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Determination of Pigment Magnitudes in Synthetic Leather by Using Scanner

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Abstract: In the present work the magnitudes of pigments in the synthetic leather, were measured by means of scanner. Initially synthetic leather samples pigmented by three different pigments of yellow, blue and red colors were prepared. Then the pigmented samples were scanned and the values of RGB of images were calculated. The regression method used to make relation between RGB values and pigment magnitudes. Two computational filters were also used to improve the accuracy of result. The method was successfully applied for the estimation of pigment magnitudes in the synthetic leather samples. The computational filter of *Sin* on polynomial regression was found to yield the most accurate results.

Key word: Synthetic leather · Pigment · Determination · Scanner · Polynomial Modeling

INTRODUCTION

Nowadays with the rapid development of computer-based image processing techniques, color images are widely used in visualization, communication and reproduction [1-5]. With the steadily improved quality and decreasing prices of digital cameras and scanners, digital photography is beginning to replace conventional film-based photography. The two main types of digital color input devices are scanners and digital cameras that record the incoming radiation through a set of color filters (typically RGB). This signals generated by a scanner are device dependent, i.e., different scanners produce different RGB signals for the same scene [5-9]. The most important point in function of scanners is their calibration. Device calibration is the process of maintaining a device with a fixed known characteristic color response and should be carried out prior to device characterization. A successful calibration operation can lead to a successful scanner based color measurement system [9]. Device characterization techniques can be classified into two categories: colorimetric and spectral. Colorimetric characterization transforms the imaging device responses, or RGB values, into device-independent CIE tristimulus values [8-14]. Typical techniques used for colorimetric characterization are least-squares-based polynomial regression [6-8, 11], look up table with interpolation and extrapolation [8, 9, 11] and artificial neural networks [8, 10, 11].

In conventional methods for obtaining accurate measurements using scanners, a relation must be established between the scanner and color values of an independent color space such as CIEXYZ or CIELAB. The maim goal of color calibration process is to attain the transformation function of "g" from device dependent elements, RGB to CIEXYZ or CIELAB elements [3, 4, 7] that the mathematical expression can be written in the form of (1):

$$[L^*, a^*, b^*] \text{ or } [X, Y Z] = g(R, G, B) \qquad (1)$$

A variety of methods such as regression, neural networks [6-11] may be used in order to obtain the above mentioned relation.

Artificial leather is a fabric or finish intended to substitute for leather in fields such as upholstery, clothing and fabrics and other uses where a leather-like finish is required but the actual material is cost-prohibitive or unsuitable. There is considerable diversity in the preparation of such materials. A common variety consists of a mixture of dispersed PVC polymer particles together with plasticizer. By heating, the plasticizer can penetrate in to the polymeric particles and finally leather Plastisol would be obtained. Some stabilizers such as Tio_2 may also be added to the synthetic leather to prevent probable environmental degradations. In addition different color synthetic leathers can be obtained by addition of pigments either single or combinatory to the synthetic leather.

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In the present work a polynomial regression method was developed in order to make relationship between color values (obtained by scanning the leather surface) and different proportions of pigments in the leather. In this way it was tried to estimate the magnitudes of pigments in the synthetic leather.

MATERIALS AND METHODS

Epoxy (stabilizer) and PVC 1302 were purchased from LG Corp. Three pigments of yellow 84 'Red 48:2 and Blue 13:3 were from PATCHAM Company. $CaCO_3$ and Sudarshan were also prepared from Zagros powder Corp. A MATHIS instrument was used for preparing the synthetic laboratory leather.

In this work 128 synthetic leather samples were pigmented by using mixtures of the three pigments and Tio2 in ratios of 0, 1, 2 and 4. For testing the efficiency of the method 85 samples were used as training samples and 43 samples were used as test samples.

The pigmented samples were scanned with a Benq ST-5550 flat scanner. Subsequently RGB values of the captured images were derived by using a Photoshop 10 cs3 software. For establishing a relation between RGB values and magnitude of pigments, a polynomial regression method was used. Device characterization by polynomial regression has been adequately explained by many other researchers [6-8, 11]. If a reference target of N color samples is assumed, for each color sample, the corresponding scanner response RGB with concentration can be represented by equation 1:

$$C_i = a_{i1} R + a_{i2} B + a_{i3} G \quad (1)$$

If only R, G, B values are used in equation 1, the transformation between RGB and C is a simple linear transform. The idea behind using polynomials is that vector C_i can be expanded by adding more terms (e.g., R^2, G^2, B^2, etc.), so that better results can be achieved.

In this study, 12 polynomial models of 3 to 32 parameters were used. After establishing a relationship between RGB values and pigments contents, the obtained transform matrix was used for estimation of pigment ratios in different mixtures.

In next step two computational filters, *Sin* and ^1/3 were used in order to improve the accuracy of the results. The difference between real concentration and predicted concentration (as relative error percentage) was evaluated by Eqn (4):

$$E = 100 \times \frac{\left|C_{actual} - C_{predicted}\right|}{C_{actual}} \quad (4)$$

RESULTS AND DISCUSSIONS

The amount of prediction error (%) in determination of concentration ratios of different pigments by using different polynomial models as well as computational filters are shown in Figures 1 to 4.

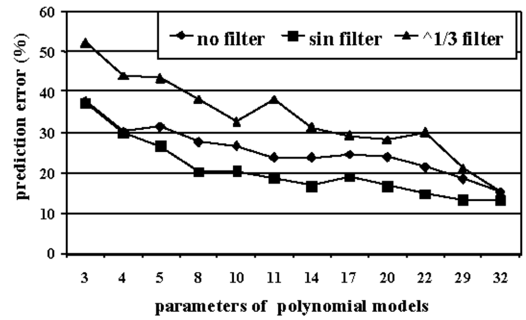

Fig. 1: Average relative errors in determination of yellow pigment

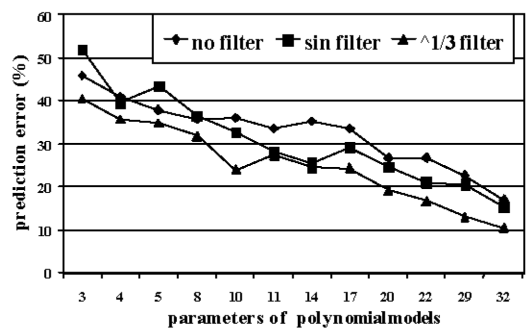

Fig. 2: Average relative errors in determination of red pigment

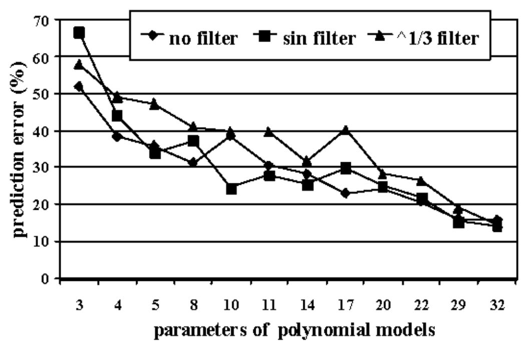

Fig. 3: Average relative errors in determination of blue pigment

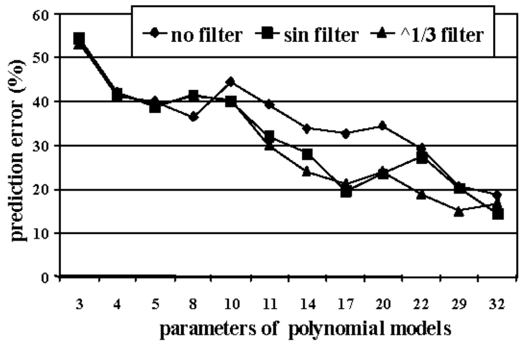

Fig. 4: Average relative errors in determination of TiO_2 pigment

Figure 1 shows the average relative errors in determination of Yellow pigment in test samples. As can be seen, by using power computational filter and a polynomial of 3 parameters, the highest level of error (54%) was achieved. While by increasing the number of parameters in polynomial, the error level decreased and lower amount of error (15%) was obtained by applying a polynomial of 32 parameters. In two other computational forms (with *Sin* computational filter and without computational filter) the amount of error decreased by increasing the polynomial parameters. As the error level by using a polynomial of 32 parameter for the two methods was (38%) while by increasing the number of polynomial parameters the amount of error decreased to 13(%) and 15 (%) respectively.

Figure 2 illustrates the percentage error of estimation of red pigment ratio. In the figure as can be seen the highest error level (53%) is obtained by applying the *Sin* computational filter and a polynomial of 3 parameters. It was observed that by increasing the number of polynomial parameters the error level decreased. When the number of parameters increased to 32, the error level reached to its lowest value. The percentage errors levels for conditions of using power and *Sin* filters as well as without using computational filter were 10, 16 and 17 respectively. The results for estimation of the blue pigment and TiO_2 are shown in Figures 3 and 4. The decrease of error level by increasing the polynomial parameters is observable in these figures. As can be seen the highest percentage of error between three methods was achieved by using a polynomial of 3 parameters and the lowest error value was obtained by applying a 32 parameters. Evaluation of the obtained results in the four figures indicates that the application of *Sin* computational filter in most of the cases could improve the results accuracy.

CONCLUSIONS

The present methods in this study can be introduced as techniques for the determination of ratio or percentage of pigments in combinatory pigment mixtures in synthetic leather or other textiles. As flat scanners are relatively low price instruments, the developed methods can be suitable for both industrial and home users.

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