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# Study on Automatic Recognition of Fabric Color and Matching to Standard Color Chip by Computer Vision and Image Analysis Technology

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**Abstract**

The Artificial visual approach to detect fabric color is easy to be affected by light and experience. In order to overcome the shortcomings of errors, this paper presents a new method for matching between textile fabric color and standard color card automatically, and establishes the automatic matching system for 1925 kinds of Pantone TCX color swatches by using computer vision and image analysis. First, the scan images of Pantone TCX color were acquired, then we extracted effective color characteristic information from the images, and constructed the database of color features. Furthermore, we designed color layered model and matching model which based on 'one to one' Support Vector Machine (SVM). Through parameter optimization and identify training for SVM model, the accuracy of color identifying is 96.89%. Finally, we used 296 unknown color samples for verification, the accuracy is 98.85%. The results show that the research provides an effective auxiliary tool objectively and quickly for color measurement.

*Keywords*: Fabric Color; Color Matching; Image Processing; Support Vector Machine (SVM); Pantone Color Swatches

## 1 Introduction

The analysis of structure parameters and color is essential for imitation of dyeing cloth and yarn-dyed fabric. At present, the color analysis is performed artificially comparing the sample and textile standard card by means of visual observation, then finds the most matching card with the sample. The procedures are usually tedious and time-consuming, and it is easily affected by light and experience to cause errors. Although there are many color measurement instruments, such as spectrophotometer, which can determine the spectral power distribution of the reflection of objects, according to the spectral measurement data to calculate the three stimulus values X, Y, Z of the CIEXYZ space in all kinds of standard illuminations. But the three stimulus values of color description is different from standard color card, which makes the technical personnel who are familiar with using standard color card to determine the color scheme should conduct additional data selection and analysis, and it is contrary to the habit of most trading companies

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and factories. From then on, we think the fabric color analysis technology should be upgraded, and it should be based on the principle of objectivity and practicality. Traditional fabric surface quality inspection is time-consuming, laborious manual inspection, which restricts the textile industry to being upgraded. Many scholars transform fabric surface to digital image by using machine vision, and get information on it, then they use the digital image analysis technology to replace manual analysis. For example, there are many researchers devoted to fabric structure analysis by computer aided [1-3], computer color classification [4], calculation of color difference [5], color fastness evaluation [6], it is expected to break through the traditional detection.

This paper presents a new method developed for automatic analysis of fabric colors by an image analysis system. We applied the color - Pantone textile color card widely used at home and abroad as reference, and captured images from Pantone TCX color, then according to the brightness level of images, we put the color images segmentation into layers based on the gray model, which imitate the physical layer principle of Pantone color card. According to the development and application of color recognition algorithm, we construct a kind of color recognition model that can map matching the unknown color with known color by introducing the Support Vector Machine (SVM, hereinafter referred to as SVM) machine learning methods. Meanwhile, we have developed a color recognition system that can make samples matching to Pantone color card accurately. The recognition system has higher correct rate, which provides an auxiliary tool for the exploration of the color measurement objectively and quickly.

# 2 System Set-up

Hardware system uses CanoScan 8800F color scanner with a resolution of 600 dpi. The scan images of Pantone TCX color and test samples were acquired and saved as a 24 bit true color images. Based on MatlabR2010b programming language, the software system is developed to realize the image preprocessing, feature extraction and color intelligentized matching. Fig. 1 is the working flow diagram of the system.

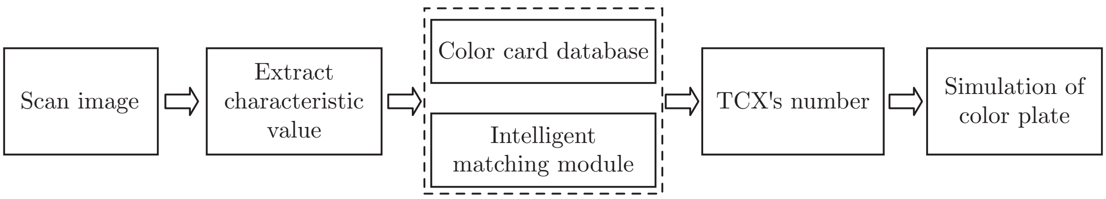


Fig. 1: Working flow diagram of the system

The task of the soft system is to set up the mapping relationship table of color characteristic value between the fabric image and standard color card image. The key task of the soft system is the development of 'Standard sample database' and 'Intelligent matching module'. Firstly, 1925 kinds of Pantone TCX color swatches are scanned, the effective color features are extracted from the scan images, and then according to the range of lightness, we construct standard sample database with 29 layers. Finally, we establish 29 SVM model. The color feature data of standard samples are input to training for each SVM model, and we use cross validation method to obtain the best parameter c, g for each SVM classifier, so 29 SVM models are optimized. And the intelligent matching module is composed of the 29 color classifiers and 29 trained SVM classifiers.

# 3 Establishment of Standard Sample Database

## 3.1 Color Image Partition

There are 1925 kinds of color cards in the cotton passport released by Pantone company, the size of each card is 1.5 cm × 1 cm. The scanning image of each card is divided into six partition by image processing program, as shown in Fig. 2.

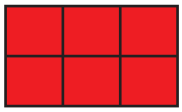

Fig. 2: Six maps of TCX color images

## 3.2 Color Feature Extraction

Fabric is composed of fiber and yarn, due to the yarn hairiness, yarn buckling of ups and downs, concave and convex of fabric texture, etc result in uneven light reflection, the change of luster has a certain degree of influence on color, all of these may make fuzzy inclusion shaded, interference or different color pixels. These random variations can cause date mutation, it will cause distortion if they are included in the statistics. Because the color value of the variation is a mutation, not in the median position, we take the median sampling method and extract R, G, B median as vector set to ensure the real pixels, and complete the standard image color quantization.

Matching unknown color with known color in database is a question of color classification. The space division of color eigenvalue affects its classification performance. However, in RGB space, the Euclidean distance between two points isn‘t linear with color distance. They belong to inhomogeneous color space, which disaccord with people‘s subjective judgment to the similarities of color. Color segmentation only with RGB can‘t obtain ideal results [7]. HSI model is based on tone color, H is the main factor to determine the color for HSI model, when it changes, the tone value will also change [8]. H value is related to the wavelength of light waves, it is one of the characteristics of color to distinguish between each other, and the color H is introduced to improve the spatial partition performance of the color feature.

## 3.3 Structure of Standard Sample Database

The standard sample database consists of two parts data, there are four color characteristics (R, G, B, H) which are extracted from six partition of each Panton TCX color card‘s image in Part I. The size of the matrix for Part I is $1925 \times \{6 \times 4\}$, it is used to train and test for SVM classifier. Part II is the data released by Pantone Company on its website, it includes number of Pantone TCX color card and RGB values. It is used for the simulation image color.

# 4 Establishment of Intelligent Color Matching Model

The physical model of Panton color card is presented in Fig. 3. It is shown that the physical model of Panton color card made up of nine color layers, 11-19 is its layered code. This floor-type color card management makes people easy to think "layer-Card" identification strategy, which is used to identify the layer first and then to identify the card. SVM classier need to analyze all the data standards databases if identify card directly,and it will lead to a highly computer's memory resources occupancy rate and the long running time, so it needs to configure high-performance computer. But if it is used to identify the layer at first, the SVM classifier only needs to identify the card for that layer, it can greatly decrease in consumption of computing and it is suitable for ordinary compute.

| Layered code |
|---|
| 11 |
| 12 |
| 13 |
| 14 |
| 15 |
| 16 |
| 17 |
| 18 |
| 19 |

Fig. 3: Layered model of TCX

## 4.1 Color Layered Model

### 4.1.1 Layered Parameter

From Fig. 3, it is obvious that the physical model of Panton color card corresponding to the color change from weak to strong has nothing to do with hue and saturation. Lightness is a physical index to describe light and dark of color for digital image, it is expressed as:

$$I = 0.299 \times R + 0.587 \times G + 0.114 \times B \tag{1}$$

We draw the brightness of Panton TCX color image for the scatter plot according to the 11-19 classification, as shown in Fig. 4. First, it can be seen the light and dark of color described by the lightness level is layered, it looks like the description of the physical model shown in Fig. 3, it shows the lightness is an effective layered parameters. Second, it can also be seen the layer boundary is not clear between adjacent layers like jagged, it shows the color layered by computer is more accurate than artificial based on the same theory model. Therefore, with the help of computer, we have a new hierarchical segmentation for images of Panton TCX color card.

### 4.1.2 Digital Hierarchy Segmentation for Images of Panton TCX Color Card

$0 \sim 255$ gray level is divided into N collections according to the TCX lightness color image gray level threshold, it means the color card belonging to the same set is the same color layer. Because the color card capacity (number) affects the computing power of the Support Vector Machine

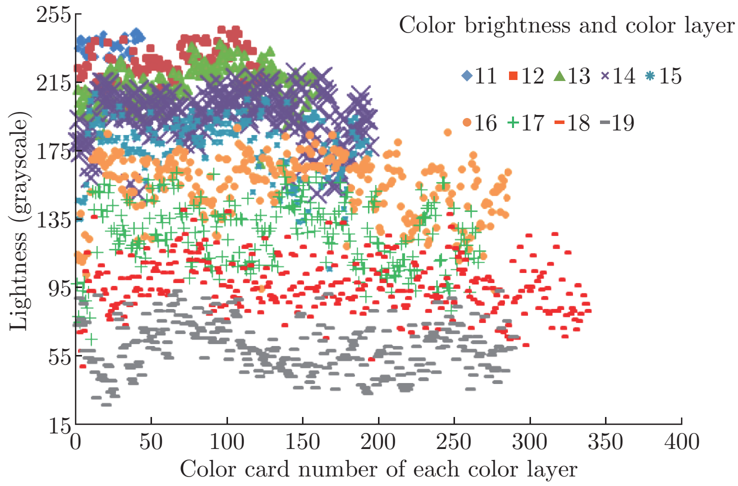


Fig. 4: TCX color image digital analysis of nine color layers

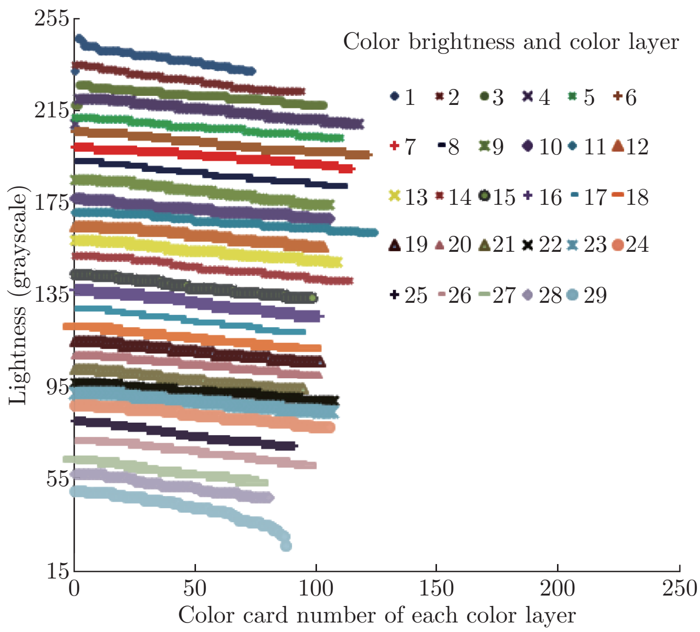


Fig. 5: 29 color layers of TCX color image

(SVM), we divided the 1925 color cards into N layers according to the capacity of 70 to 120 color cards/layer, N should be 29. The relationship between I and color layer are presented in Table 1. Fig. 5 is the scatter plot of 29 color layer' image, it can be seen each layer is independent and the boundary is clear between adjacent layers.

### 4.1.3 Expansion of Adjacent Layer Boundary

In theory, the gray column series of the color layer is consecutive integers and they are distinct between levels. In fact, the calculation results of grey level may be a non-integer. If the grey level value is located in the boundary of the two layers and the data is rounded to an integer with a tiny fluctuations, it leads to the layer or the adjacent layer for two possible results. The key issue is whether the sample falls into which of the two layers, the SVM can find the matching color

Table 1: Color hierarchical data tables based on I threshold

| Color layer | I(grayscal) | Color layer | I(grayscal) | Color layer | I(grayscal) |
|---|---|---|---|---|---|
| 1 | $\geq 234$ | 11 | 169-164 | 21 | 101-96 |
| 2 | 233-225 | 12 | 163-158 | 22 | 95-91 |
| 3 | 224-219 | 13 | 157-151 | 23 | 90-86 |
| 4 | 218-211 | 14 | 150-143 | 24 | 85-79 |
| 5 | 210-205 | 15 | 142-136 | 25 | 78-71 |
| 6 | 204-198 | 16 | 135-128 | 26 | 70-63 |
| 7 | 197-192 | 17 | 127-121 | 27 | 62-56 |
| 8 | 191-184 | 18 | 120-114 | 28 | 55-49 |
| 9 | 183-176 | 19 | 113-108 | 29 | $\leq 48$ |
| 10 | 175-170 | 20 | 107-102 | | |

card with the sample. Therefore, we take the method of adjacent boundary expansion. As shown in Fig. 6, if the horizontal direction is descending direction of grey level, the solid line represents the gray threshold position. Based on the threshold, each layer expands capacity of two gray level (dotted portion) to each other within the layers, within the scope of this originally belonged to the other layers of the card also included in. After the expansion, regardless of the tested sample falls into which of the two layers, the SVM can match to the same color card, thereby eliminating the possible boundary effect.

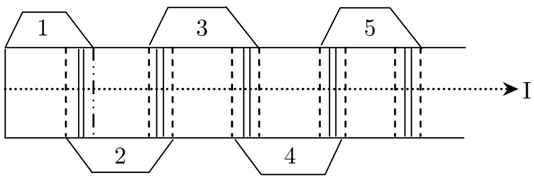


Fig. 6: Shematic diagram of color layer boundary expansion method

## 4.2 Color Matching Model Based on SVM

Color matching is a complicated problem about nonlinear classification and the sample data is less, the traditional analytic theory and statistical regression method is difficult to solve this problem. Theoretical concept of SVM model is to solve the problem of linear separable, but in the case of linear inseparable, it can be solved by translating the linearly inseparable sample in low-dimensional space into the linearly separable sample in high-dimensional space by using the nonlinear mapping algorithm, thus the nonlinear problem is solved fundamentally.

SVM itself is a two categories classifier. For multiple classification problems, combined multi categories SVM classifier is needed to construct. In this paper, 'one against one' SVM classifier applied is a multi categories classifier which combined various two categories classifier. As shown in Fig. 7, the algorithm principle of 'one against one' SVM is based on construct SVM for all possible combinations of two categories by selecting two classes of samples every time from all the samples, there are $n(n-1)/2$ SVM in total. The voting method is used to determine the category of samples, the sample will get a category number when passing a SVM classifier, namely the sample get one vote. Count votes after the sample have passed all SVM classifiers. The category that has the most votes is the most possible category. If there are some categories that have the same votes, input the sample to the SVM classifier that is related to those categories. Circling the process until get the most votes.

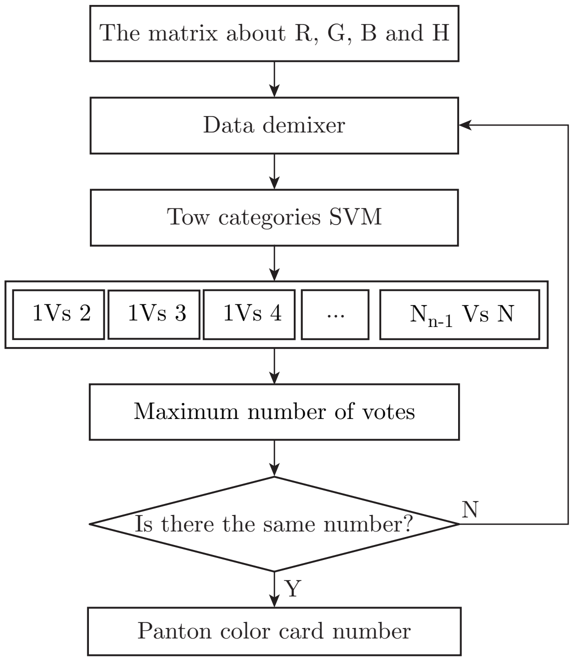


Fig. 7: Principle diagram of one-to-one SVM prediction model

# 5 Implementation and Verification of the Color Matching Model

## 5.1 Optimization of SVM Model Parameters

Selection of parameters includes kernel function and model formula. After the kernel function is determined, we can adjust the parameters for the penalty coefficient c and kernel function g, they play an important role to the model's complexity, structure and performance. RBF radial basis function has the characteristics that make the similar samples close to each other and different types of samples separated from each other, so we choose the RBF radial basis function as the kernel function. The training sets of the 29 color layers are used cross-comparison exercise for SVM respectively, then we get 29 SVM optimal parameters c and g, the results shown in Table 2.

## 5.2 Verify Model

With the best parameters in Table 2 for 29 training sets to get 29 SVM model through training. The 29 training sets are brought back to the corresponding SVM model to investigate the identification accuracy, then we elect 296 unknown color samples as test set to test the system, and the accurate evaluation results are given by using Pantone Company's digital Color measurement

Table 2: CV method to be best parameter c and g

| SVM | c | g | SVM | c | g | SVM | c | g | SVM | c | g |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.66 | 16 | 9 | 0.25 | 0.0625 | 17 | 0.25 | 0.0625 | 25 | 0.25 | 0.0625 |
| 2 | 16 | 11.31 | 10 | 16 | 16 | 18 | 8 | 16 | 26 | 16 | 16 |
| 3 | 16 | 16 | 11 | 8 | 16 | 19 | 8 | 16 | 27 | 16 | 16 |
| 4 | 16 | 16 | 12 | 0.25 | 0.025 | 20 | 16 | 16 | 28 | 16 | 16 |
| 5 | 11.31 | 16 | 13 | 0.25 | 5.66 | 21 | 11.31 | 16 | 29 | 4 | 11 |
| 6 | 16 | 16 | 14 | 4 | 16 | 22 | 8 | 16 | | | |
| 7 | 0.25 | 0.0625 | 15 | 11.31 | 16 | 23 | 8 | 16 | | | |
| 8 | 16 | 16 | 16 | 0.25 | 0.088 | 24 | 0.25 | 0.0625 | | | |

Table 3: Experimental results of training set and testing set

| SVM code | Training set | | Test set | | SVM code | Training set | | Test set | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample number | identification accuracy/% | Sample number | identification accuracy/% | | Sample number | identification accuracy/% | Sample number | identification accuracy/% |
| 1 | 222 | 84.2 | 15 | 100 | 16 | 303 | 97.4 | 39 | 100 |
| 2 | 282 | 91.3 | 18 | 100 | 17 | 279 | 98.6 | 18 | 100 |
| 3 | 309 | 94.2 | 6 | 100 | 18 | 291 | 99.3 | 24 | 100 |
| 4 | 354 | 94.1 | 18 | 94.4 | 19 | 306 | 98.7 | 36 | 100 |
| 5 | 330 | 96.7 | 30 | 95.5 | 20 | 303 | 99 | 24 | 100 |
| 6 | 366 | 97 | 39 | 100 | 21 | 285 | 96.1 | 54 | 100 |
| 7 | 345 | 96.8 | 18 | 100 | 22 | 324 | 97.8 | 18 | 100 |
| 8 | 330 | 99.4 | 21 | 100 | 23 | 321 | 98.1 | 39 | 100 |
| 9 | 318 | 98.7 | 42 | 100 | 24 | 318 | 98.1 | 33 | 100 |
| 10 | 318 | 98.1 | 45 | 100 | 25 | 273 | 96.8 | 45 | 95.6 |
| 11 | 375 | 98.9 | 51 | 100 | 26 | 285 | 97.4 | 36 | 100 |
| 12 | 309 | 99.7 | 30 | 100 | 27 | 225 | 94.7 | 45 | 97.8 |
| 13 | 327 | 97.6 | 24 | 100 | 28 | 243 | 97.1 | 15 | 100 |
| 14 | 342 | 97.3 | 60 | 100 | 29 | 264 | 96.5 | 6 | 83.3 |
| 15 | 297 | 98.5 | 39 | 100 | Aaverage identification accuracy: Training set—96.89%<br>Test set—98.85% | | | | |

instrument "Color Cue2". Based on the results, we can understand its identification accuracy by this system test, the results are listed in Table 3.

From Table 3, it is obvious that the average recognition rate of training set is 96.89%, it is high and indicates that the method of support vector machine is suitable for classification and forecasting of small sample data, which is similar with fabric color classification. Only recognition rate of SVM-1 is 84.2%, it is because the gray level values of these two color cards are more than 225, and they belong to the shallowest color, the chrominance data of adjacent color card is relatively close, it will result in insufficient sensitivity of chromaticity eigenvalues, and affect the validity of identification. It can also be seen from Table 3, the average recognition rate of test set is 98.85%, the majority recognition rate of SVM model is 100%. Its recognition performance is superior to the training set, which indicates that the system has a strong generalization ability to the future samples. The correct rate of SVM-29 is only 83.3 percent, because we can not find the matching color card with the test sample in Pantone TCX color card, it is not a system performance problem. It indicates the system of the invention can also provide data to fill a vacancy for color card manufacturer.

# 6 Conclusion

In this paper, by taking Pantone Textile Special Color Card as a reference, we acquire the scan images of Pantone TCX color card and have a new hierarchical segmentation for images of Panton TCX color card by using bright color model, which imitates the physical layered model of Pantone color card, we introduce a kind of machine learning method of support vector machines, and establish a set of automatic matching system between textile fabric color and Pantone color card. As long as scanning images to the tested sample, the system will give the matching Pantone color card number, it is simple operation, small error, and without manual matching color cards, and it improves work efficiency and eliminates the human observer bias. The system can also simulate the color of an image into the color of standard color card, meanwhile, it provides an effective auxiliary tool objectively and quickly for color measurement. It is beneficial for e-commerce, custom clothing and other industry to remote communication and management of textile color.

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