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Rice Grain Classification using Fourier Transform and Morphological Features

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Abstract

Background: Rice (Oryzasativa) is one of the most widely consumed staple foods, especially in the Asian subcontinent. Traditionally, grain testers who make use of calipers and other specialized tools for measuring features of grains are employed for classifying rice grains into different varieties. However, besides size and shape, various other characteristics, such as whiteness and chalkiness, also contribute towards its taste and overall quality. **Objective:** Computerized classification of rice grains can help in reducing errors of manual grading and in considering more features that indicate quality. The proposed work considers few commercially available rice grains in the South-Indian region to identify new attributes for better grain classification. **Methodology:** Rice samples were collected from rice outlets across Karnataka. Images of the grains were captured using flat-bed scanning technique and processed to extract new features that represented chalkiness and whiteness of grains along with other morphological features such as area, perimeter, major and minor axes, etc. Machine learning algorithms were used to create classification rule. **Findings:** The new features extracted were found to contribute significantly towards the classification. Nine varieties of rice grains were considered for the study and the system was able to successfully classify the grains with an accuracy of 95.78% using the NB Tree and SMO classifiers. **Novelty:** Many studies that consider the morphological features of grains such as its area, shape etc. have already been performed. However, the shapes and sizes of the different varieties are too varied to generalize a common formula for the classification of all varieties of rice. In this paper, Fourier features are also extracted from grain images in addition to the spatial features to arrive at an improved accuracy for classification.

Keywords: Fast Fourier Transform (FFT), Grain Classification, Naive Bayes Tree (NB Tree), Rice (Oryzasativa), SMO (Sequential Minimal Optimization)

1. Introduction

India is the second largest producer of rice in the world after China. Being a tropical plant, it sustains comfortably in hot and humid climate that India has to offer. Due to its long history of cultivation and selection under diverse environments, O. sativa has acquired a broad range of adaptability and tolerance so that it can be grown in a wide range of water-soil regimens[1]. Besides India and China, rice has proved to adapt well in many countries such as Indonesia, Bangladesh, Vietnam and many others. This wide geographical scatter results in differences in climate, temperature, soil mineral and moisture content, humidity etc. Such variations in their growing conditions bring about changes in their interior chemical composition as well as physical structure. A few of the factors that contribute towards the different varieties are summarized in Figure 1.

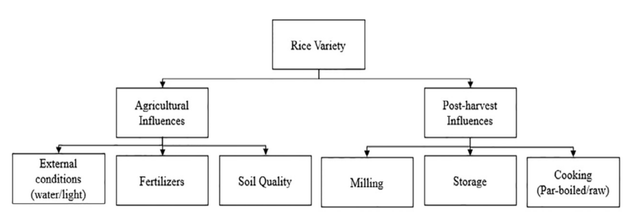

Figure 1. Factors contributing to different rice varieties.

The taste, aroma and quality of each variety differ and each variety is, therefore, used for a different purpose. The quality and variety of rice grains is usually determined

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based on its shape features (such as roundness, length, area, perimeter etc.), color features (such as chalkiness, whiteness and milling degree) and chemical features (such as amylose content, gelatinization temperature and gel consistency). Proper classification of grains is very important to make the best use of each kind and to improve the quality of rice exports in the country. In the field of agriculture, numerous attempts that make use of image processing have been made to improve the quality of products. The application of image processing in rice grading has been the focus of numerous works and many systems have been developed that can effectively classify grains based on their physical features such as shape, area etc.

Although studies have been made to identify rice grains based on color and texture features, the application of the same for Indian varieties, specifically in the Southern region are yet to be verified. Moreover, the use of frequency spectrum based features in rice grain classification has not received much consideration. More beneficial features of the image can be obtained from the frequency domain than in the spatial domain. The frequency domain representation of an image can accurately capture the changes in intensity between the pixels in the spatial domain image. Hence, the minute changes in pixel intensity on the epidermis of rice grains, which represents chalkiness and whiteness of the grain, can be captured with the help of Fourier features.

Many works have made use of external morphological features for classification of grains[2–6]. A neural network using Scaled Conjugate Gradient for grading of basmati rice granules based on major axis, minor axis area and perimeter of the kernels was set up in[2]. The system made use of median filters, thresholding and canny edge detection to acquire the dimensions. Another solution to the problem of basmati rice grading using physical features was presented in[3] wherein grain shape and size were acquired using edge detection algorithms. Based on the length, breadth and length-breadth ratio of entire sample, each grain was classified into one of five classes. Top hat transformation was used to eliminate the problem of non-uniform illumination before extracting the features of basmati grains to classify between long, normal and small grains in[4].

Other works were identified to have concentrated on shape of the grains as the main feature for classification[7], introduced parametric superiority method for quality assessment and Q-curves for quantification and assessment of rice grains based on major and minor axes, eccentricity and area of the grains. A new system to describe rice kernel boundaries using a Radius Fourier Descriptors which enables the inclusion of almost all the shape information of rice kernels was presented in[8]. Multi-class SVM was used to extract ten geometric features and identify the percentage of head rice, broken and brewers kernels in a sample of rice in the study performed by[9].

Many classifications were performed based on area of grains as the main feature[10,11] made use of area of rice grains to classify them into small, medium or large. Purity of rice sample was also predicted by[11] by making use of the area of rice grains. Another approach towards purity was devised by[12] for the classification of ‘KhaoDawk Mali 105’ rice grains into pure and impure breeding seeds. The RGB features of the rice images were captured and fuzzy rules were developed for pure breeding seeds. Color features were used for classification in[13] also wherein individual neural networks for the morphological, color and texture feature sets of rice grain images as well as a combined neural network from all the feature sets for the classification of 9 rice samples were developed.

Various machine learning algorithms were used by many researchers to draw classification rules from their datasets[14–16]. However, it was evident that most researchers have made use of only spatial domain features for classification. Not much work has been done that considered Fourier based features for classification of rice grains. Moreover, there hasn’t been much research work done for classifying commercially available rice grains in the South Indian region. This motivated us to work on classifying South Indian rice grains using Fourier features. In this study, the classification of grains is carried out in two levels. Primary classification is carried out to classify grains into Basmati, Broken, Idli, Red raw and Sona rice grains. Further classification is carried out in the next stage to classify Sona grains further into Bullet, Boiled, SG, Supreme and Titanic Sona grains. NB Tree and SMO (Sequential Minimal Optimization) classifiers are used for the first and second level classifications respectively.

2. Materials and Methods

2.1 Data Collection

The dataset for the work was collected from retail rice outlets across Karnataka and comprised of nine varieties of rice which are most commonly consumed by the people of the region. The varieties considered are mentioned below:

- Basmati rice.
- Broken rice.
- Red raw.
- Idli rice.
- Supreme Sona.
- Titanic Sona.
- SG Sona.
- Bullet Sona.
- Sona boiled.

Flatbed scanning technique was used to capture image of samples from each variety. A sample drawn from each variety was placed on a flatbed scanner and a thick black paper was placed over the grains to obtain a uniform background. The grains were scanned using an HP Scanjet 2610 model flatbed scanner with a resolution of 300 dpi. This technique is used as it eliminates problems of non-uniform illumination and variation in the distance between camera and rice samples Figure 2. In this manner, a scanned image was obtained for each of the nine varieties of rice considered.

Further, individual grain images were cropped from the whole image using the bounding box algorithm Figure 3. For each rice sample, an average of 40 grains was considered.

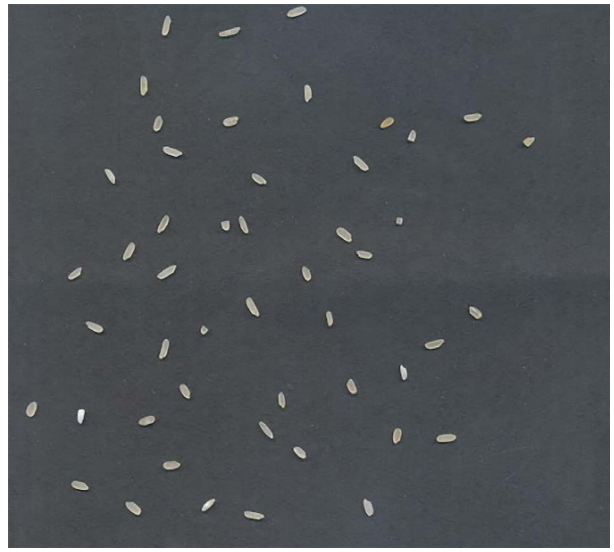

Figure 2. Image obtained using flatbed scanning technique.

The cropped grains were named in the order in which they were detected in the whole image of the sample and saved in the disk in .jpg format Figure3.

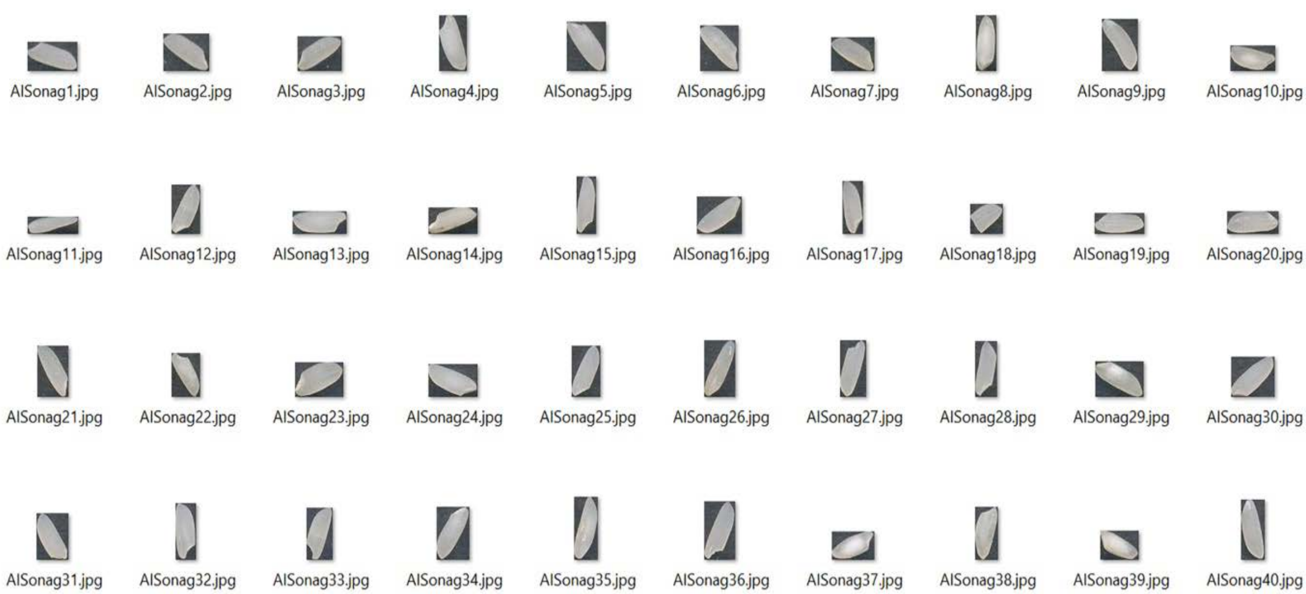

Figure 3. Individual grains extracted from whole image of sample.

2.2 Preprocessing

Since most preprocessing steps would interfere with the transition in pixel intensities within the image, the images were not subjected to preprocessing steps that could tamper the actual pixel frequencies. They were segregated into their different color spectrums to extract features from each spectrum.

2.3 Feature Extraction

2.3.1 Fast Fourier Transform (FFT)

The Fourier Transform is used to represent an image in its frequency domain Figure 4. The output of the transformation represents the image in the frequency domain. FFT is used to extract value that represents the change in pixel intensity. This value is expected to represent the internal composition of rice kernels as the change in external color is a reflection of internal health of kernel.

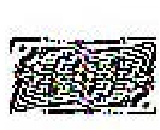

Figure 4. Image of grain in frequency domain after applying FFT to the image.

The features extracted were the standard deviation of the real part of the center of the image which contains the most information regarding the image. Other features extracted using Fourier transform included the standard deviation of the real part of the frequency domain image as a whole in red, green and blue spectrums. The standard deviation of the center of the shifted image was identified as the best feature that contributed most to the classification.

The algorithm for extracting the frequency features of the grains is as follows:

Algorithm (Fast Fourier Transform).
Input: Scanned image of rice grain.
Output: Feature vector.
Method:

- Separate Red, Green and Blue components of the original image. This forms 3 images.
- Apply Fourier Transform to these three images to obtain the frequency spectrum of rice seed images.
- Extract low frequency component from the Fourier transformed images using low pass filter.
- Calculate standard deviation for the real part of low frequency images.

2.3.2 Morphological Features

In addition to the frequency related features of the image, morphological features such as the area, perimeter, major axis length and minor axis length are also extracted from the grain images using MATLAB.

2.4 Classification

Classification is performed on the data set using WEKA tool. Supervised classification techniques are used to classify the grains into different kinds. The rice grains are classified in two stages: First stage comprises classification among primary grain categories, i.e. Basmati, Broken, Idli, Red Raw and Sona grains. In the second stage, Sona grains are further grouped into Bullet Sona, Supreme Sona, Titanic Sona, SG Sona and Sona boiled grains.

The proposed work flow is depicted in the Figure 5.

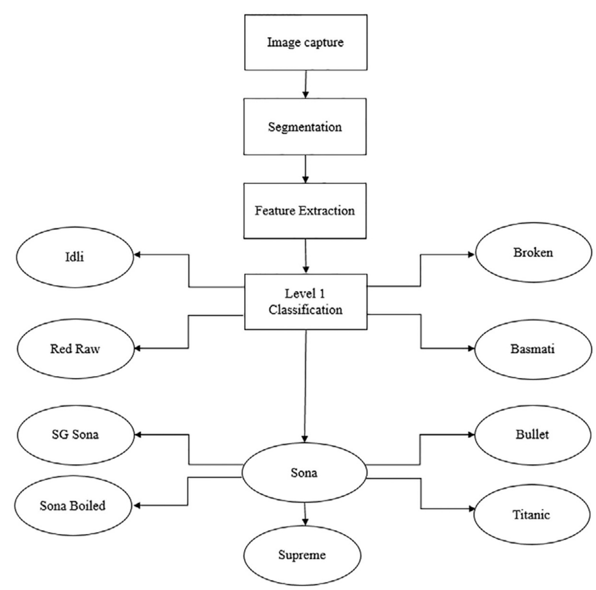

Figure 5. System flowchart.

3. Results and Discussion

The classification performed using Multi-layer perceptron, Naive Bayes Tree and SMO classifier. To measure the performance of the proposed system, both

70-30 and 80-20 percentage splits were considered for training and testing. Moreover, k fold cross validation was also performed for different values of k as mentioned in the result Tables 1 and 2.

The results obtained for the primary classification, i.e. between Basmati, Broken, Idli, Red Raw and Sona grains are depicted in Table 1.

Table 1. Results of primary classification

Classifier	% Split		Cross Validation folds		
	70%	80%	3	7	10
Multi-Layer Perceptron	89.62	90.14	89.23	90.09	90.65
NBTree	93.40	95.78	90.37	91.21	92.92
SMO	93.40	94.37	90.66	92.35	92.91

The results were observed to be most encouraging when the experiment was carried out using NB Tree classifier with an accuracy of 95.78%. Other classifiers were also observed to achieve above average accuracies.

Similarly, the second stage classification was able to achieve an accuracy of 87.07% using the SMO classifier. The results are shown in Table 2.

Table 2. Result of secondary classification

Classifier	% Split		Cross Validation folds		
	70%	80%	4	7	10
Multi-Layer Perceptron	84.90	80.56	85.96	84.27	85.96
NBTree	86.80	86.11	82.02	78.09	80.90
SMO	83.01	86.11	85.40	82.59	87.08

The Fourier features extracted were found to contribute significantly towards the classification as it was able to classify even amongst the different varieties of Sona grains with above average accuracy.

4. Conclusion

In this work, new features for classification of rice grains were presented. Both spatial and frequency based features were used for classification of 9 varieties of commercially available grains in the South Indian region. The classification is performed in two stages that make use of NB Tree classifier in the first level and SMO classifier in the second level. The study was able to achieve remarkable accuracy as it made use of internal features of the grains in addition to the spatial features. Hence, the frequency domain features were observed to be a good feature set for classification. The scope of this work can be further enhanced by making use of photographic images for classification as the current system suffers from a number of environmental constrains

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