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A Comparative Study of Neural Network Approach and Linear Regression for Analysis of Multivariate Data of the Defect Color on the Color CRT Displays

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Synopsis

A comparative study of neural network approach and linear regression method for analyzing multivariate data of the defect color on the color CRT (Cathode Ray Tube) displays has been conducted. Multivariate data consist of the results of observations of different parameters for a number of defect color. An artificial neural network learning algorithm implementation to the problem is examined, with the different input parameter and dimensionality reduction; which means by relatively fewer parameters for a large body of data without loss of information.

A multi-layer feed forward neural network utilizing the backpropagation algorithm has been employed to the recognition of defect color on the color CRT display. A simulation program develops the defect color on the color CRT display. Human eyes perform evaluation of the white uniformity grade by comparing with the standard grade. This is as a supervisor of the learning process of neural network. By using the same data, is also compared the performance of analysis with conventional statistic linear regression method. We identify the grade level of defect color into six grades, both methods have similar performance, however, for the intelligent purpose in automatic production process, the neural network approach is more convenient.

KEYWORDS: artificial neural networks, linear regression, multivariate data, defects color, and color CRT displays

1. Introduction

Modern electronic displays provide multi purpose and more interactive to the user. Widely and fast growing interest in using electronic display, color CRT (Cathode Ray Tube) displays still selected as monitor display for active visual media communication. The reason is competitive price and high synthetic image quality that resulted on the displays. High quality of the synthetic image can be obtained by increasing the quality of the display and or the transformation from real image to the synthetic image. Usually a camera performs the transformation.

This work is addressed to find the best relationship between the synthetic image on the display with the real image parameters. The relationship is useful for initiative in improving the quality of display. To obtain the goodness of image on the color CRT displays some adjustment is required, and nowadays the automated of color recognition for color CRT displays is extensive. Some studies have been done, and the result as predicted is given in the reference. [4,5,6] The relative different in uniformity surroundings color regions called defect color. The framework of present experiment is also addresses to identify the defects color and classify the grade level of the defect color on the color CRT displays. The ANN techniques have been widely used in many recognition and identification systems. [2,3] Moreover, for defect color detection has proven and shown in the reference. [7,8] For validation purpose in this study we also use the conventional statistic linear regression method.

By the proposed method, the recognition of the defect color, is expected could work as well as human eyes recognition. The simulation is used to demonstrate the proposed method; we simulate the defect colors on the monitor screen by a simulation program in the personal computer. Selected parameters of defect color as input data of neural networks, these parameters are essential parameters, which are most sensitive to the change of synthetic image quality on the monitor screen. The input data parameters of the network are different with the previous work. [8] Human observations to the condition of screen are verified in grade scale of certainty number by comparing with the provided standard. The standard grade is determined. This observation is used as the targets of training data. The gradient descent square of the backpropagation method is used for the learning process. Then, the trained network is used for recognizing other defect color data called testing data. To evaluate the success of recognition method by ANN, the result is compared with observation by the human eyes.

Basically, the supervised learning neural network is used to find a mapping model that will correctly associate the input parameter with the objectives.

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Thus, in this work the training data consist of human observation result as target, and seven parameters of defect color. The training data set was chosen carefully, this is to avoid the weakness of analysis technique by supervised learning method to the inefficiently initializing data. Better network can be achieved by providing a number of samples covering the desired target range.

Learning in neural network is finding the appropriate weight connection among neuron, in statistic method known as regression analysis. The regression analysis term is used to find the best set of parameters, which verify the functional relationship between dependent parameter and independent parameters in many situations. Comparisons the performance of analysis result between neural network approach and conventional statistic is presented. The next section will be described the simulation process of this experiment, the defect color pattern which is used for experiment, neural network structures, input parameters of network, and some results of experiments also given.

2. Simulation Process

2.1. Block Diagram of the Experiment System

Figure 1 shown the block diagram of the experimental process. A simulation program in personal computer generates the defect color patterns on the monitor display. The human eyes evaluate the white uniformity of color display, and verify in grade scale of certainty number. In this experiment number from 0 to 5 denotes the grade scale of recognition, each grade scale has a meaning as follows.

- 0 (could not be recognized)
- 1 (could be recognized occasionally)
- 2 (could be recognized weakly)
- 3 (could be recognized fairly)
- 4 (could be recognized steadily)
- 5 (could be recognized strongly)

The standard grade is defined by prior generate the defect color in six different grades. Observer performs several times of recognition to avoid confusion in verifying grade of their recognition.

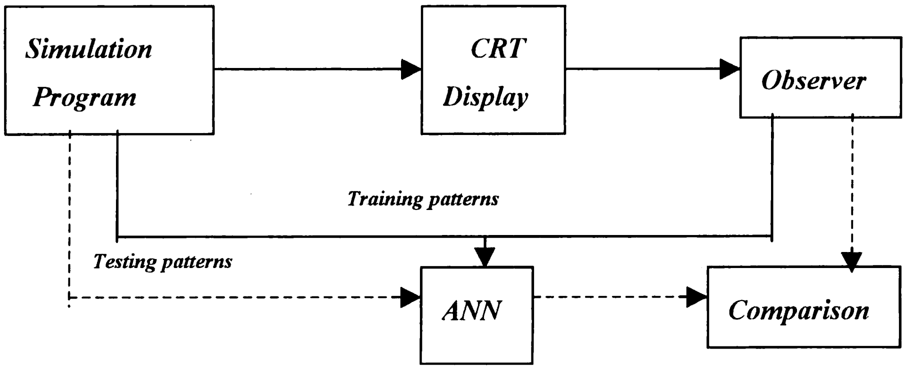

Fig. 1 Block diagram of experiment system

Parameters of the defect color pattern as input of artificial neural networks supervised by human eye evaluation result to the white uniformity of color CRT display. The condition of defect color, as well as position, brightness, color, luminance can be changed appropriate with the necessaries of experiment. In details are offered in the next sub sections. Figure 2 is flow diagram of the realization of the simulation process.

2.2. Characteristics of Defect Color Patterns

The simulation program generate some abnormal conditions which appear in the color CRT display which is called defect color or irregular color. The defect color patterns is simulated as an ellipse form. The shape of defect color as depicted in figure 3. Several parameters of a color defect are, back ground color as well as red, green and blue with initial value is 200 level for each principal color (R = red, G = green, B = blue); luminance is 70 cd / m^2, and chromatically are x = 0.283, y = 0.298. The other parameters are explained in figure 3: A is short

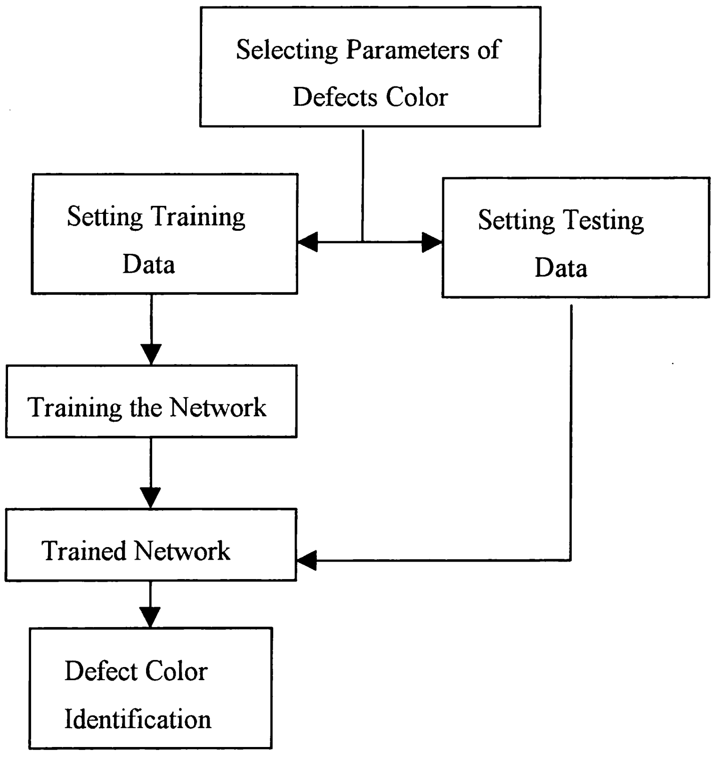

Fig. 2 Flow diagram of the simulation process of defect color identification

axis of inner ellipse length, A‘ is short axis outer ellipse, B and B` are long axis of inner and outer ellipse respectively, and C are values of Δ R, Δ G, Δ B respectively. The values of C are automatically calculated in the simulation program for R, G, and B colors respectively. Thus, we can change the characteristic of shape including color, position, and size by modification the parameters as mentioned above. We do not use these parameters directly to the network; however, it is necessary to modify and selected based on their sensitivity to the change of the synthetic image. Detail of selecting the input parameter is presented in the section of preparation data and neural network topology.

3. Preparation Data and The Network Structure

3.1. Input Data Parameters

Taking the data is randomly. Human eyes as observer, recognize and classify the conditions of color CRT display, then, the result of each screen condition recognition by observer are indicated on six grades coding number.

Selecting the essential input data parameters of image pattern is important point that must be thought, because those parameters reflect to image quality. The parameters that used in current experiment are rather different with parameters that used in references. [4,5]

Based on reference [4], for this experiment the following parameters are considered to select the appropriate input parameters of neural network. The parameters related to the position of the defect color on the monitor screen are discarded. We consider parameters, which has relation with the size of color defect, and parameters that are related to color of the defect color. Deal with the size of color defect, are the following parameters. Short axis and long axis of inner ellipse length, short axis and long axis of outer ellipse length, length difference of outer and inner short axis, length difference of outer and inner long axis, and surface area of color defect. Color of the defect color parameters cover, luminance, hue, saturation, and luminance defect of each color. In this experiment the rotation of color defect is also ignored. The parameters are selected after a careful analysis of the defect color characteristics. The most sensitive parameters reflect to the image quality plays an important role in determining input data parameter of artificial neural network. Training data and input data of the network that is used for this experiment are combination among subsequent parameters: luminance (1), saturation (2), hue (3), area (4), elliptical (5), color-edge

(6), and luminance-edge (7).

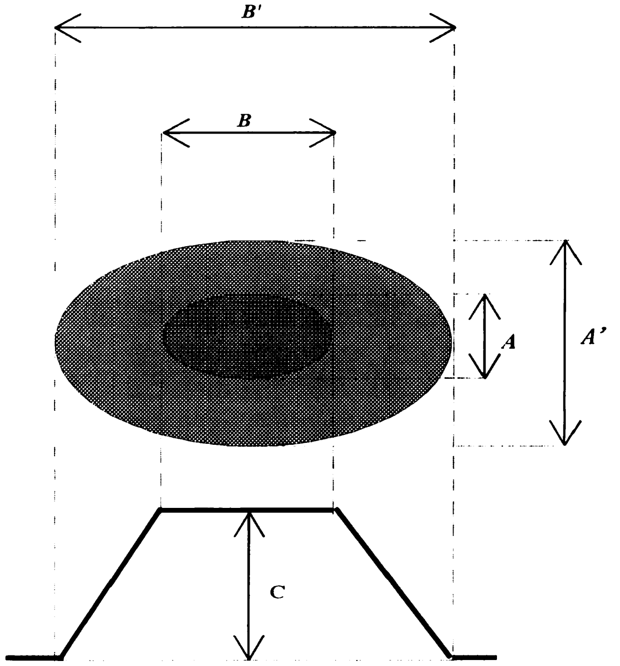

Fig. 3 Feature of Color Defect

$$\Delta Y = 0.3\Delta R + 0.6\Delta G + 0.1\Delta B \quad (1)$$

$$Sat = \sqrt{(\Delta R - \Delta Y)^2 + (\Delta B - \Delta Y)^2} \quad (2)$$

$$\delta = \tan^{-1}\frac{\Delta R - \Delta Y}{\Delta B - \Delta Y} \quad (3)$$

$$Area = \frac{B'+B}{2} x \frac{A'+A}{2} \quad (4)$$

$$Elp = \frac{B'+B}{A'+A} \quad (5)$$

$$C - edge = \max\left\{\left|\frac{Sat}{B'-B}\right|, \left|\frac{Sat}{A'-A}\right|\right\} \quad (6)$$

$$L - edge = \max\left\{\left|\frac{\Delta Y}{B'-B}\right|, \left|\frac{\Delta Y}{A'-A}\right|\right\} \quad (7)$$

We divide hue parameter into 7 classes as shown in table 1. The classification level is used as input parameter. Image pattern of defect color on the monitor screen is depending on each parameter as mention in equation (1) until equation (7). If each equation is denoted as x, general function of defect color can be verified as linear function as follows;

$$defect\_color = f(x_1, x_2, \ldots\ldots x_7) \quad (8)$$

Table 1 Hue classification

Class	*Color*	$\theta[^{o}]$
0	*None*	
1	*Magenta*	*21 - 79*
2	*Red*	*80 - 144*
3	*Yellow*	*145 - 200*
4	*Green*	*201 - 259*
5	*Cyan*	*260 - 324*
6	*Blue*	*325 - 20*

Optimization of equation (8) as utility function of defect color is linearly weighted by numerical factors measuring the relative significance of different qualifications. Statistically speaking, this process is regression analysis. Iterative changes of weights can be performed by a gradient descent method, which is used in the backpropagation learning algorithm. Therefore the backpropagation learning algorithm is used in this experiment.

3.2. Artificial Neural Network Structure and Learning Process

There is immense progress in developing ANN research and their application has been made, especially in pattern recognition, one of successfully works is depicted in the reference [3]. In this work organizing nodes form the network structures into layers and connecting these layers of neurons with modifiable weight interconnections. The three-layer feed forward neural network is used, and the backpropagation algorithm is employed for weight modification. [1] The sigmoid function is used as the activation function for each neuron output as given in (10). Adjusting the weight to obtain the appropriate network by using the equation below.

$$w_{ij}(t+1) = w_{ij}(t) + \eta\delta_{pj}o_{pi} + \alpha(w_{ij}(t) - w_{ij}(t-1)) \qquad (9)$$

where, w_{ij} are weights, η is a learning rate coefficient, δ_{pj} is an output unit, and α is a momentum coefficient. The momentum term is used to speed up the learning process.

$$h_{ji}(x) = (1 + e^{-\alpha x_{ji}})^{-1} \qquad (10)$$

The network topology for this experiment is shown in figure 4. As shown in table 1, based on hue classification the training and testing data are divided into six classes. Thus, there were six networks that used for each class of hue. The first weights are initialized randomly, then set of training patterns of defect color, include the corresponding desired outputs (evaluation result by human eyes) are fed into the networks. Before inputted data set to the networks, we scaling the data set to be constrain to lie between 0 and 1, and performed by the following equation,

$$D_n = \frac{D_o - D_{\min}}{D_{\max} - D_{\min}} \qquad (11)$$

where,

D_n is the normalized data
D_o is the original data
$D_{\min}$ is the minimum data
$D_{\max}$ is the maximum data

After the output of the networks is yield, then the weights are updated, and the sum squared error is used to minimize of weight of each network. This process has done continuously by changing the weights until the error in the output layer is reduced to a certain value or a maximum number of iterations are reached, for this experiment the number of iteration was varied from 10000 to 20000 for each hue class of training data. Then, this learned network can be used to recognize the other irregular color data, which is called testing data. The learning rate taken in this experiment is 0.5, and the momentum coefficient is 0.5.

Configuration of ANN that used in this work, for each hue class the network consists of 7 input units, a hidden layer of 14 units and an output layer of one unit. This network is chosen, after we select some different networks with different number of hidden unit. Average number of training data for each hue class was varied between 30-50. The same number for testing data is used too.

4. The Recognition Results by Neural Network and Linear Regression

The neural network require a long time to learn the training data, however, the recognition process by the trained network can be done quickly. Selecting the input parameter data and the appropriate network structure, will affecting the stability of recognition result. Thus, the input parameters must be selected carefully.

We have studied on some dependencies of defect color recognition to the different in hue and color, for the same number of training set and the network structure. The dependence of recognition success rate on the number of input parameter using a network with 14 hidden units is shown in the figures 5. The average success rate for recognition result by linear regression is shown in figure 6.

Both computations result by neural network and regression analysis shows same performance of recognition. The different is requirement of iteration in regression method for each new input data, and this is not happened in neural network method after the learning process is finished. Therefore, for an automatic intelligent purpose the neural network more convenient then the regression method.

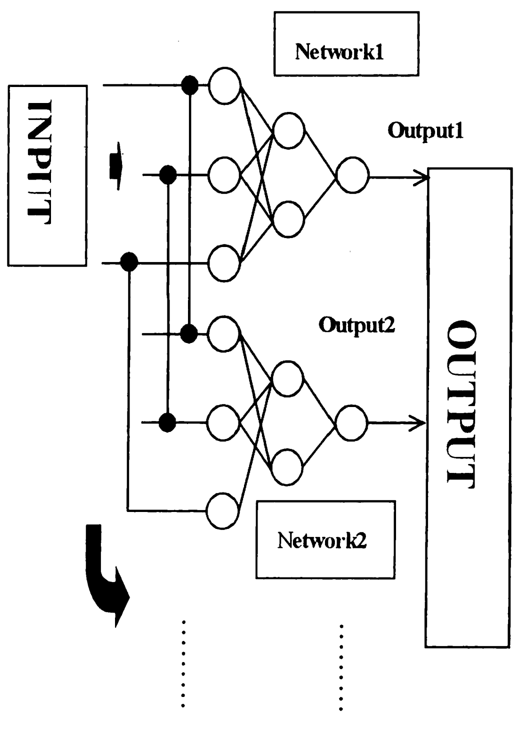

Fig. 4 Neural network structure

Concluding Remarks

Implementation of ANN and linear regression for color defect pattern recognition on the color display is presented. Both methods can be used to identify and classify grade level of defect color on the color CRT displays. This work has been done very well for detecting the availability of defect color on the color CRT displays, and recognition by the artificial neural network utilizing the backpropagation algorithm is stable as well as linear regression method. This research is still continued to increase the ability and sensitivity in identifying and classifying grade level of defect color. In color CRT production process this work can be applied as a part of automated inspection of color CRT displays, and replacing the human eyes function for checking the quality of color CRT displays. Future works, we will try to recognize multi-defect color on the monitor screen, also speeding up the computation process and finding the most significant relation between quality of image on monitor screen and physical image parameters

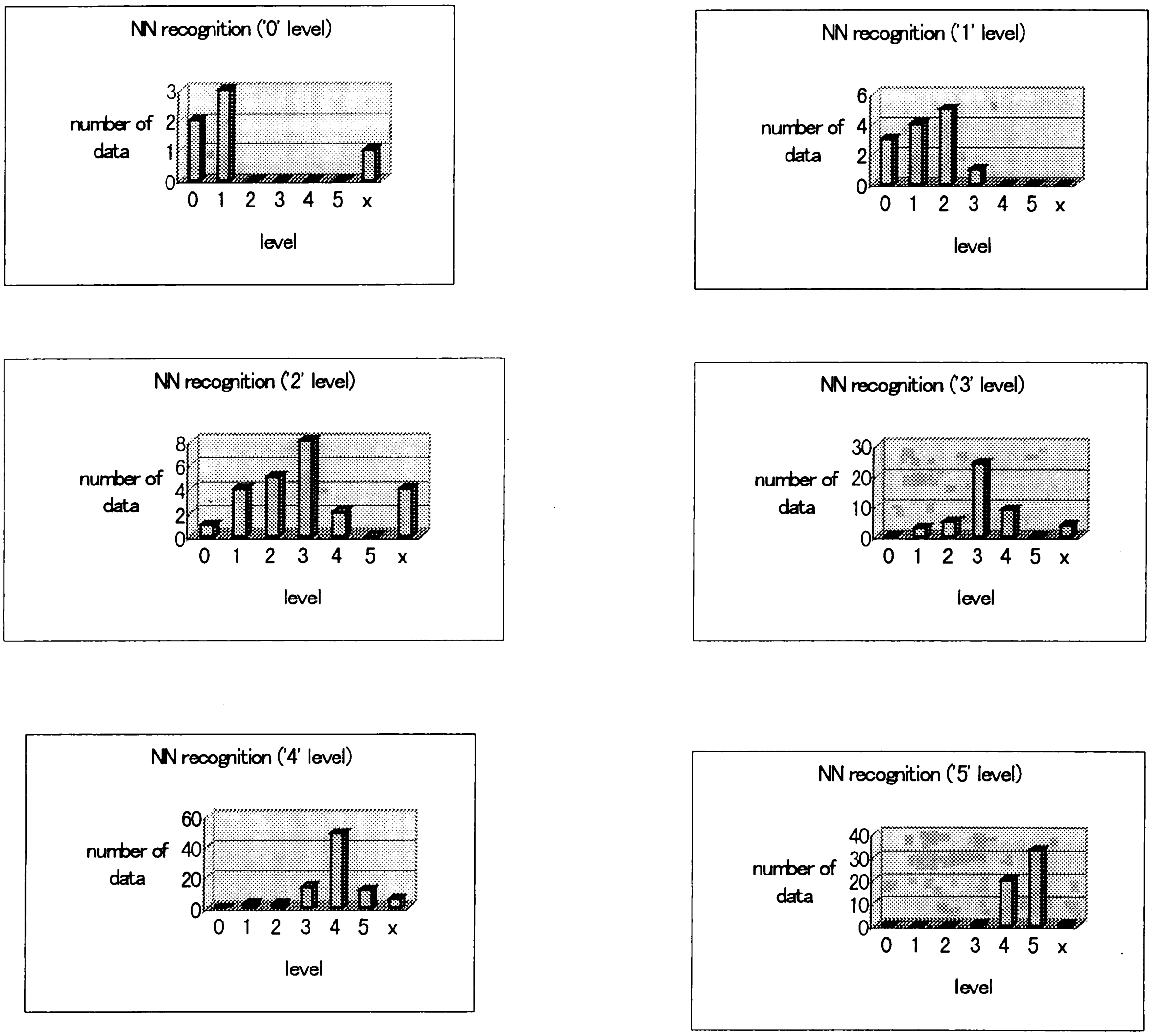

Figure 5 Success rates of neural network recognition

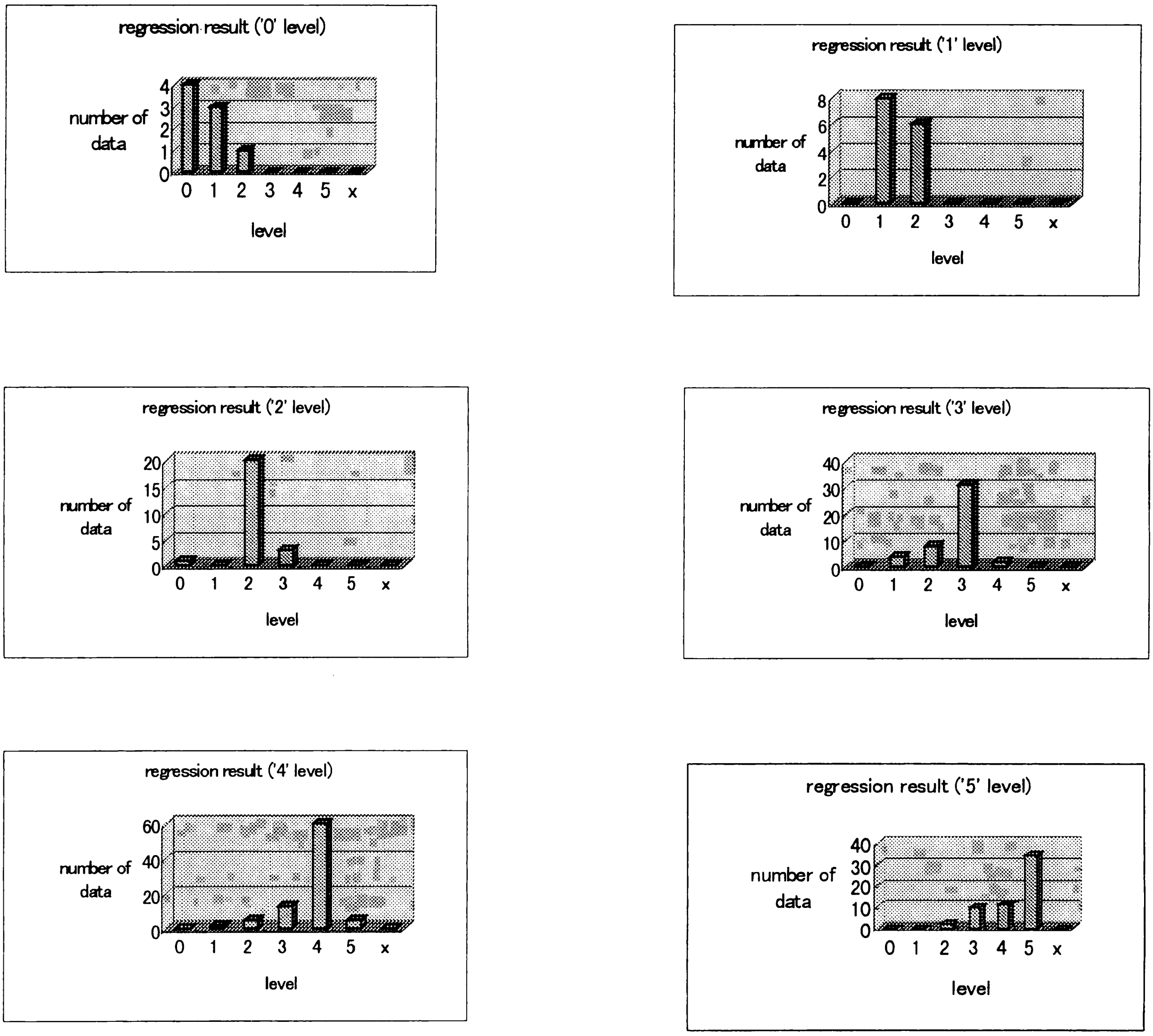

Figure 6 Success rates of regression method

References

1) D.E.Rumelhart, C.E Hinton, and J.R.William, *MIT Press, Cambridge, MA*, 318 (1986)
2) K.S.Narendra and P.Kannan, *IEEE Trans.Neural Networks*, **1**,4 (1990)
3) F.Takeda and S.Omatu, *IEEE Trans.Neural Networks*, **6-1**,73 (1995)
4) T. Asano, K Kawame, J .Mochizuki and N Fukuhara, *IEICE Transc.Information Processing*,**J73-D-II**,6 (1990) (in Japanese).
5) T. Asano, et.al. , *Proc.of IECON* , 703 (1987)
6) T .Asano, et.al., *Proc. of IECON*, 725 (1992)
7) M.H.Purnomo, et.al, *Proc. of International Panel Conf. on Soft and Intelligent Computing (SIC '96)*, 235, (1996)
8) M.H.Purnomo, et.al, *Proc. of International Symposium on Nonlinear And its Applications (NOLTA '96)*, (1996)
9) M.H. Purnomo, et.al, *Proc.of the International Conf. on Computers and Industrial Engineering*, (1997) (in press).