



Color reproduction method by support vector regression for color computer vision

Bo Yang^{a,b,*}, Hung-Yu Chou^b, Tsung-Hsun Yang^b

^a School of Electronic & Information Engineering, Chongqing University of Science & Technology, Chongqing 401331, China

^b Department of Optics and Photonics, National Central University, Chung-Li 320, Taiwan

ARTICLE INFO

Article history:

Received 7 November 2012

Accepted 2 April 2013

Keywords:

Color reproduction

Support vector regression

Successive 3σ filter

Least mean squared validating errors

ABSTRACT

In the color computer vision system, the nonlinearity of the camera and computer screen may result in different colors between the screen and the actual color of objects, which requires for color calibration. In this paper, support vector regression (SVR) method was introduced to reproduce the colors of the nonlinear imaging system. Firstly, successive 3σ method was used to eliminate the large errors found in the color measurement. Then, based on the training set measured in advance, SVR model of RBF kernel was applied to map the nonlinear imaging system. In this step, two important parameters (C , γ) were optimized by the Least Mean Squared Validating Errors algorithm to get the best SVR model. Finally, this optimized model could predict the real values displayed on the screen. Compared with quadratic polynomial regression, BP neural network and relevance vector machine, the optimized SVR model has better ability in color reproduction performance and generalization.

© 2013 Elsevier GmbH. All rights reserved.

1. Introduction

In recent years, ICC (International Color Consortium) color management is gradually being received and adopted. The core of its management is to characterize the behavior of color description of each device in imaging systems, namely, the establishment of a function between RGB or CMYK of device control signal values and the tristimulus values. This function is often described in different ways, such as Look-up Table (LUT) combined with the interpolation [1], multiple regression [2] and neural networks [3,4], etc.

Under normal circumstances, the Look-up Table method provides a precision higher than other methods, but it requires a lot of calibration samples. To reduce the data dimension of calibration samples, Wang et al. used the color correction technology for the domain partition of the multi-channel printer color correction [5]. Multiple regression works by means of polynomial approximation to the nonlinear characteristics of device color, featured in a simple conversion relationship and the lower calibration accuracy. Furthermore, the polynomial as a global function may lead to the local distortion to be extended to the whole color space. An effective way is to narrow the range of correction, that is, correction partition [6,7]. Theoretically, the neural network can approximate

any nonlinear relationship, so it has a high applicability when used for color correction. One concern is the difficulty to determine the internal structure of neural networks, such as the hidden layer.

In recent years, support vector machine based on the statistical learning theory has been playing a big role in terms of pattern recognition, image classification, function approximation, etc. And it also finds its way to be applied in the field of color correction [8]. However, research in this area is also relatively less. This paper presented an attempt to introduce a support vector machine model for establishing color correction, with correction of experimental data being used to test the accuracy of the model.

2. Color correction program

In the general color system of a computer, as shown in Fig. 1, the color of an object was captured by CCD camera in standard lighting conditions (e.g. the D50 light source), and presented on the screen through the computer. ICC is responsible to define color capture and to display the device-independent color space, plus that now there are many acquisition and display devices that support color management, such as gamma correction, color balance, etc. Nonetheless, due to the characteristics of individual equipment, color display on the screen of a computer still has differences in the color system from the actual color, so color correction is needed.

In the color system of a computer, the color correction can be done in two steps, as shown in Fig. 1a and b below.

First is the need to create color correction model. In Fig. 1a, the actual color on the standard color patch was known, and marked

* Corresponding author at: School of Electronic & Information Engineering, Chongqing University of Science & Technology, Chongqing 401331, China. Tel.: +86 2365022172; fax: +86 2365022172.

E-mail address: bob.cq@163.com (B. Yang).

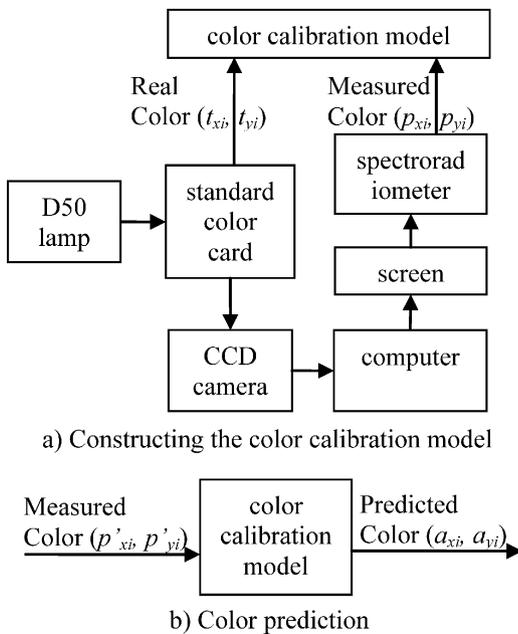


Fig. 1. Color calibration model.

with the tristimulus values (t_{xi}, t_{yi}) . In the D50 standard illumination conditions, the standard card had the colors displayed on the screen through the camera, and that are usually different from the actual color of the card. Screen showed its colors by the colors using a spectroradiometer, referred to here as the screen colors or measuring colors, marked with the color coordinates (p_{xi}, p_{yi}) . The establishment of a color correction model actually means to establish the mapping relationship between measurement color T and the actual color P . As described in section I, this mapping relationship can be established with the help of the look-up table, multiple regression or neural network methods. In this paper, support vector regression was employed to establish the mapping relationship, where the standard color patch used to establish color correction model was here known as the training sample.

In color prediction stage, as shown in Fig. 1b, the color of the unknown samples could be measured using the spectroradiometer regarding the color displayed via the camera and screen, which was marked with P' (p'_{xi}, p'_{yi}) . A well-established model of color correction could be used to obtain the predicted color A (a_{xi}, a_{yi}) , which can be used to estimate the actual value T for the unknown color samples. As evidenced later in the experiment, by selecting the appropriate color correction model, the predicted color A , compared to the screen display color P' , was able to better estimate the actual color of unknown samples T .

Support Vector Regression for color calibration based on Least Mean Squared Test Errors Algorithm

2.1. Support vector regression (SVR)

In its present form, the SV machine is a nonlinear generalization of the Generalized Portrait algorithm largely developed at AT&T Bell Laboratories by Vapnik and co-workers [9]. It is firmly grounded in the framework of statistical learning theory, or VC theory [10]. In a nutshell, VC theory characterizes properties of learning machines which enable them to generalize well to unseen data. Due to the industrial context, SV research has up to date had a sound orientation toward real-world applications. In regression applications, excellent performances were obtained [11].

Given a set of data points, $\{(x_1; y_1), \dots, (x_l, y_l)\}$, such that $x_i \in R^l$ is an input and $y_i \in R^l$ is a target output, the goal of ϵ -SV regression

[10] is to find a function $f(x)$ that has at most ϵ deviation from the actually obtained targets y_i for all the data points, and at the same time is as flat as possible. Hence the standard form of support vector regression is [12]:

$$\min \frac{1}{2} \|w\|^2 + C \sum_{i=1}^n (\xi_i + \xi_i^*)$$

$$\text{subject to} \begin{cases} y_i - \langle w, x_i \rangle - b \leq \epsilon + \xi_i \\ \langle w, x_i \rangle + b - y_i \leq \epsilon + \xi_i^* \\ \xi_i, \xi_i^* \geq 0 \end{cases} \quad (1)$$

where $\langle \cdot, \cdot \rangle$ denotes the dot product. The constant $C > 0$ determines the trade-off between the flatness of f and the amount up to which deviations larger than ϵ are tolerated.

The dual is:

$$\min \begin{cases} \frac{1}{2} \sum_{i,j=1}^l (c_i - c_i^*)(c_j - c_j^*) \langle x_i, x_j \rangle \\ -\epsilon \sum_{i=1}^l (c_i + c_i^*) + \sum_{i=1}^l y_i (c_i - c_i^*) \end{cases} \quad (2)$$

$$\text{subject to} \sum_{i=1}^l (c_i - c_i^*) = 0 \text{ and } c_i, c_i^* \in [0, C]$$

Thus the approximate function is:

$$f(x) = \sum_{i=1}^l (c_i - c_i^*) K(x_i, x) + b \quad (3)$$

This is the so-called Support Vector expansion, i.e. w can be completely described as a linear combination of the input data x_i . In a sense, the complexity of a function's representation by SVs is independent of the dimensionality of the input space, and depends only on the number of SVs.

Furthermore, $K(x_i, x)$ is called the kernel function. Though new kernels are being proposed by researchers, the RBF kernel is a reasonable first choice in general. This kernel nonlinearly maps samples into a higher dimensional space so it, unlike the linear kernel, can handle the case when the relation between the target out and the input is nonlinear. Thus, the RBF kernel used in this paper is as:

$$K(x, y) = e^{-\gamma \|x-y\|^2} \quad (4)$$

2.2. Successive 3σ filter

3σ rule uses the fact that 99.73% of all values of a normally distributed parameter fall within three standard deviations of the average [13]. Although the 3σ rule uses the normal distribution as a basis, the same is true of other distributions [14].

In the acquisition process of the color coordinate measurement value and the actual value, the light, measuring instruments and recording process may be random to the introduction of random error. This study involved the use of the 3σ criterion to filter the original data. Taking into account the sample data with the original dimension of 2, the actual 3σ filtering was based on the distance between measured value and actual value as criterion, used to determine whether the data was in a reasonable range.

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات