grains by human investigators is neither objective in nature nor effective on the grounds because sometimes of the results may not be trustworthy due to inexperienced inspectors or manmade errors. Additionally, conventional investigation of rice quality is tedious work. Therefore, to remove the inadequacies present in conventional inspection methods, modernized and advanced techniques i.e., automatic rice quality grading systems with the assistance of effective and reliable image processing techniques are being proposed or developed. There is an excess of research work available utilizing machine and computer vision for the evaluation of rice quality. In context of computerized rice grading and quality, inspection utilizing machine as well as computer vision is desirable. In recent times, machine as well as computer vision and image processing are generally ideal in field of agricultural and biological research due to advancements and improvement in new computer advances resulting in reduced cost in software available for digital imaging.

Rice grading can be regarded as a process of sorting, assigning rice into its different classes or grades. The quality grading of rice has a pivotal role in method applied for rice quality determination in the industries of rice production and to determine the subsequent rice price in the food grain market (Komal et al, 2020). Rice Quality relies on numerous parameters of rice, for example, color, shape size and number of damaged and broken kernels. Machine as well as computer vision have been applied in most research studies to differentiate rice grading dependent on features of rice like length, shape, shading, chalkiness and internal damaging of rice. Rapid advancements and developments in hardware and software for image processing have supported several research studies on the advancement of CV frameworks for evaluating quality of raw and processed foods (Abdullah et al. 2000). For the quality sorting, inspection and quality evaluation of rice, there is a huge contribution of recently created computer technologies (Parmar et al. 2011). In most of the research studies, it has been found that researchers are keen in working on morphological features of rice.

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II. Nutritional value of Rice

Rice contains carbohydrate or starch that is a most important component that's why it is considered as nutritional staple food. But in this an amount of nitrogenous substances is very less that is 8% and almost negligible or 1 % amount of lipids or fat (Kuo et al., 2015). Due to all these factors, it is considered as complete food for eating. Various food materials are made using it as it contains large amount of starch and is also used in making alcoholic malt, pottery, glass and porcelain using rice straw. The environmental and variety conditions of area of crop also make changes in variability of characteristics and composition of rice. The range of protein in husked rice is 7 to 12% and amount of amino acids get increased by use of nitrogen fertilizers (Liu et al., 2005). Cooking procedures can reduce the richness of vitamins and minerals in rice, and in fact, cooking is usually done with water which is then neglected and much of these nutrients dissolve in water and get wasted. In preparation of specific diets, rice is used against stomach processes intestinal diseases and feeding old peoples. Rice is used in these due to its good digestible character.

III. Phases of Rice Quality Grading System

Different research studies carried out for creating automatic rice quality grading system; most of the researchers have used the following stages for the purpose of rice quality analysis. The various stages of framework are briefly explained as:

1. **Image Acquisition:** First of all, Rice sample is acquired through the procedure of Image Acquisition. The collection of images of various rice varieties are done through scanning with the assistance of scanner or camera under constrained or un-constrained condition.
2. **Image Pre-processing:** The images can have noise, impurities in rice samples etc. Quality of results can vary due to low nature of images. So, there is need of pre-processing of the images. In pre-processing stage, various types of tasks are performed to prepare images for segmentation purpose.
3. **Image Segmentation:** Segmentation process comprises of decomposition of the sample image into objects and to extract region of interest for the purpose of feature extraction.
4. **Features Extraction of Images:** In feature extraction stage, required features are extracted from the sample image and these features are utilized to prepare database. Different sort of feature extraction methods/techniques are accessible for the extraction of features from segmented image.
5. **Grading or Classification:** This stage is the decision making for the quality investigation or evaluating of rice. In this phase, classifiers are utilized to analyze or grade the rice based on separated features of the image.

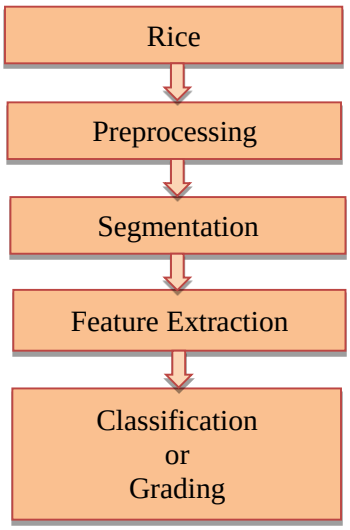

Figure 1. Phases of Rice Quality Grading System

IV. Literature Review

A. Research studies based on morphological features

Morphology consists of larger set of operations of image processing for processing of images on the basis of shapes. Some of the morphological features of rice kernels are Area, Perimeter, Major axis length, Minor axis length, Eccentricity, Solidity, Rectangularity, Circularity, Compactness, Equivalent Diameter etc. Researchers have mixed the morphological features with other features to attain higher accuracy. There is an further improvement in classification accuracies with addition of textural features and other features. Guzman and Peralta (2008) proposed the improvement of framework comprised of machine vision technology and multilayer artificial neural systems for identification of the rice sizes, rice shapes, and rice varieties of five varietal groups automatically. Multilayer ANNs choose 13 morphological features from each rice image. The ANN classifiers yielded accuracy for sizes and shapes 98.76% and 96.67% respectively. In the group classification of 52 varieties the developed system was able to yield 70% mean accuracy. Verma (2010) utilized a quicker CV system for sorting and analysis of rice kernels. On three Indian rice varieties Hafed Basmati, Markfed Supreme and Golden Smoothing, binarization methods of image processing were applied for estimation of the extracted parameters area, perimeter, maximum width, maximum length, compactness and elongation. A classification accuracy lying between 90-95% was accomplished based on differences in, chalkiness, shape, cracked, damaged and broken rice kernels of three varieties. Lilhare and Bawane (2012) trained a feed forward neural network to classify rice seed of mixed varieties on the basis of their morphological features with the help of image processing. The ANN successfully classified rice samples in small, medium and large category. Rad et al. (2012) proposed a system for classification of five distinct Iranian rice varieties based on morphological features. A total of 18 features of rice kernels was

extracted. 6 superior features were picked after removal of insignificant, noisy and redundant data. For classification purpose, a BP classifier of neural system was proposed which resulted in yielding overall accuracy of 98.40%. Ajay et al. (2013) deployed the utilization of morphological methods for quality analysis of rice grains. Shape descriptors were taken into consideration for the quantity analysis of broken kernels from the mixture of rice grains. After the feature extraction of geometric nature, the lengths of rice grains were acquired up to a threshold value. Ordinary grains below 75% length were resolved as broken kernels. Kambo and Yerpude (2014) proposed a new PCA approach using morphological features with help of KNN classifier to classify three types of Basmati rice achieved overall accuracy of 79%. Kambo and Yerpude (2014) classified three types of basmati rice in their proposed system using principal component analysis with help of KNN classifier produced overall accuracy of 73%. Tanck and Kaushal (2014) proposed a digital system for Agmark Standardization of Rice demonstrating the use of machine vision. They illustrated a technique which is useful for the extraction of features of morphological nature like length, region and edge and so on. The developed system yielded classification accuracy over 90% of the grains at a very minimal cost. Abirami et al. (2014) proposed neural network system of SCG training for grading rice granules of basmati rice seeds with the help of image processing. The measurement of rice granules in the sample were considered for grading purpose. The twenty-two rice image samples recognized as Grade I, twenty rice samples as Grade II and Thirty-Four rice samples as Grade III. Without overlapping the accuracy of classification was 98.7% and with overlapping of grains, the network yielded the accuracy 91.3%. Kumbharkar et al. (2016) proposed a new approach using morphological features with help of digital image processing to classify rice grains using 30 types of grains.

Table 1. Research studies based on morphological features

Researchers	**Region of Research**	**Food Type**	**No. of Samples**	**Features Used**	**Techniques**	**Results / Accuracy**
Guzman and Peralta (2008)	Philippines	Rice	26000 Samples	Morphological	Artificial Neural Networks Classifiers, Machine Vision	70%
Verma (2010)	India	Rice	50-60 Samples	Morphological	Neural Networks	90-95%
Rad et al. (2012)	Iran	Rice	1500 Samples	Morphological	Feed Forward Neural Network	98.4%.
Lilhare and Bawane (2012)	India	Rice	100 Samples	Morphological	Feed Forward Neural Network	Small, Medium, Large
Ajay et al. (2013)	India	Rice	Mixed Samples	Morphological	Computer Vision	Recognition Rate 75%
Tanck and Kaushal (2014)	India	Rice	5 Samples	Morphological	Machine Vision	90%
Abirami et al. (2014)	India	Rice	77 Samples	Morphological	Neural Network	98.7%
Kambo and Yerpude (2014)	India	Rice	15 Samples	Morphological	KNN Classifier	73%
Kambo and Yerpude (2014)	India	Rice	14 Samples	Morphological	KNN Classifier	79%
Veena and Latharani (2014)	India	Rice	Mixed Samples	Morphological	Digital Image Processing	NR*
Mahale and Korde (2014)	India	Rice	30 Samples	Morphological	Digital Image Processing	NR*
Ghatkamble (2016)	India	Rice	2 Varieties	Morphological	Probability Neural Network	NR*
Kumbharkar et al. (2016)	India	Rice	30 Samples	Morphological	Digital Image Processing	NR*
Patel et al. (2017)	India	Rice	45 Samples	Morphological	Canny Edge Detection	NR*

*Not Reported

B. Research studies based on blending of morphological with other features

Color features of an image contains information about the color distribution, color moments and dominance of colors, Textural features are one of the vital characteristics of objects, in addition to color and shape features. Textural are formed due to variance present in color and the intensity. Shantaiya and Ansari (2010) developed an algorithm of digital image analysis based on color, textural and morphological features for identification of the 6 rice seed varieties. A blend of 9 morphological, 6 color and 2 textural features were considered for purpose of discriminant analysis. A BP ANN classifier was developed for distinguishing of the unknown grain types and delivered the average accuracy of 84.88%. Silva and Sonnadara (2013) developed a system of consisting machine vision and neural network for 9 different rice seeds classification. Different algorithms extracted 13 morphological, 6 color and 15 textural features from each rice seed color image samples. The accuracies of classification were improved impressively with trained system with optimal dataset. The overall accuracy of classification 92% was accomplished with combined feature set. Pazoki et al. (2014) proposed a classification method for 5 main Iranian rice grain varieties. 24 color, 11 morphological and 4 shape features of color images of every individual rice grain were extracted for classification. Neuro-fuzzy and MLP systems yielded 99.73% and 99.46% accuracy for rice grains of different variety. Khunkhett and Remsungnen (2014) applied digital image analysis for non-destructive identification of pure breeding rice seed. The presence of rice, such as, its shape and color is required to be the significant features in agricultural reproducing and quality testing. The right classification rates for two stages are: Good rice seeds 98% and pure breeding rice seeds 82%. Neelam and Gupta (2015) introduced CV system for identification as well as classification of rice. In this, training algorithm was based on using Levenberg Marquardt. The system was trained and tested on given parameters with accuracy approximately 89.7%. Devi et al. (2017) proposed a machine vision algorithm considering about physical and compound features to assess and sorting of rice grains. In the proposed algorithm, average values of the attributes separated were considered for grading and quality analysis of rice grains with the implemented in MatLab with accuracy of 94.28%.

Table 2. Research studies based on blending of morphological with other features

Researchers	Region of Research	Food Type	No. of Samples	Features Used	Techniques	Results / Accuracy
Shantaiya and Ansari (2010)	India	Rice	60 Samples	Color, Morphological, Textural	Image Warping and Image Analysis	84.83%
Silva and Sonnadara (2013)	Sri Lanka	Rice	450 Samples	Morphological , Color, Textural	Multi-Layer Perception	92%.
Pazoki et al (2014)	Iran	Rice	450 Samples	Morphological, Color, Shape	Multi-Layer Perceptron and Neuro-Fuzzy	99.46%, 99.73%
Khunkhett and Remsungnen (2014)	Thailand	Rice	200 Samples	Color , Morphological	Digital Image Analysis, Machine Vision	Good Seeds 98%, Pure Breeding Seeds 82%
Neelam and Gupta (2015)	India	Rice	4 Samples	Morphological, Color	Levenberg-Marquardt	89.70%
Devi et al. (2017)	India	Rice	4 Samples	Morphological , Color, Textural	Machine Vision	94.28%

C. Research studies based on other features

Shape features constitutes visual or external appearance of an image depicting its boundaries whereas geometric features only depict the appearance of an image. Hobson et al. (2007) in their work developed a low cost imaging system of nondestructive and non-intrusive type to analyze characteristics of eight different rice varieties. Techniques of unsupervised clustering were deployed for the assessment of features on different common varieties for their identification. Rad et al. (2011) proposed a system for classification of five Iranian rice varieties considering texture and color features. An aggregate of 60 texture as well as color features of rice kernels were extracted. 22 superior features were picked after removal of irrelevant, noisy and redundant data by four distinct algorithms from the set of features. For classification purpose, a BP Classifier was proposed which yielded accuracy of 96.67%. Kaur and Singh (2013) proposed a multi-class SVM for classification and rice grading. Firstly, Noise was expelled from captured images during preprocessing and images converted into binary images using image segmentation. The geometric features were considered for determination of head rice, brewers and broken rice rate in rice samples. Multi-class SVM examined shape, chalkiness and percentage of broken kernels, for classification, accurately above 86%. Chaugule and Mali (2014)

proposed algorithm for classification of grains based on shape, texture and surface n-shape features. Various algorithms were produced for extraction of features from high-resolution images of rice kernels of 4 grain types for order. The accuracy delivered by various features for example 82.61% for shape, 88.00% for texture and 87.27% for texture n-shape respectively. Siddagangappa and Kulkarni (2014) suggested an automatic probabilistic neural network for distinguishing proof and quality investigation and grading. The proposed neural system used color as well as geometrical features for classification. The size of rice grain kernel and impurities present in kernel were considered for rice grading purpose. The proposed network model succeeded in achieving accuracy of 98%, 90% and 92% for identification, quality determination and grading respectively. Tahir et al. (2015) discussed about the various methods utilized for quality analysis and grading of rice with the help of image processing. They proposed the use of another method with accuracy of just 46.60% using image processing for the quality analysis and grading of rice based on color, shape and length features. Anami et al. (2015) proposed a method for identification of paddy rice grain varieties from bulk paddy rice grain image samples based on color as well as textural features of 15 paddy varieties. The color as well as textural features was extracted from H, S and I shading planes and their combinations. The reduced feature set of the HSI plane incorporates Energy, Entropy and Correlation features from Hue plane and Energy, Entropy, Contrast, and Correlation features from Saturation plane. The paddy grain images are recognized a multiplayer feed-forward artificial neural system with 92.33% recognition accuracy. Pandey et al. (2015) used technique of content based image retrieval with help of ANN and Euclidean distance for seed classification automatically considering features (shape, color) of food grains and achieved accuracy by ANN and ED, 95% and 84.4% respectively. Patil and Malemath (2015) proposed image processing framework considering about morphological features for rice grading. The images of rice were at first preprocessed and the individual rice grains were segmented. The features of geometric nature of rice grain like major axis length as well as minor axis length and area were extracted and classification of grain was done as grade I, grade II and grade III with achieving 93% accuracy. Wah et al. (2018) proposed a image processing algorithm for rice grading. The proposed algorithm's performance was tested with three grades of Paw-San rice. The proposed algorithm yielded accuracy for three Classes A is 100%, B is 93% and C is 83% respectively during testing of Paw-San rice. Kuchekar and Yerigeri (2018) proposed a system consisting of image processing for grading of rice grains using features of physical and chemical nature. The image segmentation was applied to segment the individual grains subsequent to preprocessing and afterward features like area, length of major axis as well as minor axis were extracted. They used grain length to determine rice grading.

Table 3. Research studies based on other features

Researchers	Region of Research	Food Type	No. of Samples	Features Used	Techniques	Results / Accuracy
Hobson et al. (2007)	UK	Rice	8 Samples	Shape , Textural	Unsupervised Clustering,	NR*
Rad et al. (2011)	Iran	Rice	500 Samples	Color, Textural	Feed-Forward Neural Network	96.67%
Kaur and Singh (2013)	India	Rice	5 Samples	Chalky Volume, Shape, Purity	Multi-Class SVM	86%
Chaugule and Mali (2014)	India	Rice	Samples of 4 Varieties	Texture, Shape, Texture-n-Shape	Back Propagation Supervised Neural Network	85.96%
Siddagangappa and Kulkarni (2014)	India	Rice	150 Samples	Color, Geometrical	Probabilistic Neural Network	92%
Tahir et al.(2015)	Malaysia	Rice	285 Samples	Color, Shape	Supervised Learning	46.60%
Anami et al. (2015)	India	Rice	Samples of 15 Varieties	Color, Textural	Multilayer Feed Forward Neural Network	92.33%
Pandey et al. (2015)	India	Mixed	200 Samples	Shape, Color	Euclidean distance, ANN	84.4%, 95%
Patil and Malemath (2015)	India	Rice	105 Samples	Geometrical	Decision Tree Classifier	93%
Wah et al. (2018)	Myanmar	Rice	329 Samples	Real-Field	KNN Classifier	92%
Kuchekar and Yerigeri (2018)	India	Rice	16 Samples	Physical, Chemical	Digital Image Processing	NR*

*Not Reported

V. Results and Discussions

During the present study it is evident that numbers of samples and accuracy are inversely proportional to each other using the only single features with traditional techniques of image processing. But when researchers used the mixture of features with techniques of machine learning as well as deep learning the accuracy becomes directly proportional to numbers of samples i.e. accuracy increases with increase in numbers of samples.

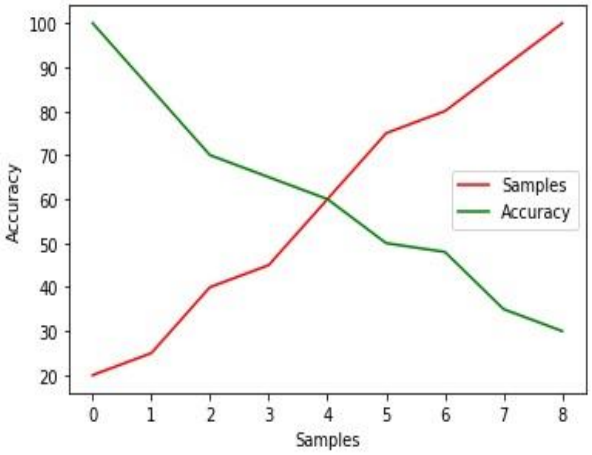

Figure 2. Results of using single features with traditional techniques

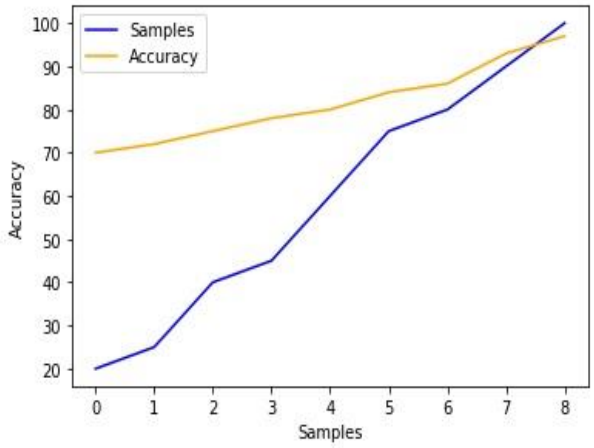

Figure 3. Results of using mixed features with machine and deep learning techniques

Conclusion

In this review paper, an exhaustive study of different research works is carried out using different techniques of machine learning, deep learning and image processing for automation of quality analysis and grading of rice in field of agriculture. It is found that morphological features of rice were the main focus of researchers to attain high accuracy in determining quality or grading of rice. Most of the researchers used other features of rice like color, texture and shape features in conjunction with morphological features to achieve higher rate of accuracy. There is a trend showing that in the quality grading of rice, the blend of the two features i.e. morphological and color, results in higher accuracy. It is evident from this study that classification accuracies further improved to a great extent with expansion of textural, shape and other features. At the point when various varieties' different features were tested for classification purpose, the resulted accuracies were very high. Although, need of selecting most appropriate techniques for decision making as an effective tool for the quality determination of rice grains, arises.

It is evident that these research studies have contributed immensely in achieving the goal of optimizing food production at world level by proposing new methods for the rice quality grading process. In future, new systems with higher accuracy can be developed with the help of ever advancing new technologies of machine learning, deep learning and image processing using conjunction of different combined feature set with a larger dataset of distinct rice varieties

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