RESEARCH OF COLOR SPACE CONVERSION BASED ON NEURAL NETWORKS

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Abstract

Color management is a key of pre-press technology in graphic arts' reproduction. And the conversion of color space is the core technology of color management. Therefore research on the color space conversion has important values in both theory research and practical application.

- The artificial neural network is a kind of mathematical model which simulates the biological neurons, imitates the behavioral characteristics of biological neural networks, and carries out the distributed parallel information processing by using a lot of small processing units, and it is a kind of important science method to research and solve many practical problems.

- This paper divides up the LAB and CMYK color spaces based on the artificial neural networks and converts them manually by using the color picker of Adobe Photoshop software, thereby obtaining the date of modeling samples and checking samples. The paper establishes the mutual conversion models between L*a*b* and CMYK color space based respectively on BP neural network and general regression neural network by programming with MATLAB 7.5 software, evaluates the conversion precisions respectively and compares the advantages and disadvantages thereof.

- In collecting the modeling samples and checking samples, the paper divides respectively up the L*a*b* and CMYK color spaces relative uniformly by using the method of dividing up of color spaces and carries out full arrangements to obtain the input date of samples, and converts respectively them into the target date of L*a*b* color spaces samples which are independent of equipment by using the color picker of Adobe Photoshop software.

- In evaluating the precision of two conversion models from L*a*b* color space which is independent of equipment to CMYK color space which are correlative with equipment, because the emulating output values are in the CMYK color space which are correlative with equipment, the color differences of conversion thereof cannot be calculated, the paper uses the “indirect method”, i.e. CMYK values of emulating output are converted back L*a*b* values manually by using color picker, then the color differences are calculated with the values and the input values of original L*a*b*. Hence the precisions of models are evaluated indirectly.

- The modeling and checking results indicate that the precisions of all conversion models of neural networks established by this paper are higher. Whereas the conversion model of BP neural network training needs more time and the number of neurons in hidden layer is not easily determined. The conversion model based on general regression neural network has a high precision and very fast training speed, and it can be used for digital proofing, direct checking of images, computer color matching, color separation of image, image remedying, development of color control software and other relative technique fields of color management.

1 Introduction

- Till now there are many algorithms to realize the conversion of output color spaces and device independent color spaces. They are mainly divided into polynomial regression method, color models based on optics and ink mixing include the Neugebauer equations, the Yule-Nielsen model, the Clapper-Yule model, the Kubelka-Munk theory, and the Beer-Bouguer law[1], 3D-LUT with interpolation and neural networks.

- Of particular relevance to this study are nonlinear regression models based on artificial neural networks and they can achieve higher precision. So there are some applications performed by using BP neural networks of color space conversions in color scanners, monitors and printers. But there are usually two main problems existing in BP neural network applications, one is low convergent speed and the other is local minimum point occurring in object function[2].

- Generalized regression neural network is presented by American scholar-Donald F. Specht in 1991[3].GRNN has very strong nonlinear mapping ability, flexible net structure and high fault tolerance and robustness. It's very suitable for nonlinear issues' research and it has advantage over BP neural networks in approximation ability and learning speed[4].So in this paper a new efficient generalized regression neural network (GRNN for short) is adopted to research CMYK and L*a*b* color space conversion.

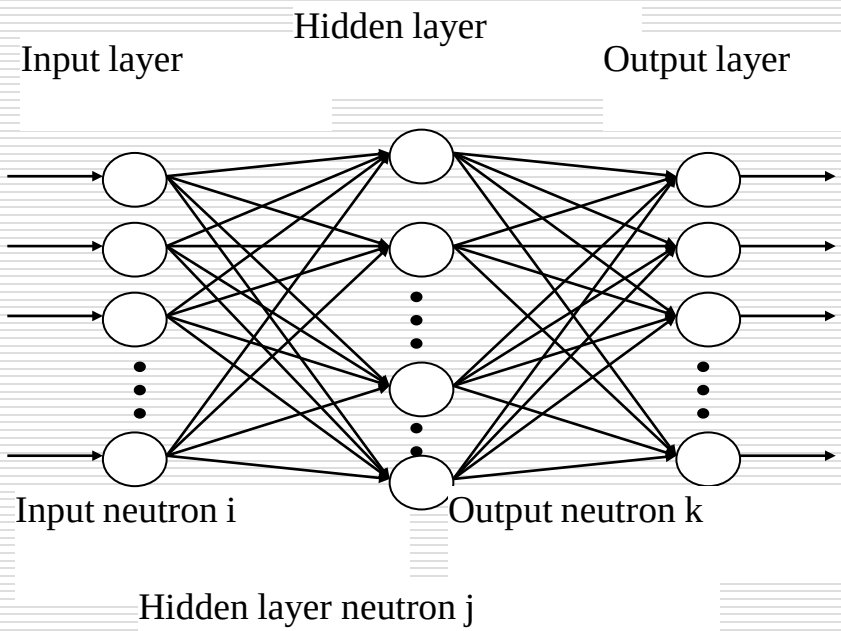
2 Selecting of Modeling Data

- Modeling CMYK data are obtained from Adobe Photoshop CS3 color picker under the condition of U.S. Web Coated（SWOP）v2. C,M,Y,K dot percentage values change from 0 to 100. They are set separately as 0,20,40,60, 80, 100 and then each number of these values do permutation and combination together.
- Therefore the modeling sets' numbers are $6\times6\times6\times6=1296$.

- These putting CMYK values and corresponding L*a*b* values are used to train the BP and GRNN neural networks for color space conversion. In the same way the 625 sets data used to verify the precision of the model are obtained, too. Set C,M,Y,K as 4,27,50,73,96 separately and do permutation. These data (5×5×5×5=625) are input into the Adobe Photoshop CS3 color picker, the corresponding L*a*b* values are then transferred.

3 Structures and Building of BP Neural Network for Color Space Conversion

3.1 Introduction to BP Neural Network



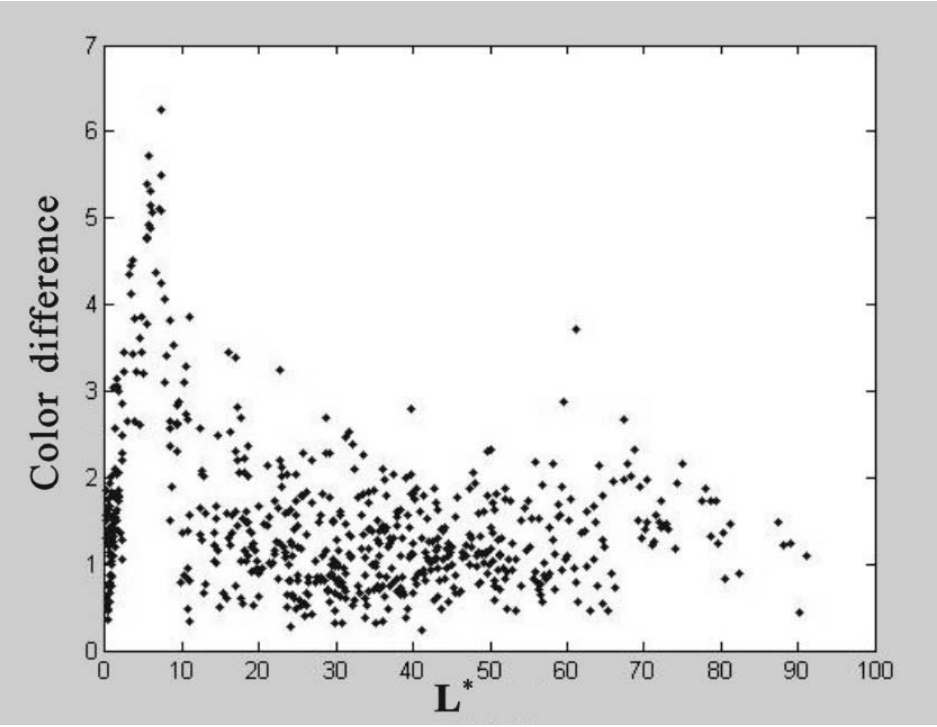
- By means of network training, calculating and judging the deviation of the output values of training model and objective samples. If the result misses the aim, back calculating is done from output layer to the first hidden layer and the net connecting weights are adjusted according to the principle of minimum deviation.
- The connecting weights of every net node are determined until total training samples meet the requirement. In this way the BP Neural Network for Color Space Conversion could be built up.

3.2 Establishment and Accuracy Test of Color Space Conversion Model between CMYK and L*a*b* based on BP Neural Network

- In this part BP Neural Networks for Color Space Conversion from CMYK to L*a*b* and L*a*b* to CMYK are built up separately using the 1296 sets CMYK values and corresponding L*a*b* values. The difference exits in the input layer and output layer variables. They are reversed, CMYK or L*a*b* sets. And the precision of models is tested using the other 625 sets CMYK values and corresponding L*a*b* values.

- The neuron numbers of hidden layer varied to build and train the models. Then the models' deviation is calculated. As a result it is set to 15.And the testing result of BP neural network model from CMYK to L*a*b* is calculated by using the CIE L*a*b* 1976 color deviation formula, as shown in Fig.2.

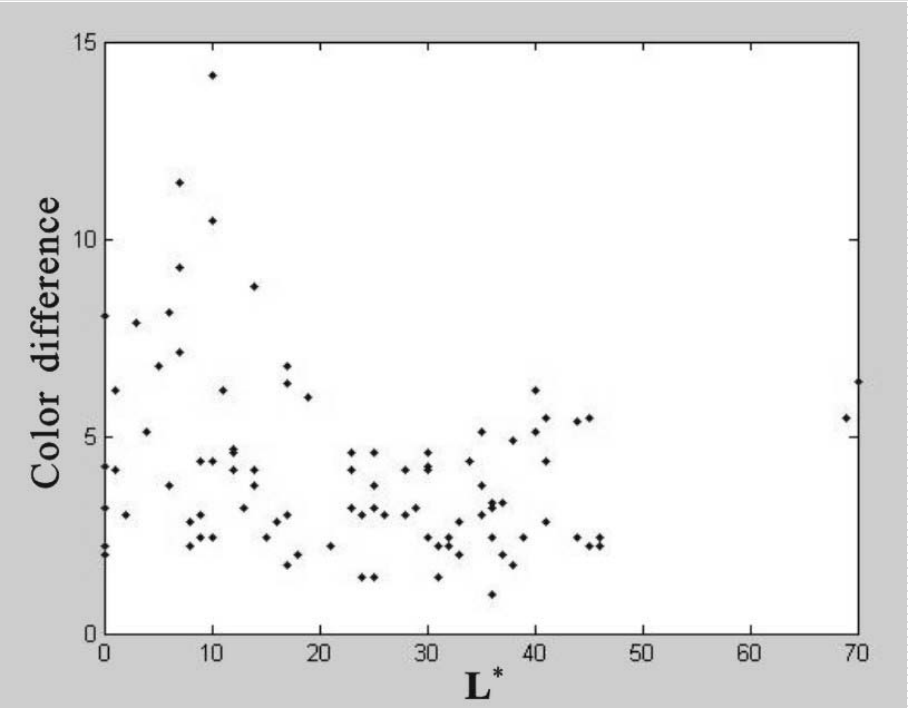
Accuracy Test of Color Space Conversion Model



The biggest color deviation between L*a*b* values of training model and objective L*a*b* values is 6.2545, while the smallest one is 0.2431. Among all testing samples the average color deviation is 1.5030 and the percentage bellowing 6 is 99.84%.

Fig. 2 Distribution chart of conversion color difference from CMYK to L*a*b*

Accuracy Test of Color Space Conversion Model



Among these 100 testing samples, the biggest color deviation between modeling and converted L*a*b* values is 14.1421, while the smallest one is 1. The average color deviation is 4.0603 and the percentage bellowing 6 is 83%. Because the statistical result is based on the upper bigger error samples, the actual precision of all testing samples is much higher.

Fig.3 Distribution chart of 100 samples with the upper bigger error converting from L*a*b* to CMYK

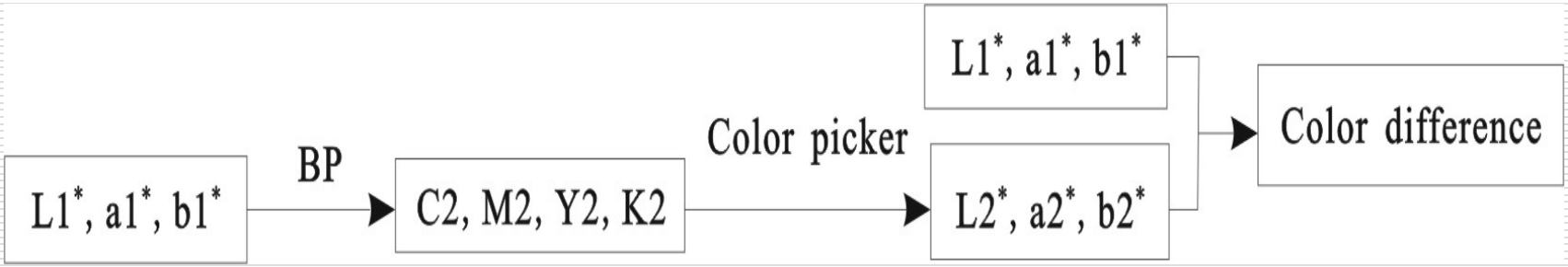


Fig. 4 Precision testing Workflow of color space conversion from L*a*b* to CMYK of BP neural network

- It’s obviously that the color conversion based on BP neural network has higher precision. But when there’s more training samples, the training speed of the neural network is very slow and the results fluctuate along with each training and simulating process.

4 Structures and Building of General Regression Neural Network for Color Space Conversion

4.1 Introduction of General Regression Neural Network

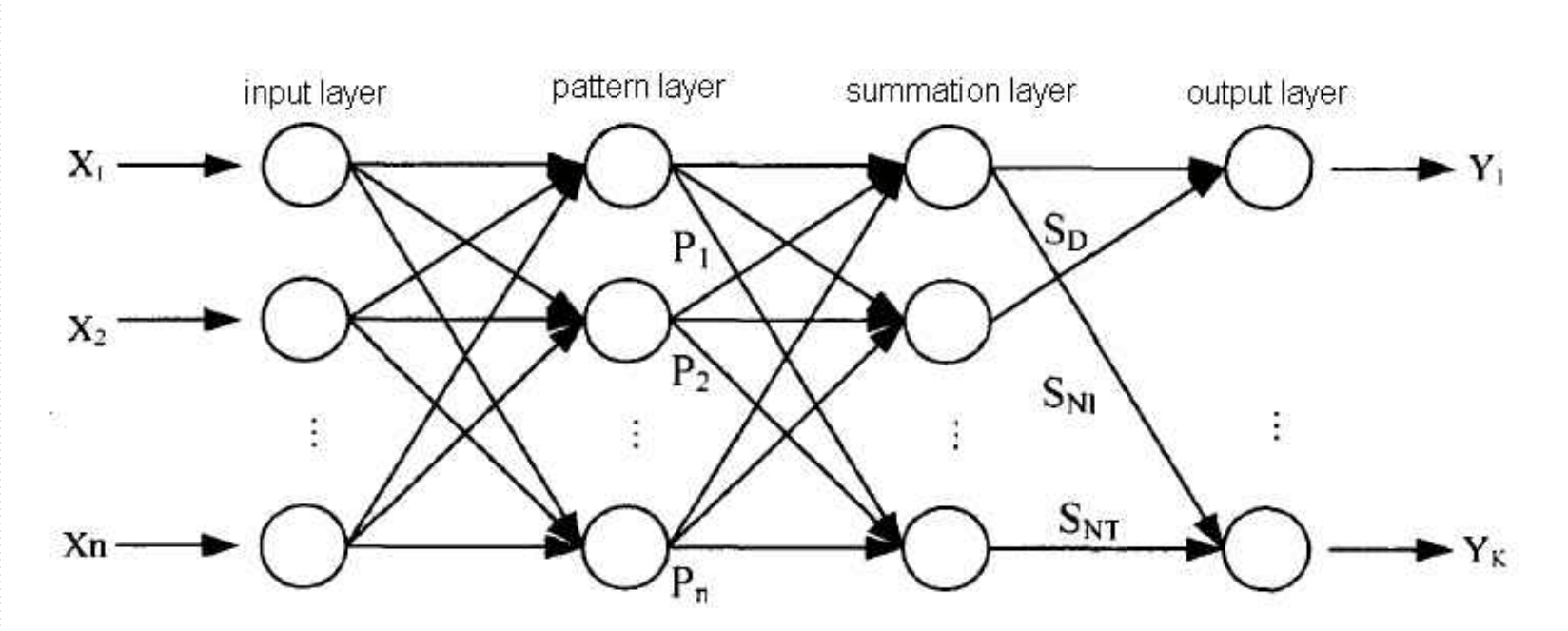


Fig. 5 Structure chart of GRNN

4.2 Establishment and Accuracy Test of Color Space Conversion Model between CMYK and L*a*b* based on GRNN

- For GRNN if the learning data is determined the corresponding network structure and weight values between neurons are also determined. So the training of network is the process to determine the SPREAD value. SPREAD value which determines spread of radial basis functions has great effect on forecast performance of the network. This paper determines SPREAD value by aid of performance function ***mse*** in Matlab.
- The detailed steps are given in the paper.

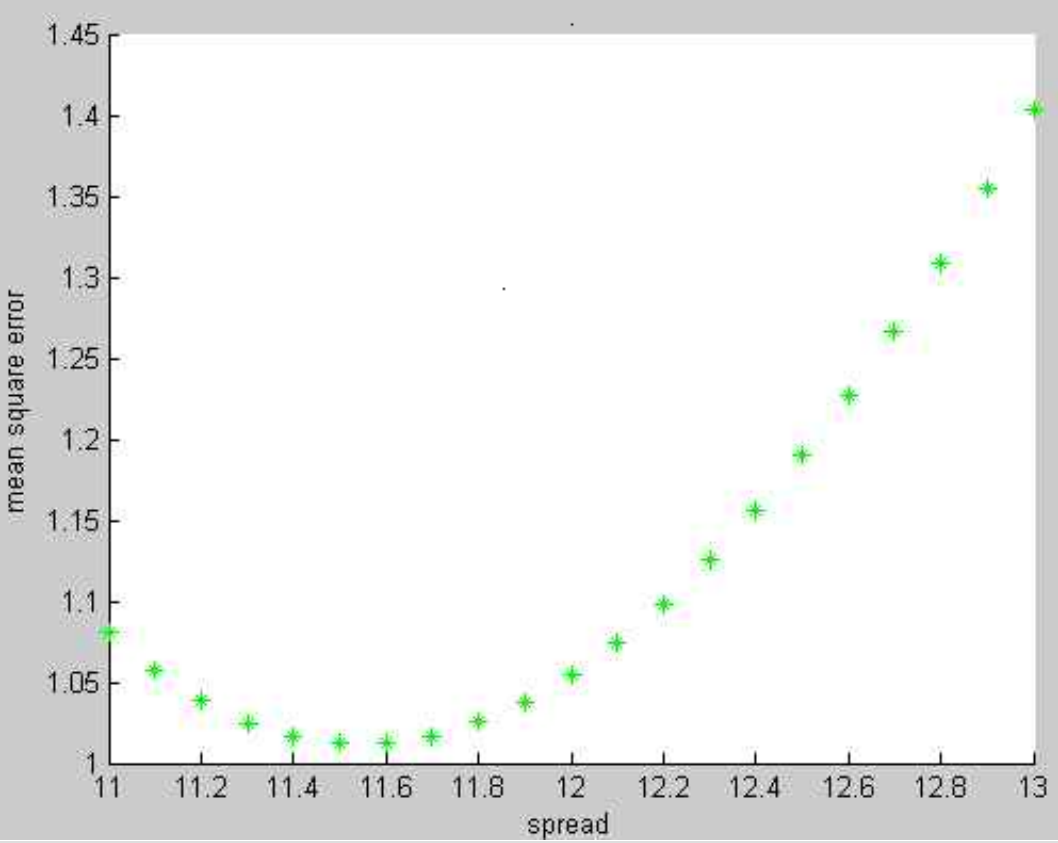


Fig.6 Optimizing chart of spread constant

The mean square error of testing sample' objective value and model' training output value is minimum to 0.7453 when spread value is 11.5.So, the optimum spread value is got. Then The GRNN transferred from CMYK to L*a*b* is built up.

- The average color difference of checking patches is 1.4139ΔEab* and the percentage of checking patches'chromatism less than 6ΔEab* accounts for 99.84%. And the maximum color deviation of training and modeling objective L*a*b* is 6.1254 while the minimum one is 0.0669.Comparing with the BP neural network built with same modeling samples, the precision of GRNN is higher and the training speed is much faster.

- Use above method to determine that the SPREAD value is 3.6.Then the color space conversion model from the input L*a*b* space to the output CMYK space based on GRNN is built.
- Finally colorimetric data of 625checking patches are fed into the color space conversion model for predicting the CMYK dot area coverage values.
- the upper bigger error converting from L*a*b* to CMYK is selected. Among these 100 testing samples, the biggest color deviation between modeling and converted L*a*b* values is 6.5574, while the smallest one is 0. The average color deviation is 3.1519 and the percentage bellowing 6 is 94%.

5 Conclusions

- This paper introduces GRNN into color conversion research and puts forward determining the spread values by aid of performance function MSE in Matllab. According to the entire training process and results analysis, it can be concluded GRNN which structure can be automatically adjusted has advantage over BP neural networks whether from the simplicity of training, training speed or accuracy.
- Hope that this work can provide wider basis and a new way for color space conversion study in color management.

References

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Thanks for your attention.

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