A Computer Vision Approach for Grade Identification of Rice Bran

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***Abstract*— Inspection of food quality is an important operation in food and agro industries. Nowadays computer vision is frequently used for such operations as it can provide fast, economical, non-invasive, consistent and objective assessment. This paper presents a study on identifying the qualitative grades of rice bran using computer vision. The study is performed using three samples of rice bran collected from rice mills along with their test reports to confirm their qualitative difference. The images of individual samples were captured in a controlled illumination environment. The image features were extracted from the cropped images after the required color conversion. The constructed feature sets were subjected to principle component analysis (PCA) for observing the cluster formation and also the K-Means cluster analysis to derive the cluster centers. The clustering analysis results show the potential of the presented method for identification of rice bran grades.**

***Keywords*— computer vision; color features; rice bran identification; cluster analysis**

I. Introduction

Quality of the food and agro product is an important aspect in todays' world. There are different standards like Hazard Analysis and Critical Control Points (HACCP) and ISO 9000 certificates been actively involved to evaluate and meet quality of such products [1]. The quality of food been assessed against many parameters that involve the chemistry of the food, the bio-agent and microbiological agent in the food, the presence of contaminating agent and many other important parameters. Observations reveal that differing from the desired composition and condition of the food and agro products results in visual changes in the food which may not be well visible always. This is one of the major reasons for popularity of applying computer vision for food and agro products' quality assessments.

Food quality assessment using computer vision is a popular research domain as it offers many advantages over conventional food and agro product testing methods like, easy implementation, non-invasive testing method, less expensive testing setup, no human intervention and subjective assessment and so on. It has been used in diverse food and agro products for example for potato sorting [2], meat and fish, pizza, cheese, bread [3], etc. Readers may find brief overview with many such applications in [4]. Rice grading using image processing has been also reported [5]. However, effort for quality assessment of rice bran using computer vision is not well reported to the best of our knowledge. The potential of gray level co-occurence matrix (GLCM) texture features for food classification been presented in [6].

Rice bran comes during the rice milling process as a by-product of rice. It contains fat, protein, fiber and many important nutritious components [7, 8]. It is majorly used for edible oil manufacturing. It is popularly used in East Asia and currently it is getting its popularity in India as well.

Rice bran is generally available in different qualities based on the oil content and some common gradations are i) raw rice bran having oil content (16 – 18) %, ii) boiled rice bran having oil content (20-26) % and iii) rough bran having oil content (10-12) % with high mixture of sand and silica content.

This paper aims to identify such grades using computer vision. The basic steps of computer vision based identification systems are employed while the color features been explored. The color feature extraction is performed in Hue-Saturation-Value (HSV) mode which is a device-independent color mode. The statistical values from the HSV channels are extracted to construct the feature sets. The feature sets are further subjected to PCA analysis [9] and observed visually along with the cluster centers obtained using K-means [10] analysis. The results show that the HSV color channel based statistical features can generate clusters for different sample with considerable seperability.

II. Presented Method

Raw samples of rice bran are mainly produced during rice milling where paddy rice goes to the silo section through the sample cleaning section. Then de-stoner section is used for separation of paddy rice from dust and stone. Then the outer layer which is mostly known as husk is separated from the paddy rice by the next separator section unit. Finally in polisher section the raw rice bran are processed from boiled rice. This is raw rice bran which is main raw materials for bran oil extraction process.

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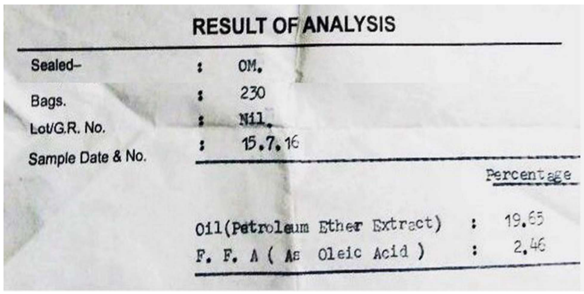
A. Rice Bran Sample Collection

The study was initiated by collecting the rice bran samples from different rice mills and then they were subjected to the conventional testing process to know their oil content. In rice mill, mainly two types of rice brans are processed , among which the first high-quality raw bran is used for the rice bran oil and the other low-quality bran is useful in the livestock feed. The quality of rice bran is generally assessed by the conventional test machineries which generate the report indicating the oil content in terms of free fatty acid (FFA). One sample of such reports is shown in Fig. 1 which indicates the FFA in terms of percentage.


RESULT OF ANALYSIS

Sealed– : OM.
Bags. : 230
Lot/G.R. No. : Nil.
Sample Date & No. : 15.7.16

Percentage

Oil(Petroleum Ether Extract) : 19.65
F. F. A (As Oleic Acid) : 2.46

Fig. 1. Sample test report.

B. Image acquistion and preprocessing

In this step the collected rice brand were placed in a controlled illumination chamber and the images were captured using high resolution camera maintaining a fixed distance of 35mm between the sample and the lens. A sample of captured images is shown in Fig. 2

Then the captured images were cropped into 600×600 pixel dimension based on the homogeneity in pixel intensity distribution. A simple neighborhood approach was employed to select the homogenous regions and some samples of the cropped images are shown in Fig. 3.

Fig. 2. Sample of captured images.

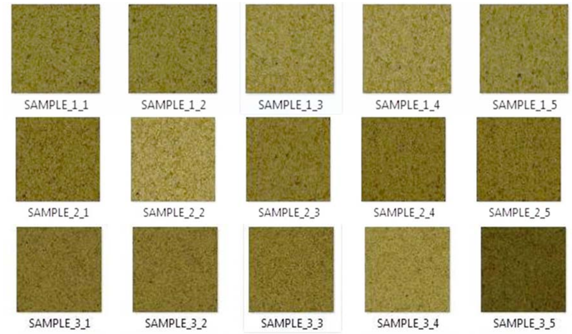


Fig. 3. Sample of cropped images *(top row)* grade 1; *(middle row)* grade 2 and *(bottom row)* grade 3.

C. Color conversion and feature extraction

The captured images were in RGB format which is a device dependent format. Hence, the images were converted to the HSV color mode which is device independent. The RGB to HSV conversion was carried using standard mathematical equations [11]. The features were extracted from each H, S and V channels. The sample of converted image and each channel are presented in Fig. 4.

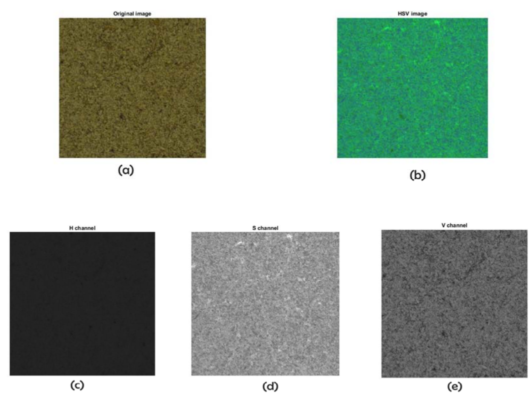


Fig. 4. Sample converted image a) original RGB image, b) HSV converted image, c) H channel, d) S channel and e) V channel.

The color channels were then subjected to statistical calculations for feature set construction. For each channel the mean, median, maximum and minimum values were added to the feature set. In addition two values were included. The entropy of the texture feature calculated from gray level co-occurrence matrix (GLCM) [12] of each channel and the channel-wise singular value decomposition (SVD) values were included in the feature set.

The co-occurrence metrics obtained using GLCM dynamics contains a correlational statistical between the intensity values of neighboring pixels. GLCM technique fundamentally generates a matrix where the number of rows and columns is equal to the number of gray levels (G). Among different Haralick features [12] extracted from the GLCM, entropy as expressed in equation (1) was used in this work. Entropy measures the informational fidelity in the transmitted signal.

$$\text{Entropy} = -\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j) \times \log\left(P(i,j)\right) \quad (1)$$

where, $P(i,j)$ is the probability obtained from the GLCM matrix.

Singular value decomposition (SVD) [13] for the $m \times n$ data matrix X can be expressed as equation (2).

$$X = UD\,V^t \quad (2)$$

where, U, the left singular vectors, is $m \times n$ orthogonal matrix i.e. $UU^t = V^tV = I$ and V, the right singular vectors, is $n \times n$ orthogonal matrix i.e. $VV^t = V^tV = I$ and D = *diag (d1, d2, dn)* with the singular vectors $d_1 \geq d_2 \geq \ldots. \geq D_n \geq 0$.

D. PCA and K-means based clustering

Principle component analysis is a popular technique majorly used for dimension reduction [9]. It creates subspaces of original data space by combining variable present in original data linearly. It finds the components with maximum variance and often used for visual representation of data.

The K-means clustering is used to calculate the cluster centers. This is an iterative technique that assesses the possible cluster centers for defined number of clusters *(k)* by minimizing an objective function expressed as equation (3) [10].

$$\min_{\{m_k\},1\leq k\leq K} \sum_{k=1}^{K}\sum_{x\in C_k} \pi_x \, dist(x, m_k) \quad (3)$$

where, K is the user defined number of clusters (3 in our case), n_k data objects are assigned cluster C_k with the cluster center m_k calculated as equation (4) [10].

$$m_k = \sum_{x\in C_k} \frac{\pi_x x}{n_k}, \quad 1 \leq k \leq K \quad (4)$$

The 'dist' function is the distance, generally calculated as Euclidian distance, between the data and the assessed cluster centers.

III. Results and Dicussions

The results of channel-wise PCA analysis are presented in Fig. 5. Fig. 5 clearly shows that the three different clusters are produced with H channel. S channel also provides different clusters but not at the degree to which the H channel does. But in V channel the amount of overlap is visibly high. Hence, among three channels the H channel result may be most acceptable. Further to the PCA analysis the K-means clustering generates the cluster centers as shown by black symbols in the plots of Fig. 5. This also reflects that the cluster centers are well apart in case of H channel, but not that visibly separate in S or V channel.

However the visual observation may be subjective and can vary from viewer to viewer. Thus a separability measure was performed using two different techniques [14, 15]. The output of separability measure as presented in Table 1 also confirms the observations drawn from the visual assessment. It can also be observed that the class separability in H channel with method [15] is considerably high which favors the use of presented technique in identification of rice bran grade.

TABLE I. Class Separability

Methods	**H**	**S**	**V**
[14]	*10.25888664*	*2.411280144*	*0.166579657*
[15]	*30.2680452*	*4.827688291*	*4.776251365*

IV. Conclusion

In this paper a computer vision based approach towards rice bran qualitative grades been presented. The samples collected from actual rice mills were subjected to conventional testing process to confirm their grades in terms of FFA present in the collected samples. The sample images were captured and preprocessed for feature extraction. The images were converted to HSV color mode and feature sets were constructed using the statistical measures from the channel-wise data. The constructed feature sets were subjected to the PCA and K-means analysis and found that H channel data can provide clusters with considerable separability as measured using separability index measures. The work can further be extended to the classification using classifiers, more robust feature extraction, inclusion of prediction models, etc. Finally, the presented work may be considered as a potential approach towards qualitative classification of rice bran grades.

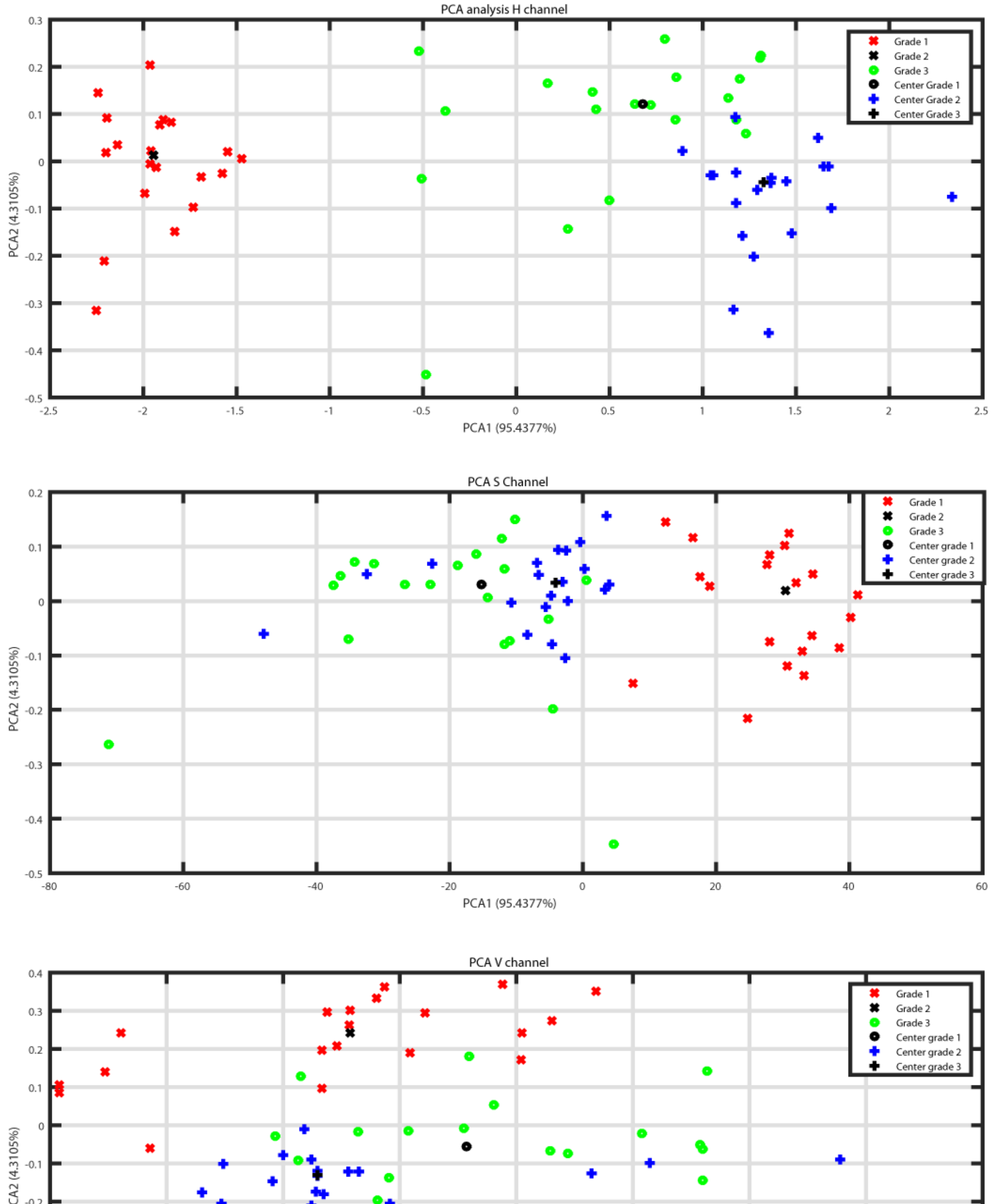


Fig. 5. PCA analysis with centers obtained using K-means clustering; (*top*) H channel, (*middle*) S channel and (*bottom*) V channel.

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