



Proceedings

4th International Conference on

Quality Control by Artificial Vision

Nov. 10-12, 1998 Takamatsu

QCAV 98

ISBN: 4-921073-01-5

CO-ORGANIZED BY

Kagawa University

Universite de Bourgogne

IEEE Industrial Electronics Society

IEEE Robotics and Automation Society

Institute of Electrical Engineers of Japan

Pole Imagerier de Bourgogne

Quality Evaluation of Brown Rice Using Optical Characteristics and Neural Network

T. Satake
Inst. of Agr. & Forest Eng.
University of Tsukuba
Tsukuba City, Ibaraki 305-8572
JAPAN

T. Furuya
Department of Information Science
Faculty of Science
Toho University
Funabashi City, Chiba 274-0072
JAPAN

A. Addo
Doctoral Program in Agric. Sciences
University of Tsukuba
Tsukuba City, Ibaraki 305-8572
JAPAN

Abstract

A simulation of the quality evaluation of brown rice using optical characteristics such as transmitted light ratio and spectral ratio, and neural network was carried out as a preliminary step into the development of a neuro-processor for the quality evaluation apparatus. The simulation classified brown rice into five quality categories such as mature rice, immature rice, severely damaged rice and colored rice, etc. based on external appearance according to optical characteristics. Based on this study, it was clarified that the judgement level of the neural network was 76-87% of that of an experienced rice quality evaluator. As a result of this simulation, it was clarified that the use of neural network was effective for quality evaluation of brown rice.

1 Introduction

In general, harvested agricultural products are sorted and graded before shipment. Rice which is one of the main agricultural products in Japan is also graded to five categories such as mature rice, immature rice, severely damaged rice and colored rice, etc. by much experienced quality evaluators according to grain conditions, such as maturity level, damage level, external skin color level, etc. On the other hand, neural network is modeled after the functions of the human cranial nerve system. This model can carry out a parallel information processing of multiple signals.

In this study, as a preliminary step into the development of new technology for external quality evaluation of brown rice, quality evaluation simulation was carried out using optical characteristics and neural network.

1.1 Previous Work

The basic study of the neural network which is one of the information processing technologies, have been carried out by Rumelhart and co-workers, and other many research scientists. On the other hand, many applied studies of the neural network such as classification, pattern recognition, multivariable control, etc. to various fields have been carried out.

2 Materials and Methods

Rice grains of Japonica varieties, *Koshihikari*, *Kirara 397*, *Minenishiki* and brown rice mixture, were used as test samples of the quality evaluation simulation. A total number of 2450 grains was used. Before simulation, these test samples were classified by much experienced technicians into five categories such as matured grains, immature grains, slightly and severely damaged grains, and colored grains. The number of grains of each category was about 100 kernels. The moisture content of test samples was 14-15% (wb).

Fig. 1 shows the schematic diagram of the apparatus used for measuring the optical characteristics of brown rice. Outputs readings of reflected photo sensor and transmitted photo sensor were input into a computer and transmitted light ratio defined as a ratio of the readings was calculated. In addition, output readings of green photo sensor and red photo sensor were also input into the computer and spectral ratio defined as a ratio of the readings was calculated.

Fig. 2 shows neural network for the quality evaluation of brown rice. This neural network

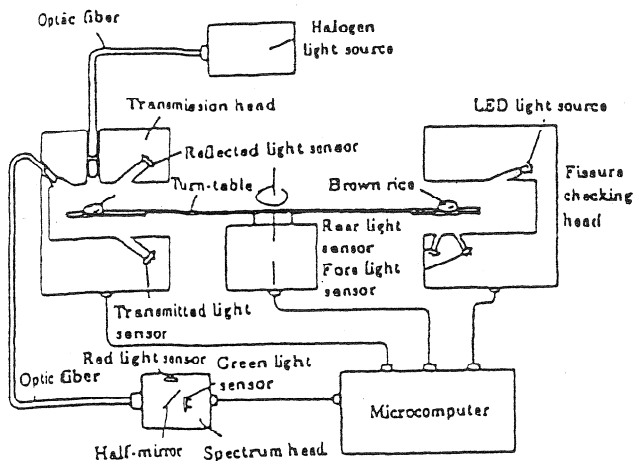


Fig. 1 Schematic diagram of the apparatus for measuring the optical characteristics of brown rice

(NN) model is composed of three layers with two elements in the input layer and five elements in the output layer. There was only one hidden layer with variable elements. Two elements at input layer corresponded to transmitted light ratio and spectral ratio, and also five elements at output layer corresponded to the five quality categories. Backpropagation network was composed on Unix Workstation (SUN 3/260) and quality evaluation simulations were carried out with variable learning cycles and number of hidden elements. During network training, the simulations were carried out with learning coefficient of 0.9 and momentum coefficient of 0.6.

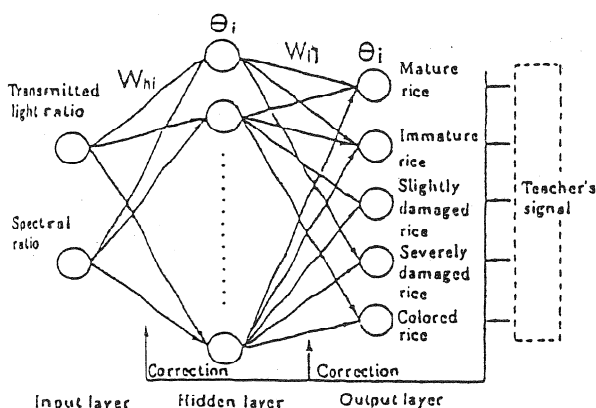


Fig. 2 Neural network for the quality evaluation of brown rice

The result of human judgement based on visual inspection by much experienced technicians were used as output data to the NN model as teaching signal. After simulation, comparison of judgement level of this NN model against the result of human judgement on visual inspection was carried out.

3 Results and Discussion

Fig 3 shows the scatter diagram of optical characteristics of brown rice used. In general, plots of each category have the tendency to form clusters. On the other hand, it is clear that the discriminant boundary was nonlinear. Therefore, it seems to be difficult to apply the threshold method which is widely utilized to distinguish quality categories. So a new classification method which has the possibility of attaining high judgement level similar to human judgement is needed.

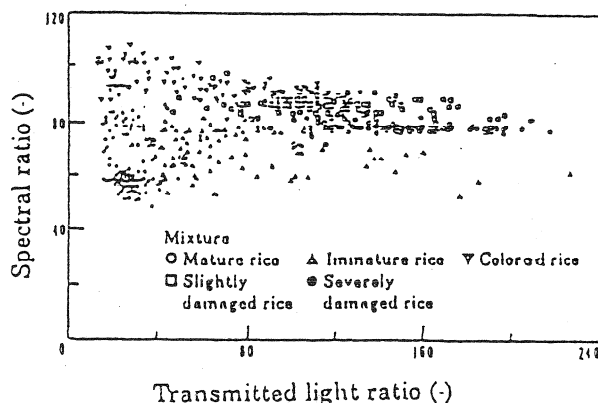


Fig. 3 Plot of optical characteristics of brown rice

Fig. 4 shows effects of number of hidden units on the average percentage of correct response. It was cleared that there is a serious effect of number of hidden units on correct response. In case that the number of hidden unit of layered network model is one, the value of average correct response ranged from 46 to 55%. On the other hand, the value of average correct response correspondingly increased with the increase in the number of hidden units.

The value of average correct response ranged from 81 to 87 % at 5 hidden units. The average correct response values showed a similar trend when the number of hidden units increased from 5 to 25.

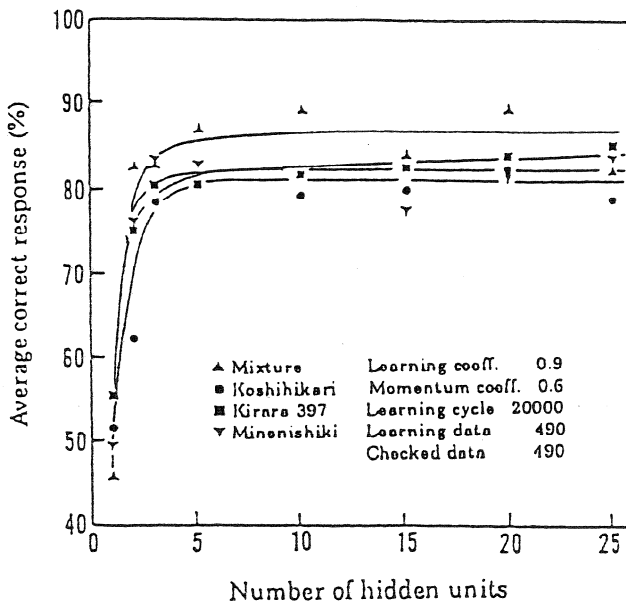


Fig. 4 Effect of the number of hidden units on the average percentage of correct response

Fig. 5 shows an example of the relationship between the percentage of correct response values of quality categories and the number of hidden units. The variance of correct response of each quality category with the increase of number of hidden units showed a fluctuation pattern.

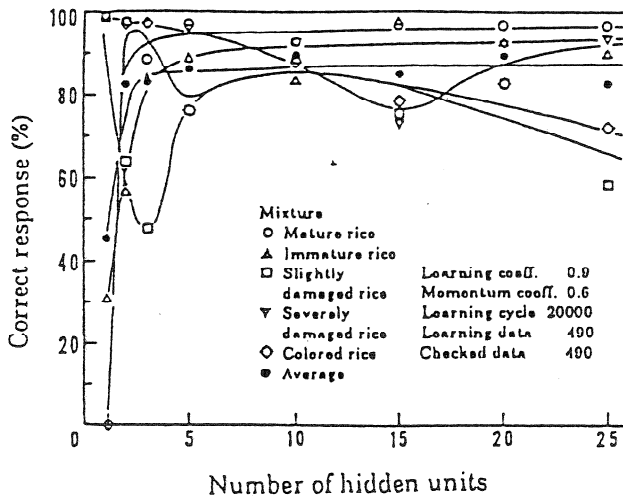


Fig. 5 Relationship between the percentage of correct response of quality categories and the number of hidden units

The variance of correct response of each quality

category at less than 5 hidden units was larger than that for correct response at more than 5 hidden units. As a reason of this pattern, it seemed that the difference of correct response of each quality category was strongly influenced by the distribution of the transmitted light ratio and spectral ratio relationship which is shown in Fig. 3. As a result of the simulation to study the effect of number of hidden units on correct response, it was clarified that the judgment level of neural network with more than 5 hidden units was nearly equal to that of an experienced rice quality evaluator.

Fig. 6 shows the effect of number of learning cycles on the average percentage of correct response. This is a result of quality evaluation of NN simulation with variable learning cycles with the number of hidden units fixed. From this simulation, it is clarified that average percentage of correct response increased with the increase of learning cycles. The average percentage of correct response reached 76–87% at more than 10,000 learning cycles. After 200,000 learning cycles, the value of average correct response reached 84–91%. On the other hand, the number of hidden units of layered type network affected the average percentage of correct response.

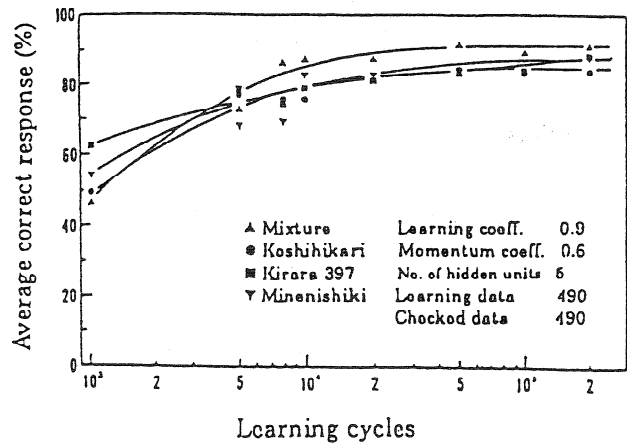


Fig. 6 Effect of the number of learning cycles on the average percentage of correct response

Fig. 7 shows an example of the relationship between the percentage of correct response of each quality category and the number of learning cycles. The variance of correct response of each quality category with the increase in the number of learning cycles showed a fluctuation pattern. The variance of correct response of each quality category at less than 10,000 learning cycles was

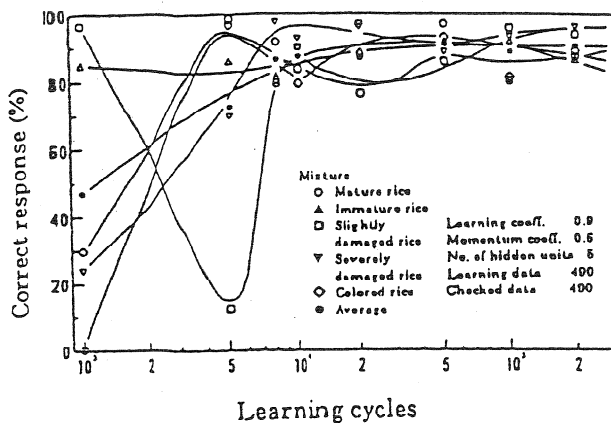


Fig. 7 Relationship between the percentage of correct response of quality categories and the number of learning cycles

larger than that for correct response at more than 10,000 learning cycles. As a reason of this pattern, it seemed that the difference of correct response of each quality category was strongly influenced by the distribution of the transmitted light ratio and spectral ratio relationship. As a result of simulations to clear the effect of number of learning cycles on correct response, it was clarified that the judgment level of neural network validation at more than 10,000 learning cycles was nearly equal to that of an experienced rice quality evaluator.

Tables 1 and 2 show one of the examples of threshold values and link weights as a result of the neural network simulation.

Table 1 Weights of the links and threshold values (input layer → hidden layer)

Unit		Hidden layer				
		1	2	3	4	5
Threshold value		-28.38	10.49	31.14	32.96	-2.62
Input layer	Transmitted light ratio	-18.48	-59.07	-18.81	1.51	6.12
	Spectral ratio	52.75	-12.45	-47.52	-63.65	-10.05

Test sample: Mixture; Average correct response: 91.8%; Learning coeff.: 0.9; Momentum coeff.: 0.6; No. of hidden layers: 5; Learning data set: 490; Number of learning cycles: 10³

Table 1 shows weight values between input and hidden layers, and table 2 the weights between hidden and output layers. The minus symbol in the tables means restrained link, and plus symbol means active link. In general, it was shown that the absolute value of link weights between hidden and output layers were lower than those between input and hidden layers. It was also shown that the absolute values of threshold at output layer were smaller than those of hidden layer.

Table 3 shows the range of data for the verification of data of the generalization of neural network model. The sets of data selected randomly from these ranges were values close to experimental data as shown in fig. 3.

Fig. 8 shows the verification of the generalization of the neural network. At the beginning of this

Table 2 Weights of the links and threshold values— (hidden layer → output layer)

Unit	Output layer					
	1 (Mature rice)	2 (Immature rice)	3 (Slightly damaged rice)	4 (Severely damaged rice)	5 (Colored rice)	
Unit	-3.34	-5.71	3.32	-12.44	-2.96	
Hidden Layer	1	-14.01	-7.49	-5.65	1.61	5.20
	2	-5.20	-8.35	-5.15	7.17	4.28
	3	-10.00	8.30	-2.23	13.17	-7.87
	4	9.10	1.43	-8.12	-4.01	-12.15
	5	-4.95	3.30	-2.86	-1.39	-5.63

Test sample: Mixture; Average correct response: 91.8%; Learning coeff.: 0.9; Momentum coeff.: 0.6; No. of hidden layers: 5; Learning data set: 490; Number of learning cycles: 10³

simulation, a set of data was used in training the network. Another set of data was presented to the trained network for validation. As a result of this simulation, it was shown that the value of correct response of neural network was 90% or more using the validation data set. Therefore, it was cleared that neural network has the ability of generalization.

4 Conclusion

Based on this study, it was clarified that the judgement level of the neural network was nearly equal to that of information processing of an experienced rice quality evaluator, and the use of neural network was effective

Table 3 Range of data for the verification of the generalization

Quality Description		Mature rice	Immature rice	Slightly damaged rice	Severely damaged rice	Colored rice
Range of validation data	T/R	100-200	40-135	58-166	18-39	15-115
	R/G	77-81	65-78	83-90	53-83	88-105

T/R : Transmitted light ratio; R/G : Spectral ratio; Validation data set for each quality description : 20

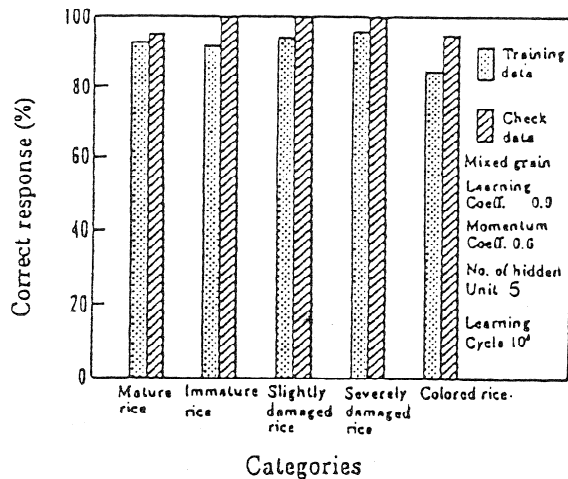


Fig. 8 Verification of the generalization of the neural network

for quality evaluation based on external appearance of brown rice.

Acknowledgements

The authors would like to thank Shizuoka Seiki Co., Ltd. for the equipment and technicians made available for this study.

References

1. K. Asakawa, Learning and Control of Robot using Neuro Computer, Computrol, Vol. 24, pp. 108-115, 1988. (In Japanese)
2. C. S. Deng, Haykin, A Multi-Layer Neural Network Classifier for Radar Clutter, IJCNN '90, pp. 241-246, 1990.
3. T. Furuya, A. Kokubu, Brain, A Structured Neural Network for Connectionist Intelligent Systems, ICNN 90, 428-432, 1990.
4. J. D. Hoyt, H. Wechsler, An Examination of the Application of Multi-Layer Neural Networks to Audio Signal Processing, IJCNN '90, pp. 305-310, 1990.
5. K. Imai, Neural Network-Collection-, Kyoritsu Publisher, 1990. (In Japanese)
6. K. Shikano, Speech Recognition Using Neural Network, Computrol, Vol. 29, pp. 42-51, 1990. (In Japanese)
7. D. E. Rumelhart, G. E. Hinton, R. J. Williams, Learning Internal Representations by Error Propagation, In Parallel Distributed Processing, Volume 1, J. L. McClelland, D. E. Rumelhart and The PDP Research Group, MIT Press, 1986.
8. D. E. Rumelhart, G. E. Hinton, R. J. Williams Learning Internal Representations by Back Propagating Errors, Nature, 323, pp. 533-536, 1986.

Nov.12 Hall

12:30 – 14:30 Environments for Machine Vision-I