IDENTIFICATION OF SEEDS OF DIFFERENT RICE VARIETIES USING IMAGE PROCESSING AND COMPUTER VISION TECHNIQUES

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ABSTRACT

This paper presents a system for automated classification of rice varieties for seed production using computer vision and image processing techniques. Rice seeds of different varieties are visually similar in color, shape and texture that make the classification of seeds of different varieties at high accuracy for evaluation of genetic purity challenging. We investigated various feature extraction techniques for efficient rice seed image representation. We analyzed the performance of powerful classifiers on the extracted features for finding the robust one. 1026 to 2229 images each of six different rice varieties in northern Viet Nam were performed. Our experiments have demonstrated that the average accuracy of our classification system can reach 90.54% by using Random Forest method with a basic feature extraction technique. This result can be used for developing a computer-aided machine vision system for automated assessment of varietal purity of rice seeds.

Keywords: Computer vision, GIST features, morphological features, Random Forest, rice seed, SVM.

Nhận dạng hạt thóc giống sử dụng kĩ thuật xử lý ảnh và thị giác máy tính

TÓM TẮT

Bài báo này giới thiệu về một hệ thống tự động nhận dạng hạt thóc giống phục vụ cho quy trình sản xuất thóc giống ứng dụng kĩ thuật xử lý ảnh và thị giác máy tính. Hạt thóc của những giống lúa khác nhau khi nhìn bằng mắt thường là rất giống nhau về màu sắc, hình dáng và kết cấu bên ngoài. Điều đó làm cho việc phân biệt các loại thóc giống khác nhau với độ chính xác cao nhằm đánh giá độ thuần chủng của thóc là một thách thức lớn. Chúng tôi tập trung vào các kĩ thuật khác nhau để trích chọn đặc trưng hình ảnh của hạt thóc giống thông qua ảnh chụp các giống lúa một cách hiệu quả. Sau đó chúng tôi phân tích hiệu năng của các bộ phân loại dựa trên các đặc trưng được trích chọn ở trên để tìm ra một phương pháp phân lớp có độ chính xác cao nhất. Hình ảnh của sáu giống lúa khác nhau đã được thu nhận ở miền Bắc Việt Nam, trong đó mỗi giống có từ 1026-2229 hình ảnh hạt lúa. Những thực nghiệm của chúng tôi đã chỉ ra rằng hệ thống phân lớp đạt độ chính xác cao nhất 90.54% khi sử dụng phương pháp rừng ngẫu nhiên dựa trên bộ đặc trưng cơ bản. Kết quả này có thể sử dụng để phát triển một hệ thống thị giác máy tính hỗ trợ việc đánh giá tự động độ thuần chủng của hạt thóc giống.

Từ khóa: Đặc trưng hình thái, đặc trưng GIST, hạt thóc giống, rừng ngẫu nhiên SVM, thị giác máy tính.

1. INTRODUCTION

Rice is the most important food crop in Viet Nam and many other countries. To obtain high crop yield , high seed quality is required, in which the genetic purity of seeds is one of the most important characteristics. The production of rice seed includes a certifivation program for quality control. Rice seeds must be dried, cleaned, and uniform in size. For the purity, the rice seeds variety must not be mixed with seeds from other varieties and have high germination

rate (greater than 85%). The assessment is to see whether the visual appearance of the seed samples meets the required standards. Currently in Viet Nam, this process is done manually by naked eyes of experts/technicians at the seed processing plants and seed testing laboratories. It is laborious, time consuming, and inefficient. Hence, developing an automatic computer-aided vision system to assess rice seeds is a demanding task.

Computer vision and image processing have attracted more and more interest of researchers because of its wide applications in many fields, ranging from industry product inspection, traffic surveillance, entertainment to medical operations (Szeliski, 2010). In agricultural production, it has been successfully applied to automatic assessing, harvesting, grading of products such as food, fruit, vegetables or plant classification (Tadhg and Sun, 2002; Du and Sun, 2006). Machine vision was also utilized for discriminating different varieties of wheat and for distinguishing wheat from non-wheat components (Zayas et al., 1986; Zayas et al., 1989) or for identifying damaged kernels in wheat (Luo et al., 1999) using a color machine vision system.

Several computer-aided machine vision systems, that automatically inspect and quantitatively measure rice grains, have been widely developed (Sun, 2008; van Dalen, 2006). These systems use computer vision technologies including several stages, which require advanced computer knowledge, especially in artificial intelligence. The most important steps are image data collection, feature extractions (such as shape, size, color, and orientation etc.) and their representation, model/algorithm selection and learning, and model testing. For example, van Dalen (2006) extracted characteristics of rice using flatbed scanning and image analysis. Jose and Engelbert (2008) investigated grain features extracted from each sample image. They then utilized multilayer artificial neural network models for automatic identification of sizes, shapes, and variety of samples of 52 rice grains. Goodman and Rao

(1984) measured physical dimensions such as grain contour, size, color variance and distribution, and damage while Lai et al. (1982) applied interactive image analysis method for determining physical dimensions and classifying the variety grains. Sakai et al. (1996) demonstrated the use of two-dimensional image analysis for the determination of the shape of brown and polished rice grains of four varieties. Zhao-yan et al. (2005) implemented identification method based on neural network to classify rice variety using color and shape features. Mousavirad et al. (2012) used morphological features and back propagation neural network to identify five different varieties And Kong et al. (2013) proposed to use Near – Infrared hyperspectral imaging and multivariate data analysis for identifying rice seed cultivar.

In Viet Nam, Industrial Machinery and Instruments Holding Joint Stock Company (IMI) has developed a machine for sorting rice grains. Thee main function of the machine is to classify grains utilizing simple boundary detection techniques and sensors for separating rice grains from artifacts (such as glass, brick rice) based on reflections of the IR light source. The system was developed for rice grain classification of colored and broken grains. It was not designed for rice seed purity assessment and rice identification has not been used by seed processing plants and farmers.

Sun (2008) showed that visual attributes of rice grains that affect the quality evaluation have been investigated using various computer vision techniques and there are many computer vision systems for industrial applications as well as in agriculture as previously mentioned. However, up to our knowledge, there was no any machine vision system for analyzing the visual features of rice seeds to determine the varietal purity of seed samples in rice seed processing. Therefore, in this paper, we focused on analyzing visual features (such as color, shape, and texture of the seeds) for efficient representation of rice seed images. We then implemented different advanced machine

learning techniques such as SVM, RF to evaluate rice seed images using these features. This allows one to select the best features for rice seed image description and a classifier with high accuracy to classify rice seed varieties. The system can assist recognizing the desired variety at high accuracy and can be deployed to aid technicians at the rice seed processing plants. The remainder of this paper was organized as follows. Section 2 introduces materials and methods. Section 3 demonstrates our experimental results and discussion. Conclusion and future work are described in Section 4.

2. MATERIALS AND METHODS

2.1. Rice seed samples

Six common cultivated rice varieties in Northern Viet Nam, viz. *BC-15, Hương thơm 1, Nếp-87, Q-5, Thiên ưu-8, Xi-23* were considered. Rice seeds were sampled from a rice seed production company where the rice was grown and harvested following certain conditions for standard rice seeds production (Thai Binh and Ha Noi regions in the north of Viet Nam).

Image Acquisition

A CMOS image sensor color camera (NIKON D300S) with resolution of 640 x 480 pixels was used to acquire images. We set up a chamber with a white table as background for taking images. Rice seeds are manually spread inside an area of 10x16 cm. Each image taken by this imaging system contains about 30 to 60 seeds. We then separated rice seed images and realized the image segmentation.

2.2. Image description

Once the image of a rice seed wasis segmented, the image descriptor was computed to input to a classifier. The image descriptor describes properties of image, image regions or individual image location. These properties are typically called "features". Research in the field of image description or feature extraction started in the 60's. Until now, a variety of image descriptors has been proposed. They can be divided into categories following some criteria such as global vs. local, intensity vs. derivative or spectral based. In general, a good feature should be invariant to rotation, scaling, illumination, and viewpoint changes.

In this work, we investigated four feature types that could be considered as representative of a main groups of features: global features (morphological features, color, texture, GIST). Morphological features are the most typical features to describe the shape of the object in image. Color and texture are very useful to distinguish objects when their shapes remain similar. GIST is a global feature computed based Gabor filter bank applied on the whole image (Oliva and Torralba, 2001). GIST shows to be very efficient for scene classification.

2.3. Basic descriptor

This is a combination of morphological features, color features and texture features to build a descriptor; we call it *basic descriptor* for reference.

a. Morphological descriptor

The morphological features were extracted from the images of individual rice seeds. A morphological feature descriptor with 8 dimensions is calculated as following:

- Area: the number of pixels inside, and including the seed boundary.
- Length: the length of the minimum bounding box of the rice seed.
- Width: the width of the minimum bounding box of the rice seed.
- Length/width: the ratio of length to width.
- Major axis length: the longest diameter of ellipse bounding rice.
- Minor axis length: the shortest diameter of ellipse bounding rice.
- Area of convex hull.
- Perimeter of convex hull.

b. Color

The RGB components of all images were analyzed. We got the mean values of individual

channels. The color feature of rice seed for image analysis consist of 6 dimensions:

- *R, G, B:* the mean values of R, G, B channel.

- *RS, GS, BS* : square root of the value mean of channel R, G, B.

c. Texture

Texture feature are calculated as:

Mean (m): $\sum_{i=1}^{L-1} z_i p(z_i)$

Standard deviation (σ): $\sqrt{(z_i - m)^2 . p(z_i)}$

Uniformity: $\sum_{t=0}^{L-1} p^2(z_i)$

Third moment : $\sum_{i=1}^{L-1} (z_i - m)^3 p(z_i)$

Where, z_i is the gray-scale intensity, $p(z_i)$ is the ratio of number of pixels that have the intensity z_i and number of pixels in an image. The texture feature has 4 components.

Finally, we combine (morphological, color, and texture descriptors to obtain 18 dimensions descriptor.

2.4. GIST descriptor

Oliva and Torralba (2001) proposed the GIST descriptor for scene classification. This descriptor represents the shape of scene itself, the relationship between the outlines of the surfaces and their properties while ignoring the local objects in the scene and their relationships. The main idea of this method was to develop a low dimensional representation of the scene, which does not require any form of segmentation. The representation of the structure of the scene was defined by a set of perceptual dimensions: naturalness, openness, roughness, expansion and ruggedness.

To compute GIST descriptor, firstly, an original image was converted and normalized to gray scale image I(x,y). We then applied a pre-filtering to I(x,y) in order to reduce illumination effects and to prevent some local image regions

to dominate the energy spectrum. The filtered image I(x,y) then was decomposed by a set of Gabor filters. A 2-D Gabor filter is defined as follows:

$$h(x, y) = e^{-\frac{1}{2}\left(\frac{x^2}{\delta_x^2} + \frac{y^2}{\delta_y^2}\right)} e^{-j2\pi(u_0 x + v_0 y)}$$

Configuration of Gabor filters contains 4 spatial scales and 8 directions. At each scale (δ_x, δ_y), by passing the image I(x,y) through a Gabor filter *h(x,y),* we obtained all those components in the image that have their energies concentrated near the spatial frequency point (u_0, v_0). Therefore, the GIST vector was calculated by using energy spectrum of 32 responses. To reduce dimensions of feature vector, we calculated average over grid of 4x4 on each response. Consequently, the GIST feature vector was reduced to 512 dimensions.

2.5. Classification

After feature extraction, a classifier was learned for identification of seeds of different rice varieties. In the following, we review some prominent classification models:

2.5.1. Support vector machine

The basic idea of support vector machine (SVM) (Vapnik, 1995) was to find an optimal hyper-plane for linearly separable patterns in a high dimensional space where features are mapped onto. There was more than one hyper-plane satisfying this criterion. The task wass to detect the one that maximizes the margin around the separating hyper-plane. This finding was based on the support vectors which are the data points that lie closest to the decision surface and have direct bearing on the optimum location of the decision surface.

SVM was extended to classify patterns that are not linearly separable by transformations of original data into new space using kernel function into a higher dimensional space where classes become linearly separable. SVM is one of the most powerful and widely used in classifier application.

2.5.2. Random Forest

Breiman (2001) proposed random forest (RF), a classification technique built by constructing an ensemble of decision trees. For each tree, RF used a different bootstrap sample of the response variable and changes how the classification or regression trees were constructed: each node was split by using the best among a sub-set of predictors randomly chosen at that node, and then grown the tree to the maximum extent without pruning. For predicting new data, a RF aggregated the outputs of all trees. It was effective and fast to deal with a large amount of data and has shown that this can perform very well compared to many other classifiers, including discriminant analysis, support vector machines and neural networks, and is robust against over-fitting (Breiman, 2001).

3. EXPERMENT AND DISCUSSION

We have conducted a set of experiments on extracted feature types and classification models to evaluate their performance on image data of six Viet Nam common rice seed varieties, i.e. BC-15, Hương thơm 1, Nếp-87, Q5, Thiên_ưu-8, and Xi-23. Examples of their images are shown in Fig. 2. Table 1. presents the number of rice seed images of each data set (for each rice variety).

Experiment set up

To conduct all experiments, we used a computer with 64bit Window 7, core i5, CPU 1.70 GHz (4 CPUs) and 4 GB main memory and other softwares, such as matlab 2013a and R version 3.2.0.

For each rice seed, we chose all of examples with positive labels and choose five other rice seeds for negative labels so that number of examples with positive labels approximate the number of examples with negative labels. About the 67% of the samples (for each rice seed type) were randomly selected as training set, while the rest of the samples were used as test set for classification.

Table 1. Description of rice seed image dataset

Rice seed name	Number of individual rice seeds
BC-15	1837
Hương thơm 1	2096
Nếp-87	1401
Q-5	1517
Thiên ưu-8	1026
Xi-23	2229

To use SVM and RF methods for classifying rice seeds, in the first step, we performed extracting different features (Morphological features, Color, Texture, GIST). In the next step, after finishing of the training process, the classification models were used to test with test datasets. The accuracy is shown in Table 2.

Classification using support vector machine was based on max margin classification and the selection of kernel function. In our research, we used linear function.

For random forest (RF), it is necessary to put two parameters to train the model: *ntree* - number of trees to be constructed in the forest and *mtry* - number of input variables randomly sampled as candidates at each node. We used *ntree* = 500, $mtry = \sqrt{number\ of\ features}$ for GIST and all of features (18 features) were chose for basic features.

Based on the results of seed classification of six rice varieties, RF model showed better performance than SVM when using basic feature in all prediction sets (all over 85%). It yielded highest classification accuracy of 95.71% for Nếp-87. BC-15 showed poor prediction accuracy in all models. This result is similar to GIST feature based models, which implied that BC-15 was difficult to identify, and appropriate models could help to obtain more accurate identification. Another results, using GIST features, SVM model demonstrated the ability of classification better than RF method.
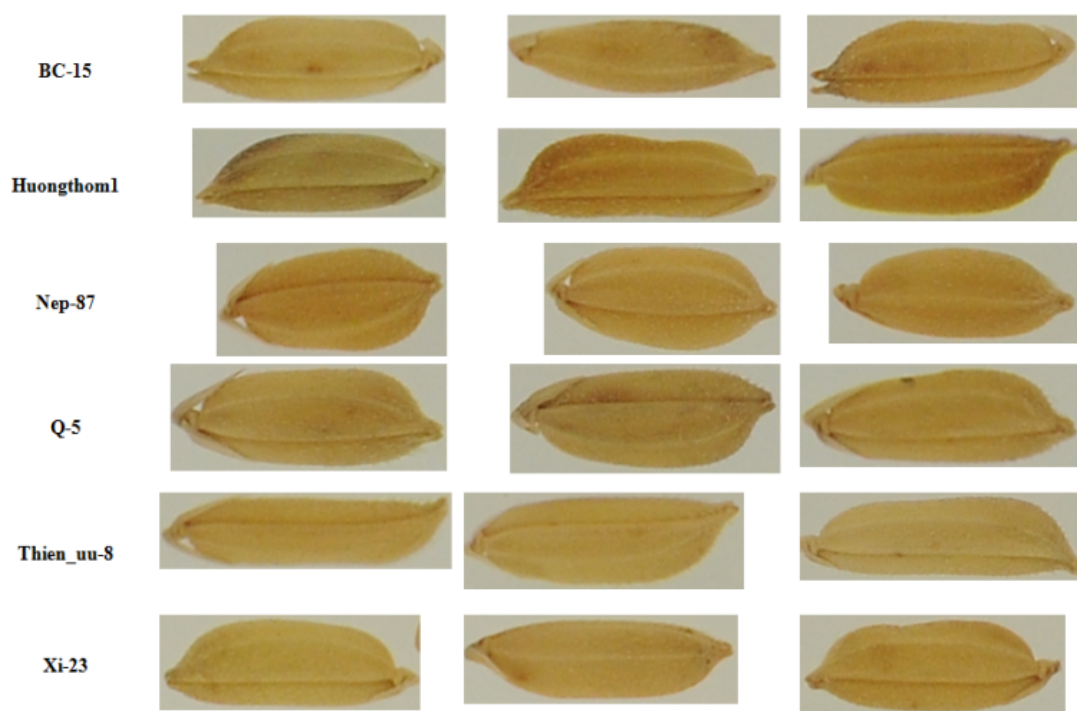
Fig. 1. The images of rice seed dataset

**Table 2. The accuracy of different classification models
on various types of features** *(%)*

Rice variety	Basic feature		GIST feature	
	SVM	*RF*	*SVM*	*RF*
BC-15	67.35	85.87	66.94	67.26
Hương thơm 1	79.87	88.63	77.46	77.07
Nếp-87	88.36	95.71	94.43	90.83
Q-5	78.52	90.40	70.47	70.70
Thiên ưu-8	63.42	93.95	92.10	88.46
Xi-23	90.66	88.67	76.66	76.15
Average	78.03	90.54	79.68	78.41

It was evident that basic feature (morphological features, color and texture) with RF method has demonstrated its strengths to identify rice seed (average accuracy achieves 90.54%) in comparison with the remaining feature. GIST has been shown to be very efficient for scene classification but it has not been strong for describing in detail to distinguish the rice seed varieties. It did not prove its advantage in describing the shape of

rice seeds, particularly their shapes remain similar, one crucial factor for classification.

4. CONCLUSION AND FUTURE WORKS

In this study, we focused on analysing visual features of rice seed images such as colour, shape, texture, GIST. Then we applied the different classification models using these types of features. This research indicated that

image processing techniques can combine with classification techniques such as SVM, RF to identify rice seeds in mixed samples. RF method using simple features proved the best for classification with average accuracy of 90.54%.

The present work can be deployed at the rice seeds processing plants in Viet Nam and extended for other varieties and other types of features can be extracted to increase the performance of classification models.

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