Identification Of Visually Similar Vegetable Seeds Using Image Processing And Fuzzy Logic

John Andrew A. Garcia, Edwin R. Arboleda, Elbert M. Galas

Abstract: Computer vision and image processing have attracted more and more interest of researchers because of its wide applications in many fields. With this in consideration, this paper conducted a study comparison and identification of two vegetable seeds through fuzzy logic and image processing. Images taken were processed and three morphological features were used as rules for the fuzzy inference system. The result was that the fuzzy inference system worked as expected even if there are only two true values for each characteristic.

Index Terms: Fuzzy Logic, Image Processing, Morphological Feature, Vegetable Seeds

1. INTRODUCTION

THE execution of computer vision (CV) automation in line with taking, processing, and evaluating pictures can be efficiently applied in the nondestructive analysis of visual quality features in agricultural crops' seeds [1]. Image processing, also termed as digital image processing, is described by the encompassing procedures of the principal and distinguished method of a computer vision system. A two-dimensional (2D) picture serves as the load of the scheme in the procedure. It generates an improved picture otherwise a group of significant variables associated with the picture [2]. Smart classifiers can memorize and perform numerous functions such as categorization or sorting [3]. The examination of the seed picture contains the strategies of image attainment, preprocessing, and understanding of which fallouts in assessment and sorting of seeds. It can deliver supplementary information in the seed's manufacture, seed class management, as well as the recognition of seed degradation [4]. Computer vision and image analysis are a non-destructive and profitable method for categorization and classifying of agricultural and food crops throughout supervision processes and trade basis. The variation of application in agricultural and food crops is associated with the diverse tactics founded on image examination and processing. These methods have involved greater attention from researchers due to its extensive use in Several computer-aided machine vision systems, that mechanically review and quantitatively measure grains, have advanced computer knowledge, especially in artificial intelligence. Data gathering, morphological characteristic extrication as well as their illustration, classifier/algorithm option and knowledge, and classifier testing are the utmost vital procedures [12]. Prior to that, the examination of a digital image gives an intention and precision measurable system for the approximation of morphological characteristics [13]. Morphological features can be identified as shape, size, color, orientation, roundness, dimension, and compactness are

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several areas. Some of them are manufacturing product review, traffic observation, leisure, and medicinal intervention. Aside from that, it has been effectively employed in agricultural manufacture in several tasks like automated evaluating, reaping, and classifying of goods such as food, fruit, vegetables or plant sorting [1]. Vegetable's enlarged manufacture entails the class of vegetable seeds and the validity of assortment as its vital considerations [5]. Clarity, propagation, and free from any ailments are the initial foundation of modifying the quality of the kernels [6]. The significant tasks in the agricultural area are the examination and sorting of the seeds. These tasks give a further worth in the manufacture, quality development, class management, and degradation determination of vegetable kernels. These activities are commonly performed by experts who manually examine and check every seed sample. Agricultural crops such as grains and vegetable seeds are of dissimilar forms and tiny dimensions [7]. Therefore, this complex procedure is heavy, tiresome and consumes a lot of time [6][8]. Machine vision is a controllable and exceptionally intelligent technology being widely used [9]. Machine vision was also utilized for discriminating different varieties of seeds and for distinguishing a type of seed from another type or for identifying damaged kernels in wheat using a color machine vision system. It was also used in the quality assessment of fodder [10]. extensively applied in evaluating automated grading, distinguishing, and investigation of goods excellence in food manufacturing [12][14]. To take out these characteristics from the pictures of the seed sample, various image processing sets of rules are accessed. This lets the machine vision appropriate for such activity [15]. In this case, the undesirable influence of the temperature, moisture, light, etc. can alter seed morphology [3].

been widely established [11]. These systems use computer vision technologies including several stages, which necessitate This study aims to identify whether the seed is a cauliflower or pechay (Chinese cabbage) through image processing and fuzzy logic. The morphological features of the image and the fuzzy inference system will all be determined using the MATLAB program. This is to aid people that are having a hard time identifying the type of seed since they look visually similar in the naked eye.

2 RESEARCH METHOD

2.1 Image Acquisition and Processing

The seeds were acquired at Aguado, Trece Martires City, from the relatives of the author. A total of 160 seeds were used in this paper: 60 pechay and 60 cauliflower seeds as training data and 20 for each seed too were used as test samples. The images for the samples were taken using a Canon PowerShot SD1300IS at 12M (4000x3000) resolution with a tripod to prevent unnecessary movements or shaking while taking the images. The flash of the camera was turned on for every image to ensure proper lighting for the samples. The seeds were placed in a way that it won't touch each so that the image will give accurate data for processing. The lenses of the camera have a distance of 8cm for every sample image for uniformity. Since the images were taken uniformly, resizing of images is not required anymore. The images of the samples taken were processed using MATLAB R2015a installed in Lenovo G41 Laptop with a processor of AMD A8 quad-core with speeds up to 2.1GHz and has a RAM of 4GB. This laptop uses Windows 10 SL operating at x64 platform. The percentage amongst image sections and diversities of dissimilar shades RGB histogram are then considered [16].

2.2 Morphological Feature

Three morphological structures of the model seeds were extricated [17][18]. These are its area, perimeter, and diameter. These features were extracted with the use of MATLAB. MATLAB is one of the simplest and most efficient software where image processing can be completed. Things can be identified and sorted, defects can be determined, and more other applications can be done in applying image processing. Also, this software is an efficient instrument in digital image processing since it can examine the RGB values for every pixel [12].

2.3 Fuzzy Inference System

A fuzzy system is implemented in the identification of the two seeds. It is known as a mathematical system that examines input values that are analog based on the variables from the values between 0 and 1. It can create intelligible and user-friendly models of real-world systems [19][20]. A control system used for controlling the fuzzy logic-based system is known as the fuzzy controller. It comes from the set of fuzzy rules that shows the behavior of the system [21][22]. An example of a fuzzy controller is shown in Figure 1.

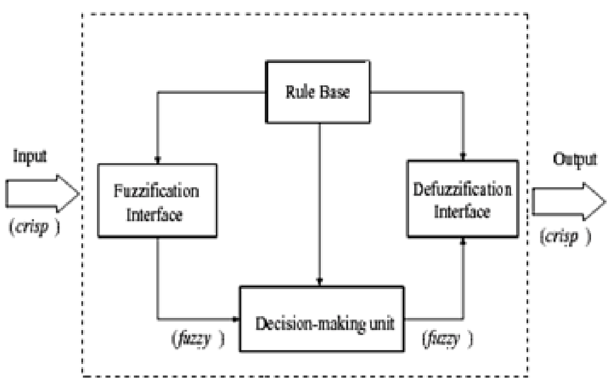

Figure 1. *Fuzzy Controller*

Fuzzy inference is known as the procedure of mapping, given from input to output through the use of fuzzy logic [23][24]. Some of the notable applications of these systems are automatic control, computer vision, analysis of decisions, expert systems, and classification of data [25][26][27][28]. Fuzzy Logic was used in this paper is identifying the type of seed, depending on the morphological data and the rules. Sugeno type of inference system was used since the outputs were constant.

3 RESULTS AND ANALYSIS

3.1 Image Processing

The image taken in RGB format shown in figure 2 underwent several processes. The first process was to format the raw image into a grayscale format. The image was then complemented and converted into a black and white format in figure 3. This turns the white areas unoccupied by the seeds into while the seeds itself becomes white. This makes it easier for the special function vislabels to label the seeds that were identified in the image.

Figure 2. *Original Image*

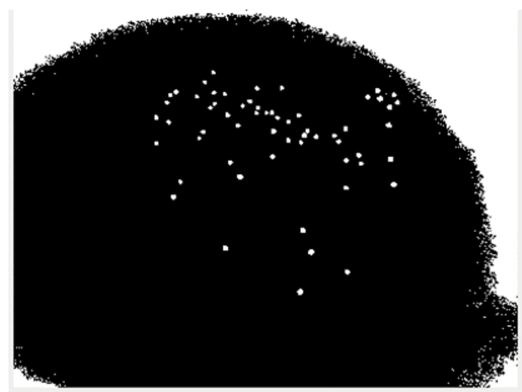

***Figure 3**. Black and White Image*

3.2 Morphological Feature Analysis

Three (3) morphological features of the seeds were measured in this paper. This is the seeds' area, perimeter, and diameter. First, after the image was processed into a black and white format, the holes are filled. The next step is to apply the vislabels function so that the seeds in the image can be labeled and distinguished from the noise of the image. Figure 4 shows the image was vislabels function was used. After this, a range of values is used for idx so that only the seeds will be left and most of the noise will be removed from the image as can be seen on the output, figure 5. Table 1 shows the minimum and maximum values for the three morphological features of the seeds. This table will be further used for the fuzzy logic analysis.

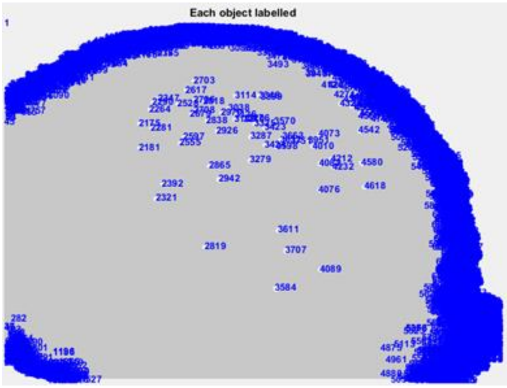

***Figure 4**. Labeled Image*

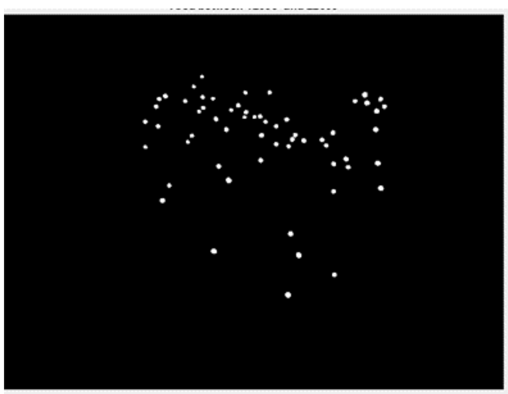

***Figure 5.** Output Image*

***TABLE** 1*

MORPHOLOGICAL FEATURES RANGES

Type	Area	Perimeter	Diameter
Petchay (Chinese Cabbage)	702 to 1616	93.106 to 163.031	29.88 to 48.38
Cauliflower	800 to 3050	103 to 220	33 to 57

The basis of these rules was the ranges of morphological features. The rules were set to be as that, as long as there are two (2) true values for the features, the output will be like the output when all of the three values are true. The minimum value rule was used in the fuzzy inference system. Figure 6 shows the fuzzy logic design. It is shown that there are three inputs which are the morphological features. Sugeno type inference was used since the output should be constant. Figure 7 shows the rule viewer where it can be seen that there are a total of fourteen rules. Here, as we move the values from the three inputs, the output changes. The outputs were labeled as pechay = 0 and cauliflower = 1. The values can be rounded off to its nearest whole number in getting the results. Values of output < 0.5 are pechay and the rest are cauliflower.

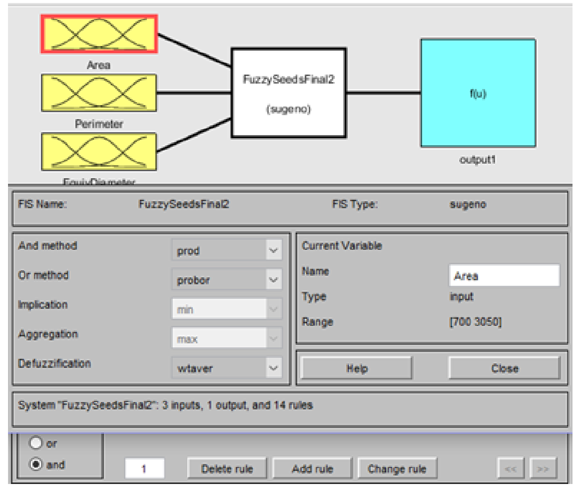

***Figure 6.** Fuzzy Design*

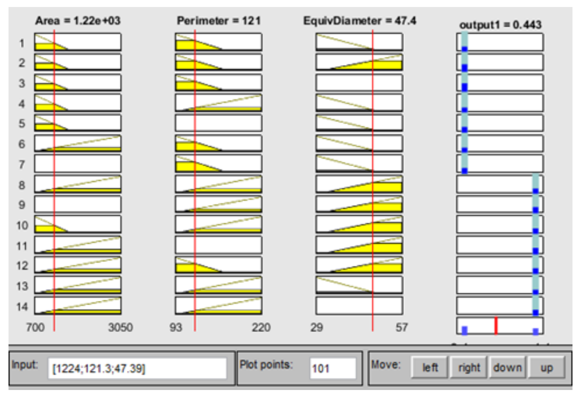

***Figure 7.** Rule Viewer*

Figure 8 shows the surface plots of the output. It can be inferred here that patola has the highest range since all of the combination in X and Y axes results with patola occupying most of the plots.

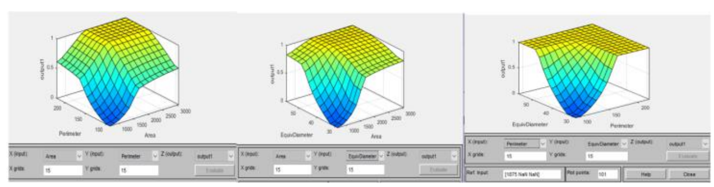

***Figure 8.** Surface Plots*

Table 2 shows the results of testing 20 samples for each type of seed. This was done by copying the test data from MS Excel into Notepad and the proper formatting so it can be pasted easily at the rule viewer of MATLAB. 100% accuracy was obtained with pechay seeds sample while only 65% accuracy was obtained with cauliflower seeds. This gives a total of 82.5% accuracy with 40 samples combined.

TABLE 2

FUZZY TESTING RESULTS

Type	No. of Success	No. of Fail	Accuracy (%)
Pechay	20	0	100
Cauliflower	13	7	65

4 CONCLUSIONS

This paper proved that the use of image processing and fuzzy logic to determine the type of seed is effective and has much fewer errors. Although the use of traditional methods of classifying of seeds is still very effective, machine vision-based ones can further improve the accuracy of this. With a result of 82.5% accuracy when the samples were combined, this paper achieved its objective. This is slightly lower than the results obtained by using K-Nearest Neighbor classifier which yielded an 85% accuracy although the fuzzy logic results at pechay test sample were more accurate. This study can be improved by using more samples and varieties of vegetable seeds since the scope of this is very limited to two types only. Future researchers may opt to use a wider variety of seeds and morphological characteristics that don't have many overlapping features.

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