RECOGNITION ALGORITHM OF DRIED OAK MUSHROOM GRADINGS USING GRAY LEVEL IMAGES

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ABSTRACT

Dried oak mushrooms have complex and various visual features. Grading and sorting of dried oak mushrooms has been done by the human expert. Though actions involved in human grading looks simple, a decision making underneath the simple action comes from the result of the complex neural processing of the visual image. Though processing details involved in human visual recognition has not been fully investigated yet, it might say human can recognize objects via one of three ways such as extracting specific features or just image itself without extracting those features or in a combined manner. In most cases, extracting some special quantitative features from the camera image requires complex algorithms and processing of the gray level image requires the heavy computing load. This fact can be worse especially in dealing with nonuniform, irregular and fuzzy shaped agricultural products, resulting in poor performance because of the sensitiveness to the crisp criteria or specific rules set up by algorithms. Also restriction of the real time processing often forces to use binary segmentation but in that case some important information of the object can be lost.

In this paper, the neuro net based real time recognition algorithm was proposed without extracting any visual feature but using only the directly captured raw gray images. Specially formatted adaptable size of grids was proposed for the network input. The compensation of illumination was also done to accomodate the variable lighting environment. The proposed grading scheme showed very successful results.

Key Words: Grading, Recognition Algorithm, Neuro-Net, Compensation Illumination, Dried Oak Mushroom

INTRODUCTION

Quality of a dried oak mushrooms depends on the moisture content and visually characterized external features which can be affected by the growing environment, drying process, handling, etc. So far, sorting oak mushrooms has been roughly done manually and grading has been performed inspecting randomly chosen sample mushrooms by the certified human expert. Though the grading criterion has been specified by the production cooperatives, its specification is quantitatively rough and involves qualitative descriptions. What is worse, it differs from each country such that the classification category in Japan is 6 types with 16 grade levels and in Korea 5 types with 12 grade levels. In most case, grading criterion of agricultural products can not be specified precisely in the quantitative sense. In a case of a dried oak mushrooms(*Lentinus Edodes L.*), the ambiguity of grading criterion increases even more because of the complex and interrelated fuzzy external shape factors.

Human decision often varies depending on the emotional state. Therefore, it is required to develop an automatic grading system which preserves the consistency of grading and improves grading efficiency with the ability of human like robust visual data processing.

Human often percepts the visual image with ease from the raw image rather than from the charateristics of the extracted features. Recent advances in the fields of artificial neural network have opened the way to a new approach to pattern recognition problems. Since neural network offers many advantages over the previously developed pattern recognition algorithms, many research efforts have been reported related to neuro-net based visual perception and system control. Network was also trained by inputing extracted quantitative features obtained from rule based image processing algorithms instead of camera captured raw gray image. Details on the process of visual feature extraction of a mushroom refers to Hwang and Lee(1992). This paper aims to develop the neuro-net based efficient grading algorithm using the gray image directly captured from the CCD B/W camera.

MATERIALS AND METHODS

Major grading features of dried oak mushrooms are the overall size and the shape of the cap, texture state(color, crack and pattern) of the cap, thickness of the cap, the rolled state(shape and amount) of the cap edge in the back side and the state(standing and color) of the inner membrane around the stalk, etc..

Generally, geometrical feature extraction algorithm require of complex processing, it is sensitive to the image noise, and it has many problems in practical points of view. Human often percepts the visual image easily from the overall raw gray input image rather than from the charateristics of the extracted features.

To improve the above disadvantage, neural-net based effective learning and recognition methods were developed. And the neural-net was trained by camera captured raw gray image instead of by extracted quantitative features obtained from the rule based image processing as shown in fig.1.

To obtain the network inputs, modified chain coding algorithm was applied to extract the size and centroid. The B/W CCD camera(Pulnix Inc.) and PcVision frame grabber(Imaging Technology Inc.) was used to digitize and store the incoming video signal to 8-bits of accuracy at a rate of 30 frames per second. The illumination compensation process using coefficient K was utilized to ensure the consistency and performance of the trained network. This process ensures the consistency of the network performance by adjusting the gray level of the acquired image under different lighting condition. K is the linearized compensation coefficient which is defined as

$$\begin{aligned} F(x,y) &= I(x,y) \times R(x,y) \\ &= K \times R(x,y) \end{aligned}$$

where F(x,y) is the 2-dimensional light intensity function and I(x,y) and R(x,y) are illumination and reflectance components respectively. K is the average gray value for the selected region of white sample sheet divided by 255. The compensation process provided nearly the external lighting invariant consistency for the input image to the trained network.

Neuro-net based image processing was designed for real time robust classification. The network input units was 76 rectangular grids composed of 8 directions and x and y size factors of input images. The size of rectangular input grids varies according to the size of the mushroom.

So far neuro-net based recognition problem has been done usually by external features obtained from rule based algorithms. Since It was desirable, however, for the system implementation to avoid the processing burden, grading was done using camera captured raw image itself. Various kinds of input representations for the network were tested and compared to ensure the grading performance. Front side and back side gray level images were used as network inputs to classify 4 grades of high quality mushrooms and to classify 8 grades of medium and low quality mushrooms respectively. Next, Front side image for 4 grades and back side image for 8 grades were used to classify 12 grades of mushrooms. Finally, both front and back side images were used as network inputs to classify 12 grades of mushrooms.

According to the prespecified compensation values of the illumination at the initial image measurement stage, captured image was compensated. Each grid output was the average gray value of pixel and was normalized between 0 and 1.

The shape of the input structure and the grid was formed as shown in fig.2. And four networks were tested using four different image inputs such as 4 grades using front side image only, 8 grades using back side image only, 4 grades using front and 8 grades using back side images, and 12 grades using both front and back side images. Number of units in the input layer was 78(76 grids + 2 size factors), 78, 78, and 154(76 grids per each side + 2 size factors) respectively. Hidden layer was formed with 5, 5, 10 and 20 processing units respectively. Output layer was formed 2, 3, 4 and 4 units respectively. The number of units in the output layer can classify all the input patterns into 4, 8, 12, 12 categories using binary bit combination.

Since all the sample oak mushrooms per each grade were not available, 240 sampled oak mushrooms(20 per each grade) was selected by an expert as 5 types with 12 grade levels. The network was trained using 240 sample image data for full grading of 5 types with 12 levels according to the Japanese grading criterion.

RESULTS AND DISCUSSIONS

Using 120 sample mushrooms(10 per each grade level), four networks were trained. Network learning rate for samples showed 100% accuracy. To verify the generalization effect of the trained network, 20 untrained sample mushrooms per each grade level(total 240) mushroom were tested for recognition rate.

Table 1 shows the recognition performance of the proposed each 4 type input representation. As seen in the test results of the various input representations, grading using the either front or back side image was as efficient as that using both sides and was better than the quantitative input data from both sides. High quality oak mushrooms such as Hwago and Gureum-Hwago have the turtle shaped cap surfaces with dark brown spots uniformly distributed over the surface. Other medium and low quality mushrooms such as Donggo, Hyanggo and Hyangsin do not have distinct shape and texture patterns and they differ from only cap size, color, and the amount of the rolled cap edge in the back side. Therfore, 2 types(Hwago, Gureum-Hwago) 4 categories could be classified from the front side image processing and other 3 types(Donggo, Hyangsin, Hyanggo) 8 categories could be classified from the back side image processing.

CONCLUSIONS

Since all oak mushrooms have their own unique and irregular visual features and some are very fuzzy and abnormal, recognition rules could not handel all the shape patterns correctly though they were enforced by the heuristics.

In this paper, grading algorithm was developed for dried oak mushrooms. It was successfully done via inputing a camera captured raw gray level image instead of inputing extracted quantitative features obtained from rule based complex algorithm. Grade recognition capability of the proposed method was almost perfect for samples used for training.

Once network was trained, grading was done in a sense of open loop. To improve the grading performance, it was suggested that more samples per each grade level would be trained.

This proposed grading network model for dried oak mushrooms was suitable for real time grading and sorting system and was implemented to our prototype system.

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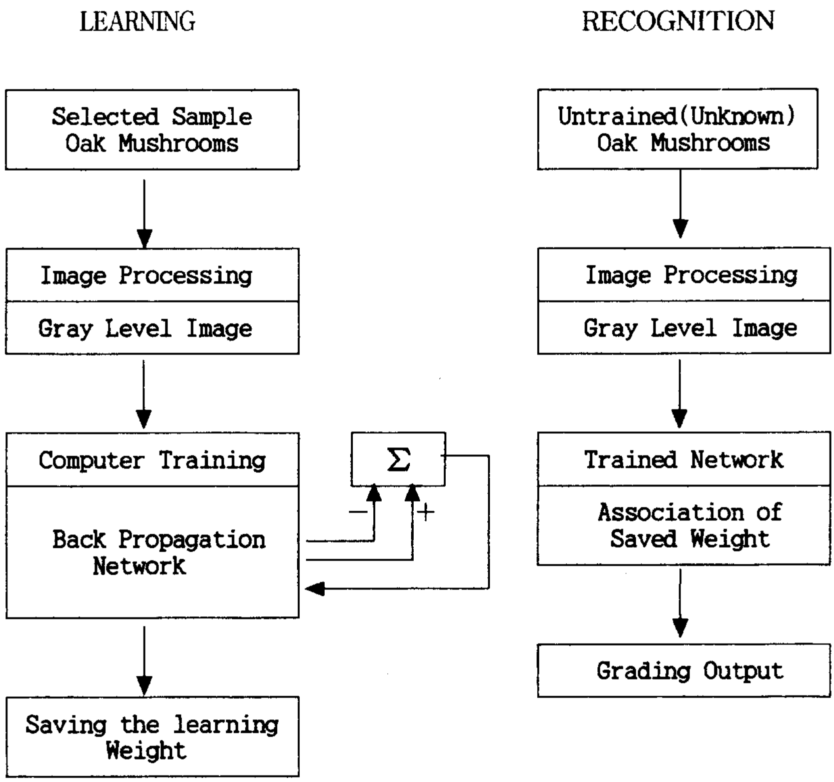
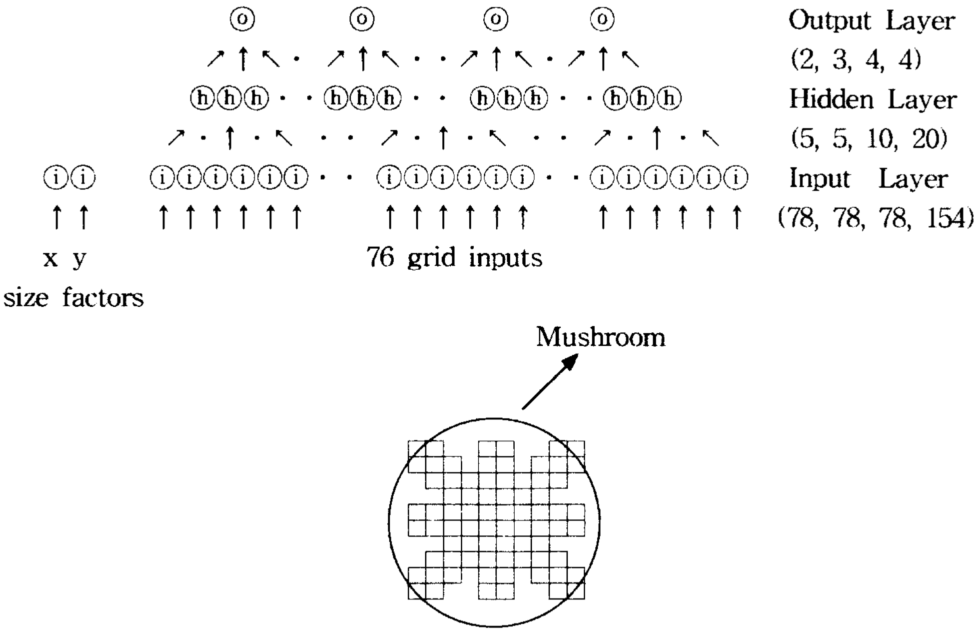


Fig 1. Block diagram of network training and recognition



ⓘ:input unit, ⓗ:hidden unit ,ⓞ:output unit

Fig. 2 Trained network models composed of three layers

Table 1 The recognition performance of the various input representations.

	Network Structure	No. of Error/Total	Classification Performance(%)
1	Front side image only (4 grade)	5/80	93.8
2	Back side image only (8 grade)	13/160	90.4
3	Front(4 grade) and back(8 grade) side image respectively	23/240	90.4
4	Front+Back Side Gray Image (12 grade)	19/240	92.1