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Rice Seed Images Recognition Based on HOG Descriptor and Trimming Imputation Approach

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Abstract

Rice seed classification is one of the most popular research topics in countries with the agricultural economy. The intention of the classification stage is to ensure the purity of rice seeds. In this paper, we propose Histogram of Oriented Gradients (HOG) descriptor to tackle this task. HOG is one of the most robust features that has a wide range of application in computer vision task. However, in practice, a problem appears after we extracted HOG descriptors from dataset contains rice seed images with different sizes. The problem is the extracted feature vectors have different numbers of dimension. This limit of HOG descriptor causes the classification stage to become impossible. As the current solutions are not optimal enough, we propose combine the HOG descriptor with missing values imputation method in order to help the obtained feature vectors gain the same number of dimensions. The proposed approach is then applied on VNRICE benchmark dataset and evaluated by KNN classifier.

Keywords: HOG descriptor, rice seed image classification, KNN classifier, missing value imputation

Introduction

Rice is a main source of food which is consumed by many countries in the world. Rice quality depends on the purity of the rice seed. In rice seed production companies, to produce high-quality rice seeds, many strict processes are applied to classify rice varieties



and the whole process are done by raw eyes of the farmers. This original method is time consuming and has a high rate of giving low-quality rice seeds. Nowadays, with the development of information technology and its wide application in classification task, the computer vision and machine learning are now able to apply into agricultural pattern recognition such as rice seed in order to increase the accuracy of the classification stage. Many approaches have been proposed to handle this task. Kuo et al. [5] recognize rice grains image by using the sparse-representation based classification on the 30 varieties rice reproduced in a local greenhouse at Taiwan. Li et al. [6] use the laser scanning system to acquire the three-dimensional point cloud of a rice seed. The length, width, thickness and shape of rice seed are computed based on the oriented bounding box.

Moreover, texture analysis is also one of the most attractive fields through years. Several image descriptors have been proposed over the years such as Local Binary Pattern (LBP), GIST, Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG), etc. Among of them, HOG descriptor has successfully made a good performance in object classification.

However, in our experiment, we observe that HOG feature vectors extracted from images with different size have different numbers of dimension. This problem causes the classification stage to become impossible. The current solution is to resize all the images in the dataset to the same size, but this method is not optimal enough. Its performance may cause additional problems such as resolution reduction, noise causing, and it also take a long time to find the size that give the best performance. Therefore, we propose another approach to tackle this limit, which is missing values imputation method, specifically is Zero imputation method. This method sequentially adds 0 in all the feature vectors until each vector gain the number of dimension equals to the maximum dimension of the original feature vectors. The rest of this paper is construct as follows. Section 2 introduces HOG descriptor. Section 3 then presents the Zero imputation method. KNN classifier is presented in Section 4. Section 5 describes the experiment protocol and its results are showed in Section 6. Finally, conclusion and futures works are presented in Section 7.



Histogram of Oriented Gradients descriptor

HOG is first proposed by Dalal and Triggs in 2005 [9]. It is widely used in many different tasks, including human detection, facial recognition, object classification, etc. Before extracting feature, several image processing algorithms are applied on these images in order to reduce noise and ill effects. Then, gradient computation is applied on the image by calculating magnitude and angle of gradient vector of each pixel using the horizontal and vertical gradients. The gradient computation of pixel at coordinate (x, y) is formulated as follows:

$$\Delta_x = |G_{(x-1,y)} - G_{(x+1,y)}| \quad (1)$$

$$\Delta_y = |G_{(x,y-1)} - G_{(x,y+1)}| \quad (2)$$

$$M_{(x,y)} = \sqrt{\Delta_x^2 + \Delta_y^2} \quad (3)$$

$$A_{(x,y)} = \arctan\left(\frac{\Delta_y}{\Delta_x}\right) \quad (4)$$

Where G is grayscale value of pixel at coordinate (x, y) . Δ_x and Δ_y define horizontal and vertical gradients. M_{xy} and A_{xy} sequentially represent gradient magnitude and angle of gradient vector.

After gradient computation process, the image is divided into cells (8 x 8 pixels per cell). In each cell, a 9-bin histogram is built based on the gradient feature of the inner pixels. The bins are usually ranged from 0 to 180 degrees for unsigned gradient ($A_{unsigned}$), or from 0 to 360 degrees for signed gradient (A_{signed}). Magnitude of each pixel is added into the corresponding index number of a bin in the histogram. This index number $B_{idx(x,y)}$ is computed by Equation (5) and used the ceiling value.

$$B_{idx(x,y)} = \left\lceil \frac{A_{(x,y)}}{\left(\frac{A_{unsigned}}{B_{num}}\right)} \right\rceil (A_{unsigned} \in (0,180], B_{num} = 9) \quad (5)$$



$$\text{or } \left[\frac{A_{(x,y)}}{\left(\frac{A_{signed}}{B_{num}}\right)} \right] (A_{signed} \in (0,360], B_{num} = 9)$$

Where B_{num} is the number of orientation bins in the histogram and $A_{(x,y)}$ is computed by Equation (4). The following step divide the image into blocks (each block contains 2×2 cells which equals to 256×256 pixels per block). This division is the preparation for the block normalization process. An effective normalization can reduce noise and the ill effects in order to produce a better performance. In each block, 50% of the surrounding blocks is overlapped so that every cell can be computed more than one time except the cells locate in the corner. Histograms in all blocks are concatenated together and then normalized by using L1-norm, L2-norm or L1-sqrt. Finally, normalized histogram of each cells is combined as a feature vector.

Zero imputation method

Zero imputation is the simplest missing values imputation method which allows to replace missing values with 0. Despite its simplicity, zero imputation still produce a good performance.

KNN classifier

After extracting HOG descriptor, we proceed to the classification stage. In this paper, the k nearest neighbor method (KNN) has been applied. This is one of the simplest classification algorithms. KNN predict class of a new image by mapping this image into the vector space where the image is represented by point. KNN then compare the distance from the new point to surrounding points (the training images whose class are known). The class which appear mostly in K nearest point will be assigned to the new image.

The experimental protocol

1. Construction the image database

We apply all the experiment on the benchmark rice seed database (VNRICE) which contains six common Vietnam rice varieties, including BC-15, Huong Thom-1, Nep-87, Q-5, Thien Uu-8, Xi-23. These rice seeds are high qualified which were grown and harvested following strict conditions for standard rice seeds production. All images are obtained by a CMOS image sensor color camera and every image have different sizes to each other. Figure 1 illustrate example images from the image set. After testing many K values and distance functions, the KNN classifier associated with the L1-distance and $K = 6$. The achievement of the classification is measured by the accuracy rate which was performed by split-sample validation with holdout sampling. Half of the image set were used as the input of the classifier to construct the training model while the rest were used to test it. Table 1 present the characteristic of VNRICE dataset via split-sample validation method.

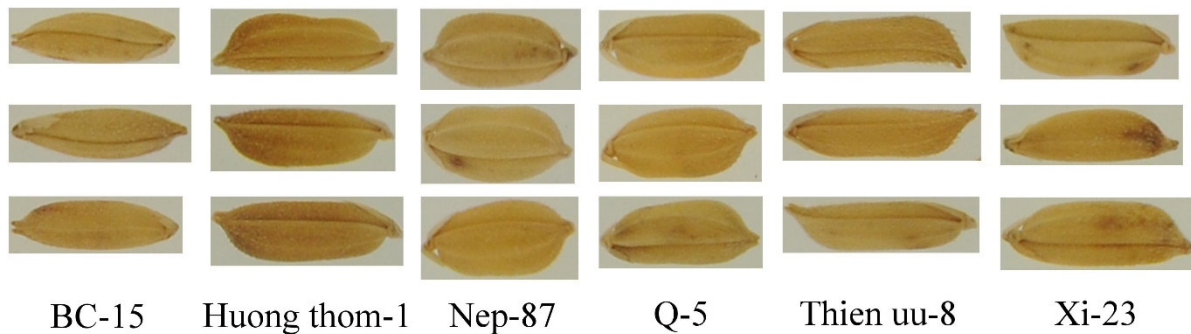


Figure 1: Example images of VNRICE dataset (Each rice varieties have three images to represent it).

Table 1: Characteristic of VNRICE dataset

Rice variety	Training set	Testing set	Total images
BC-15	917	917	1,834
Huong Thom-1	1,048	1,048	2,096
Nep-87	699	700	1,399
Q-5	962	962	1,924
Thien Uu-8	513	513	1,026
Xi-23	1,113	1,113	2,226



2. Experimental scenarios

First, we resize each image from the dataset into similar size before extracting HOG descriptor. The image sizes are randomly chosen based on the maximum and minimum of width and height of rice seed image. The results of the classification stage are showed in Table 2.

For evaluation of Zero imputation method, we extract HOG feature vectors from the original images. In order to compare result of the Zero imputation method, we first trim all the achieved feature vectors whose dimensions are higher than the minimum number of dimensions in the dataset, so that all vectors then have the same dimension for classifying. The lowest and highest dimension of feature vectors which can be obtained, are 3,888 and 12,636 respectively. Then, zero imputation method is applied to the original feature vectors by adding 0 to these vectors until the feature vectors gain the same dimension.

Experimental results

Scenario 1: Rice seed classification based on HOG descriptor and resize image method.

Table 2: Accuracy rate on the VNRICE dataset with random selected image size values

No.	Image size	Number of dimensions of HOG feature vector	6-NN (%)
1	46 x 46	576	67.53
2	50 x 100	1,980	74.24
3	46 x169	2,880	74.50
4	103 x 103	4,356	74.93
5	46 x 380	6,624	72.63
6	100 x 150	6,732	75.62
7	77 x 229	7,776	75.55
8	103 x 169	7,920	77.18
9	101 x 300	14,256	74.14
10	169 x 169	14,400	75.52
11	103 x 380	18,216	73.39
12	120 x 400	24,696	72.71
Average accuracy rate			74.00



The minimum and maximum of height (H) and width (W) of rice images from VNRICE are $W_{min} = 169$, $H_{min} = 46$, $W_{max} = 380$, $H_{max} = 103$. The other values are randomized.

In Table 2, the second column represents the width and height of images after resizing. The third column represents the numbers of dimension of obtained HOG feature vectors. In our observation, the best accuracy is reached when images are resized to 103 x 169. However, it is impossible to figure out an optimal size in many random sizes. Moreover, the dimension space of HOG features also increases when the image size is bigger. This issue causes the extraction and classification stage consume more time.

Scenario 2: Rice seed classification based on HOG descriptor and Zero imputation method.

Table 3: Experimental results of Zero imputation compare to trim method on the original images.

Image size	Method	Number of dimensions	6-NN (%)
Original images with different image sizes	Trimming method	3,888	72.96
	Zero imputation	6,000	74.96
		9,000	79.24
		12,636	79.36
		15,000	78.94

According to Table 3, the results of Zero imputation method successfully make a better performance than the trimming method. In addition to the 12,636-dimension vectors, we also make several experiments with other numbers of dimension which are also lower and higher than the highest dimension space in the image set for comparison. We recognize that the accuracy of the classification result in reduction when the number of dimension higher than 12,636. The Zero imputation method with 6-NN gives the highest accuracy rate



with 79.36%. This improvement is more than 5% compared to the average accuracy with the random resize method in table 2.

Conclusion

In this paper, we propose to apply Zero imputation method to solve the problem about HOG descriptors extraction from images with different sizes. The proposed approaches are efficient by successfully improving the classification performance on VNRICE image database. The future of this work is to continue applying the proposed methods to other data type. Other missing values imputation methods are applied to seek improvement.

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