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APPLICATIONS OF NEURO-FUZZY TECHNIQUES TO COLOR IMAGE PROCESSINGS

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Abstract: We focus our attention on grading of table meat in accordance with the standard of Japan Meat Grading Association, and construct a beef grading system by image processing. For image processing of beef grading, it needs some techniques such as a shading correction, separation of color image data, and classification of color image data into some grades, for the system construction. However, there are various kinds of weak points in usually used methods for these techniques. Then the authors propose and introduce new approaches using Neural networks and fuzzy inference for the techniques above mentioned, which is very convenient and ensure the high precision.

1. Introduction

Recently factory automation (FA) has been quickly developed in various fields. There are increasing the needs to develop the industrial image processing system in FA using CCD (charge coupled device) camera which is used as vision sensor instead of human eye. Most system in these image processing systems are requiring to judge more sensitively the objects like a expert's judge which includes a various human sense. In realizing these systems which satisfy the above requirements, it needs some pre-processing of color image data from CCD camera for system inputs, such as a shading correction and separation of color image data, for the purpose of getting their features correctly. In this paper, we apply new methods of shading correction and separation of color image data to Meat Grading System, and also use these pre-processed image data as the input data of a neural network, so called a hybrid neural network, in the system to grade the table meat in accordance with the standard of Japan Meat Grading Association.

2. Shading Correction

Input color image data are affected the various lighting environments, and generally include some shadings, because it is difficult that we keep the lighting condition uniformly. Then, we need a shading correction of the color image data from CCD camera as a pre-processing of the data. Two methods such as 1) difference method and 2) changing concentration method have been generally used as the shading correction methods in most real image processing systems. However, as the color image data treated in the previous methods are strongly affected the various noise, we propose a new method using the fuzzy inference which can except the noise affection.

2.1 Fuzzy shading correction

The shading correction is to except the irregularity in the brightness, and to keep the constant illumination of the object in the image from CCD camera. The correction value generally depend on the points in the image area. In the fuzzy shading correction, we use the fuzzy inference rules instead of the reference correction curve to correct the shading. For this purpose, we firstly divide the correction area in the image into some cross sectional area, and determine the shading value, say brightness value, at each cross point from the standard image. Using these values, we form the fuzzy rules at the point corresponding to the cross point by <u>a learning type</u> simplified fuzzy reasoning [1] as follows:

If x is A(i) and y is B(j)
then z1 is W1(k(i,j)),
z2 is W2(k(i,j)),
z3 is W3(k(i,j)), (1)

where x, y are input variables representing the coordinates of the image, and W1, W2, and W3 are singletons. We can calculate correction values at any point in the correction area by these fuzzy rules. Fig.1 shows the configuration of the fuzzy shading correction.

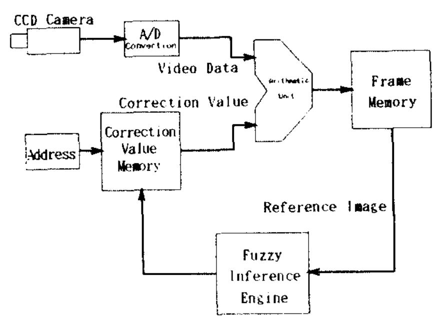


Fig.1 Configuration of fuzzy shading correction

Fig.2 shows the input device of image in the fuzzy shading correction system. Fig.3 (a) and (b) also show the original image of a part of the beef and resultant picture of the fuzzy shading correction, respectively.

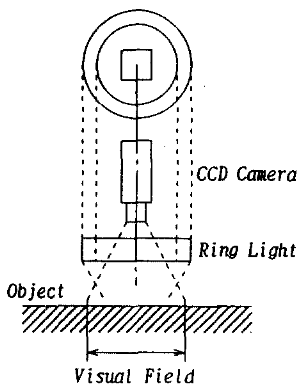


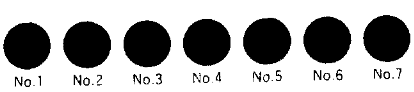
Fig.2 Input device of image.

(a) Original image (b) Correcting image

Fig.3 Original image and result of fuzzy shading correction

3. Separation of Color Image Data

In this paper, we focus our attention on grading the beef in accordance with the standard of Japan Meat Grading Association. The beef color and beef fat color are classified into 7 grades by Beef Color Standard (BCS) and Beef Fat Color Standard (BFS) [2] as shown in Fig.4-(a) and (b),



(a) Beef color standard

(b) Beef fat color standard

Fig.4 Color standards of beef and beef fat

respectively. We have to separate the beef color and beef fat color to extract the feature of the beef marbling. However, the boundary between the beef and fat is not the sharp boundary, and also the color of the boundary depends on the beef color and fat color in each grade. Then, it has been a very difficult to separate the beef color and beef fat color of all grade meats by only one fixed threshold value which is the method in generally used methods for color image separation.

3.1 Fuzzy separation of color image data

As the colors of the beef and beef fat depend on their grades, we have to determine the threshold values depending on their grades to separate the beef and fat. We use the <u>learning type</u> simplified fuzzy inference to determine these threshold values as follows:

If x is $A(i)$ then y is $W(j)$, (2)

$$y = \Sigma\mu(i)W(i), \quad (3)$$

$$\delta = \hat{y} - y, \quad (4)$$

$$W(t+1) = W(t) + \varepsilon\mu(t)\delta(t), \quad (5)$$

where x stands for a mean value of each R(red), G(green), and B(blue), and the singleton y is a threshold value. Eq.(5) represents a update equation of the singleton in the simplified fuzzy inference rule.

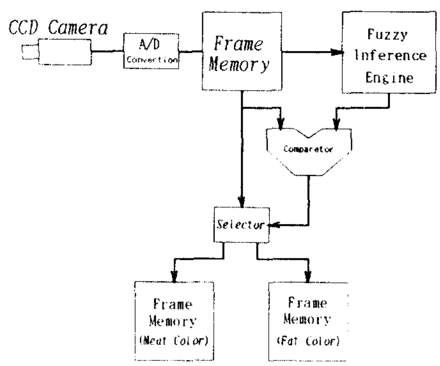


Fig.5 System configuration of fuzzy separation of color image data

In the real separation procedures, if the values of input data are less than threshold value, they are the beef colors, and otherwise, they are the beef fat colors. Then we can separate the beef and their fat colors by using the threshold vaues which are learn by learning type simplified fuzzy inference, and these information are sent to image memory as shown in Fig.5.

3.2 Experiments

The threshold value has to change its value in accordance with the change of the beef color which depends on its grade. Fig.6 shows the change of the threshold value, where horizontal axis represents the value of R, G, and B colors. As easily seen, the threshold value of each R, G, and B colors different from their value, and these curves show a little saturation characteristics. These curves are also different from that representing the thresold value of generally used methods in image processing (separation),

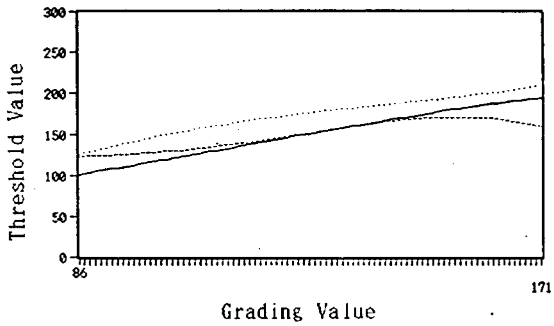
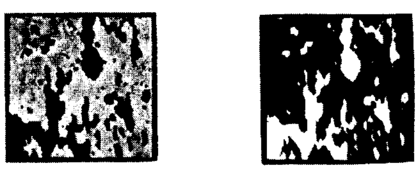


Fig.6 Change of threshold value for colors

and we obtain a good result of two color separation of beef and beef fat colors by fuzzy separation method. As the shading in color image has to be corrected as mentioned above, we correct the shading in the rectangle area of 100x100 elements as shown in Fig.3. Fig.7 (a) and (b) shows a resultant pictures in which the left and right hand side pictures represent a beef and beef fat colors region, respectively. As easily seen, the very complex image marbling beef fat is finely separated into two colors. We can accept this result with great enough.



(a) Beef color (b) Beef fat color

Fig.7 Separation of beef and beef fat colors

4. Hybrid Neural Networks

We use a neural network, so called a hybrid neural network [3], to grade the beef in accordance with the standard of Japan Meat Grading Association. The hybrid neural network is composed of a counter propagation networks and Perceptron type neural network whose units in a hidden layer are partitioned into some groups as shown in Fig.8. This type of Perceptron is called as a partitioned neural network in this paper. The number of the partitioned groups in the hidden layer equals to that of the outputs of the counter propagation network. That is, the units of hidden layer are partitioned into some groups whose number equals to that of the pattern categories classified by the counter propagation network. Then, a set of the weights connecting the input and output layer via each group of

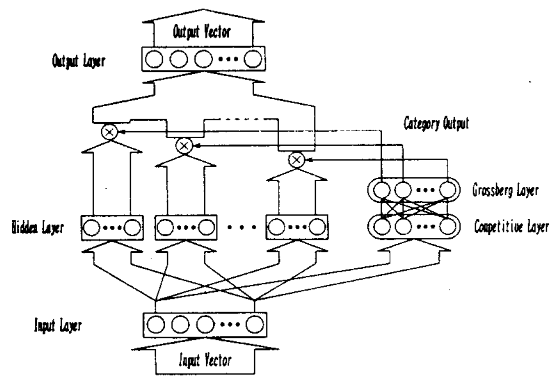


Fig.8 Hybrid neural network

units in the hidden layer represents the only feature of the patterns which are belonging the category classified by the counter propagation network. So we can effectively and sensitively extract the feature parts of the patterns by this partitioned structure of the hidden layer.

The counter propagation network acts as the category classifier of the patterns, and each group of the units in the hidden layer of the partitioned network is corresponding to the category classified by the counter propagation network. That is, the number of the groups equal to the that of the outputs of the counter propagation network. Each output information (category) of the counter propagation network is fed back to a learning parameter & momentum term and outputs of the units in the group corresponding to that category.

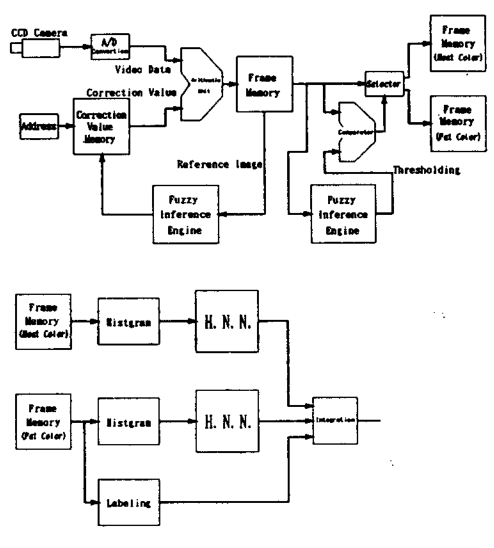
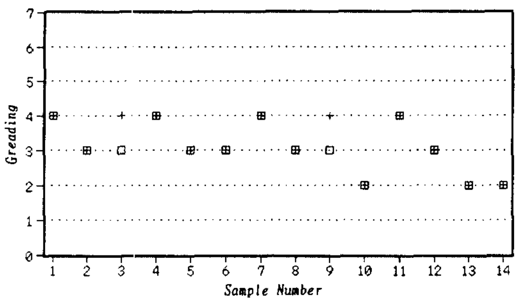


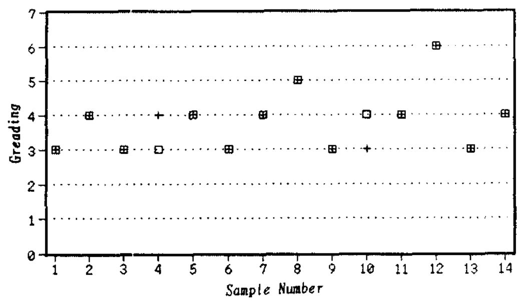
Fig.9 Configuration of beef grading system

We denote the output of the counter propagation network by a vector B as follows:

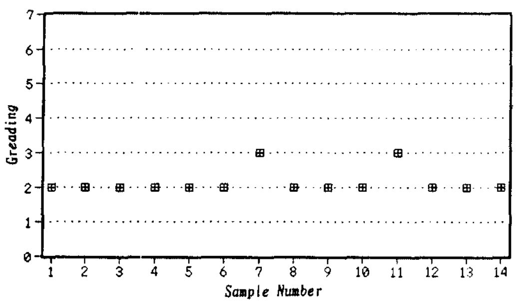
$$B = (b1, b2, \dots , bs). \quad (6)$$



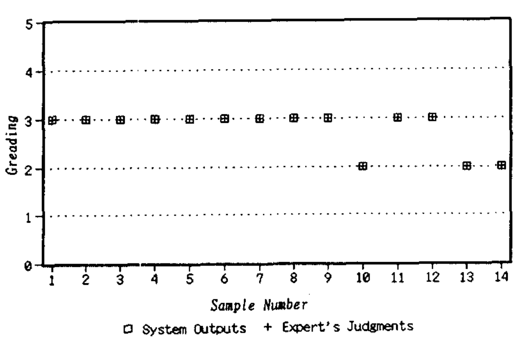
(a) Beef marbling



(b) Beef colors



(c) Beef fat colors



(d) Beef quality

Fig.10 Final results of beef grading system

We make the partitioned neural network to learn the feature of patterns by an error back propagation algorithm. The weights connecting units between output layer and hidden layer are updated by ordinary back propagation algorithm. However, we update the weights connecting units between the partitioned groups in the hidden layer and input layer by a learning rate $\eta(k)$ and momentum term $\alpha(k)$ as follows:

$$\eta(k) = b(k)\eta, \quad (7)$$

$$\alpha(k) = b(k)\alpha, \quad (8)$$

where b is the output of the counter propagation network, and η & α are the initial learning rate and momentum term, respectively. That is, the weights between the units in each group of the hidden layer and that of the output layer are learned separately according to the group.

5. Beef Grading Systems

We construct a beef grading system as shown in Fig. 9 by using the techniques such as the fuzzy shading correction, fuzzy separation of image data, and hybrid neural network above mentioned. In the first process, we correct the shading of the image data from CCD camera, and send this information to next process of fuzzy separation of them. In the second process, the image corrected the shading are separeted into two colors of beef and beef fat by the fuzzy separation technique, and these information are sent to the hybrid neural network as the input data. Finally, the image are graded in accordance with the standards by the hybrid neural network.

Fig.10 (a)-(d) show the final results of the beef marbling, beef color, beef fat color, and beef quality, respectively. These figures also show that the most results of this system agree with the expert's judgments.

6. Conclusion

We have proposed the fuzzy shading correction method, fuzzy separation method of color image data, and hybrid neural network for image processing techniques. We have also construct the beef grading system in accordance with the standard of Japan Grading Association. The results of this system have been accepted with great satisfaction.

References

[1] H. Ichhashi, et al.: "Learning Control by Fuzzy Models Using a Simplified Fuzzy Reasoning," J.of SOFT, Vol.2, No.3, pp429-437, 1990 (in Japanese)

[2] Japan Meat Grading Association: "The Standard of Table Meat," 1989.

[3] T. Takagi et al.: "On Error Back Propagation Algorithm Incorporating Counter Propagation Network," Proc. of ConFuSE'92, pp.157-160, 1992.