www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 6 Issue 11 November 2017, Page No. 22848-22853
Index Copernicus value (2015): 58.10 DOI: 10.18535/ijecs/v6i11.04

Measurement of Colour Shade Variation & Colour Strength for Uniform Colour using LAB Space Model for Computer Generated Images

Suhas R. Desai[1], Vishal Patil[2]
E&TC Department
SGMCOE, Mahagaon, India

Abstract
The colour shade of dyed fabric or printed fabric color defect plays a major role in deciding the quality of fabric color. Hence there is a need for inspection of color shade for its quality. Traditionally inspection for quality of color and defect in color shade is carried out either manually in majority of industries or by using spectrophotometer scanning technique. In this paper, the focus is on the inspection of the variations in colour strength and colour shade of single uniform color using various LAB space models on computer generated image samples without any manual help for interpretation. Among the LAB space models tested, the CMC l:c model has proved to be more accurate than CIE76 and CIE94 for measurement of colour shade variation where coloro matrix is used as a performance parameter. Also colour intensity, I measurement using HSI model has been found to agree fairly with lab spectrometer results

***Index Terms*— Spectrometer, CIELAB, distance matrix, intensity.**

Introduction

In industries, image processing methods are very frequently used for fault detection and analysis in variety of applications in various fields. But in colour industry detection of colour shade variation in fabric after dying or printing is not yet successfully accomplished by image processing technique. Researchers have tried to fully automate inspection of uniform colour, but yet today expertise is needed for complete solution. The state–of-art for this as on today still lacks full automation besides being very costly and also not easily affordable by small scale industries. Different image acquisition techniques are used for acquiring of various types of images of colored surface. The perfect and proper image is a very important factor for further detection of defects in color variation and measurement of strength of color. But the challenge is to automate the process of inspection for quality of colour.

In image processing, for uniform color space, International Commission on Illumination (CIE) recommends “Lab” space model. For non-uniform color space, RGB is used which is almost universally accepted by the image processing community as the means for representing color. On the other hand, perceptually uniform spaces, such as ‘Lab’, as well as approximate uniform color spaces, such as HSV, exist in which measured color differences are proportional to the human perception. The CIE L*a*b* uniform color space recommended by CIE in 1976 is adopted widely for uniform color space. The various CIE series for color space are CIE76, CIE94 and CIE2000 [1, 2, 3]. These use color difference formulae based on ‘Lab’ color space for application in different fields.

The details of present theory and practice followed for color strength measurement and analyzing of color variation, it is explained further point.

Present Theories And Practices

There are two traditional techniques used for color comparison and for finding color strength viz.; manual and spectrophotometer technique. Out of these two techniques only manual technique is used for both uniform and mixed color inspection where as spectrophotometer technique is used only on uniform color [4]. These techniques are explained as below.

Manual Technique

Normally, in small scale industry, inspection for correct color is carried out manually by comparing with standard color charts. But due to limitations such as human error and time involved, this method needs automation for quality control. However these limitations are reduced by using spectrophotometer technique.

Spectrophotometer Scanner Technique:-

(a) (b) (c)

Fig. 2. Shade variation in Red colour

Spectrophotometer method uses spectrophotometer scanner device as shown in Fig. 1. This is most popular method for color shade and color strength measurement of a uniform single color. It involves the quantitative measurement of the reflection or transmission properties of a material as a function of wavelength. It deals with visible light, near-ultraviolet and near-infrared.

The most common spectrophotometers operate in the UV and visible regions of the spectrum and some of these instruments also operate into the near-infrared region as well. The spectrophotometer technique used to check i.colour shade quality an ii.color strength measurement, as explained further.

Color Shade Quality Comparison by Spectrometer

For color shade comparison, the traditional spectrophotometer device scans the input image and saves is in ".qtx" format. It uses software such as "Treepoint", "LOEPFE" on the input image which then is compared with standard file consisting of similar values. The mean difference, i.e. distance metric, ΔE of standard color shade fabric with sample fabric is calculated by computing deviation. For example in fig.1 Sample images to illustrate the uniform colour concept as shown in Figure.1 which has 10% colour variation in red colour. Sample images to illustrate the uniform colour concept as shown in Fig.2 which has 10% uniform colour variation in red colour with respect to Fig. 2 a, b and c.

Here the deviation can be found by different mathematical formulas recommended by CIE such as CIE76, CIE94 and also by Color Measurement Committee (CMC) and its variants namely CMC 1:1, CMC 2:1 which take colour tolerance limits into consideration as per standard of acceptability of color shade.

1) *Color strength*: In calculation of color strength the spectrophotometer uses ultraviolet (UV) rays. Light from the source lamp is passed through a monochromator, which diffracts the light into a "rainbow" of wavelengths and outputs narrow bandwidths of this diffracted spectrum. These discrete frequencies are transmitted through the test sample. Then the photon flux density of the transmitted or reflected light is measured with a photodiode, charge coupled device or other light sensor. The transmittance (K) or reflectance (S) value for each incident wavelength on the test sample is then compared with the transmission values from the reference sample. In short, the sequence of events in a modern spectrophotometer is as follows to find out color strength, is as explained further.

a) The light source is made to incident on or through the sample which is reflected.

b) The detector detects quantity of light reflected from the sample or transmitted through the sample and converted it into a number.

Then the graph of transmittance by reflectance (K/S) value versus wavelength is plotted.

In comparison with manual method, spectrophotometer is better method as it gives result in quantitative terms for measurement of deviation in color shade and color strength. But there are some limitations and disadvantages of spectrophotometer technique such as, Cost of spectrophotometer scanner is high, it is useful for single uniform color and online inspection is not possible.

To reduce these limitations in this paper we have presented a new methodology based on LAB colour space model. This also has helped to improve accuracy of colour deviation and colour strength results. The theoretical analysis of related presented work is explained next section.

Theoretical Analysis

For the analysis of uniform color shade, computation of mean color difference between standard color shade sample and test sample color shade. It also involves color strength measurement. "Lab" color approximates human vision unlike RGB and CMYK. Here L represent the lightness of the color; a*, indicates the color position between red/magenta and green; and b*, indicates the color position between yellow and blue. Primary advantage of Lab is that 'L' closely matches human perception of lightness and the second advantage of making accurate color balance corrections by modifying a and b components or by adjusting L component. Analysis of single uniform color use different 'LAB' space models for finding color deviation in and for calculation of strength using HSI color model.

Analysis of "Lab" for color deviation of uniform single color:

In uniform color the performance parameters like L*, a*, b* and ΔE* are obtained from (i) CIE76, (ii) CIE94, (iii) CMC l: c which is used in the presented work. These parameters are useful for obtaining ΔE*, i.e. means color difference between color standard shade sample and color shade of test sample. Calculation of ΔE* requires values L*, a* and b* of standard color shade and sample color shade.

CIELAB/ CIE76

The three coordinates of CIELAB models are L*, a* and b* since the model is three dimension model. Red-green and yellow-blue opponent channels are computed as differences of lightness transformations of cone responses. Chromatic value is CIELAB color space. The CIE defines distance metric ΔE*ab which is difference of L*, a* and b* between standard sample and test sample as in (1).

Using as the test sample values of single color shade and as the standard color shade sample values, Calculate ΔE* i.e. distance metric as in (1).

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2} \quad (1)$$

As accuracy of ΔE^*_{ab} given by CIELAB/CIE76 is limited, a more accurate ΔE* computation was developed, by CIE94.

CIE94:

The 1976 definition was extended to address perceptual non-uniformities, while retaining the L*, a* and b* color space, by the introduction of application-specific weight derived from an automotive paint test's tolerance data.

ΔE (1994) is defined in the L*, C* and h* color space with differences in lightness, chroma and hue calculated from L*a*b* coordinates. Given a reference color $L^*_1 a^*_1 b^*_1$ and another colour $L^*_2 a^*_2 b^*_2$, the difference in reference and other color, ΔE^*_{ab} is given by (2).

$$\Delta E^*_{ab} = \sqrt{(\frac{\Delta L^*}{K_L})^2 + (\frac{\Delta C_{ab}{}^*}{1+K_1 C_1{}^*})^2 + (\frac{\Delta H^*_{ab}}{1+K_2 C_1{}^*})^2} \quad (2)$$

Where,

$$\Delta L = L^*_2 - L^*_1 \quad (3)$$

$$C^*_1 = \sqrt{(a^{*2}_1) + (b^{*2}_1)} \quad (4)$$

$$C^*_2 = \sqrt{(a^{*2}_2) + (b^{*2}_2)} \quad (5)$$

$$\Delta c^*_{ab} = C^*_1 - C^*_2 \quad (6)$$

And

$$\Delta H^*_{ab} = \sqrt{(\Delta E^*_{ab})^2 - (\Delta L^*)^2 - (\Delta c^*_{ab})^2}$$
$$= \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2 - (\Delta c^*_{ab})^2} \qquad (7)$$

Where;

$$\Delta a^* = a_1^* - a_2^* \qquad (8)$$
$$\Delta b^* = b_1^* - b_2^* \qquad (9)$$

Here the weighting factors K depend on the applications. In textiles K_L, K_1, K_2 values are respectively 2, 0.048 and 0.014 and for graphic art K values are 1, 0.045 and 0.015 respectively.

The CMC l:c gives more accurate method for distance metrics ΔE* mean which is highly suitable for uniform colour cloth.

2) CMC l:c

In 1984, the CMC Color Measurement Committee of the Society of Dyers and Colorists defined a difference measure based on the L*C*h color model. Named after the developing committee, their metric is called CMC l: c. The quasi metric has two parameters: lightness (l) and chroma (c), allowing the users to weight the difference based on the ratio of l:c that is deemed appropriate for the application. Commonly used ratio for l & c values are 2:1 for acceptability and 1:1 for the threshold of imperceptibility. The distance of a color between test sample and reference sample is is given by (10).

$$\Delta E^*_{CMC} = \sqrt{\left(\frac{L_2^* - L_1^*}{lS_L}\right)^2 + \left(\frac{C_2^* - C_1^*}{cS_C}\right)^2 + \left(\frac{\Delta H^*_{ab}}{S_H}\right)^2} \qquad (10)$$

Where;

$$S_L = \begin{cases} 0.511 & L_1^* < 16 \\ \dfrac{0.040975 L_1^*}{1 + 0.01765 L_1^*} & L_1^* \geq 16 \end{cases} \qquad (11)$$

$$S_C = \frac{0.0638 C_2^*}{1 + 0.0131 C_2^*} + 0.638 \qquad (12)$$

$$S_H = S_C(FT + 1 - F) \qquad (13)$$

In (13), F and T are given by (14) and (15)

$$F = \sqrt{\frac{C_1^{*4}}{C_1^{*4} + 1900}} \qquad (14)$$

$$T = \begin{cases} 0.56 + |0.2\cos(h_1 + 168^0)| & 164^0 \leq h_1 \leq 345^0 \\ 0.36 + |0.4\cos(h_1 + 35^0)| & otherwise \end{cases} \qquad (15)$$

Where; S_L = Compensation for lightness;
S_C = Compensation for chroma;
S_H = Compensation for hue

Calculation of the color strength of uniform single color

Calculation of color strength which is second parameter in our presented work is based on HSI color model. It requires single uniform color samples. In this RGB input color model is converted to HSI [5] color model because of the RGB, CMY and other similar color models do not well suit for describing color in terms that are practical for human interpretation. Hue is a color attribute that describes a pure color, where as saturation gives a measure of degree to which pure color is diluted by white light and brightness is a subjective descriptor that is practically impossible to measure. It embodies that achromatic notation of intensity and the factor in describing color sensation. Image in RGB color format, H component of each RGB pixel is obtained using the (16).

$$H = \begin{cases} \theta & if\ B \leq G \\ 360 - \theta & if\ B > G \end{cases} \qquad (16)$$

Where,

$$\theta = \cos^{-1}\left\{\frac{[(R-G) + (R-B)]/2}{[(R-G)^2 + (R-B)(G-B)^{1/2}]}\right\} \qquad (17)$$

The saturation 'S' of HSI component is given by

$$S = 1 - \frac{3}{(R+G+B)}[\min(R, G, B)] \qquad (18)$$

Finally, the intensity 'I' in HSI component is given by (19) "I" represent the strength of color fabric.

$$I = \frac{(R+G+B)}{3} \qquad (19)$$

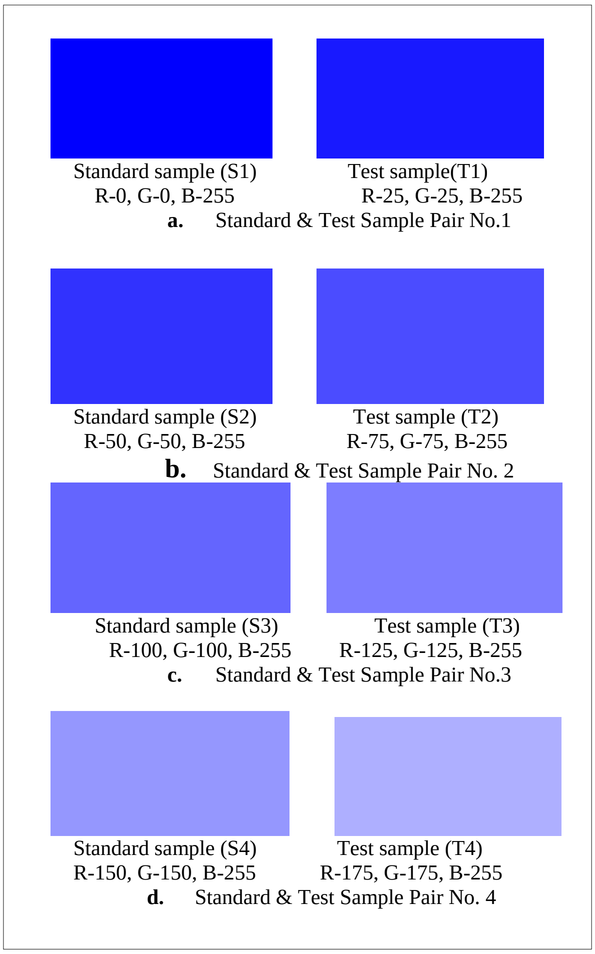

Fig. 3 Example of computer generated Blue Color Samples

Preparation Of Data Base: Computer Generated Samples:

Standard samples viz., S1, S2, S3 and S4 with blue colour shade variation of 20% were prepared in Microsoft paint brush.

Test sample viz., T1, T2, T3 and T4 with blue colour shade variation of 20% were prepared in Microsoft paint brush. The blue colour variation of 10% was adopted between pair of standard sample S1 and test sample T1. Similar strategy was followed for the other pairs namely S2 & T2, S3 & T3 and S4 & T4, these generated samples are shown in Fig..3. These pairs of samples were used for finding the colour shade by traditional spectrometer technique and our presented image processing technique.

Experimentation

The following steps were followed for uniform color shade.

Steps for calculation of mean difference in uniform color:

- Take the computer generated image test sample from the data base and convert them into an image "Lab" colour space model.
- Calculate L*, a* and b* values of standard sample and test sample using MATLAB instructions makecform('srgb2lab') and applycform( )
- Compute the coloro matrix parameter, ΔE* i.e. means difference between standard sample and test sample values using (1), (2) and (10) for different models viz.; CIE76, CIE94 and CMC l:c.
- Display the ΔE* values.

Steps for measurement of colour strength

- Take computer generated image test sample from the data base convert them into "HSI" colour model.
- Calculate intensity, 'I' value of standard and test image sample using (19).
- Compare 'I' value of spectrometer method and our implemented method using CMC l:C model.
- Display the 'I' of test sample and standard sample.

Flow chart for measurement of Colour variation (ΔE):-

Figure 4 shows the flowchart of experimentation on on measurement of color shade variation. Computer generated image is taken form the data base; which is in RGB colour format. Then RGB colour image is resized to 512*512 pixels. This image converted in to Lab space model by standard CIELAB and CMC equations. After converting Lab space model, average L*, a* and b* values of sample image are computed and then compared with L*, a* and b* values of standard sample. Computation of mean deviation i.e. coloro matrix, ΔE using different space models viz; CIE76, CIE94 and CMC l:c was carried out then ΔE was checked for its acceptance, i.e. ΔE value, if ΔE its greater than 1, then the sample is rejected and if ΔE is less than one then the sample is accepted.

3) Results:-

In Table I, we have shown the results of computer generated blue sample by using CIE76, CIE94 and CMC l:c models. It also shows the comparison of results obtained from the textile lab spectrometer device and our implemented LAB space model for the same samples. Different mathematical models viz., CIE76, CIE94 and CMC l:c have been used to find ΔE by using LAB space model. Form Table I, it is observed that the results obtained by both traditional and implemented techniques fairly agree. It is seen that for the LAB76 model the color matrix difference (ΔE) between traditional and implemented method varies from -0.704 to +0.6 . In case of LAB94 model, the error difference varies between -0.818 to +0.512. And for CMC l:c model the range of ΔE varies from -0.63 to +0.27. These computed values indicate the, ΔE values are approximately more near to the results obtained by spectrometer than that for the results obtained for other models.

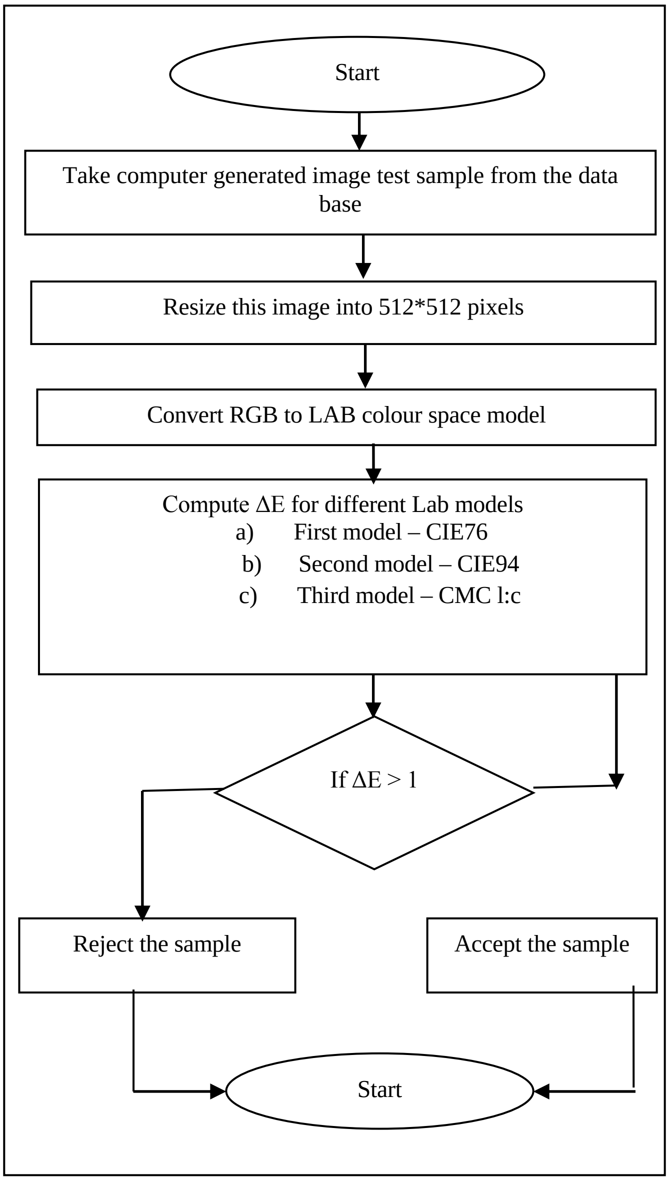

Fig.4. For measurement of Colour variation (delE)

Compute Values Of ∆E For Various Standard And Test Samples

Sample image pair	Computed value of ∆E by spectrometer method and different color models								
	∆E76 of CIE76			*∆E94 of CIE94*			*∆Ecmc of CMC l:c*		
	Spectrometer Technique	LAB space model	Difference ∆E	Spectrometer Technique	LAB space model	Difference ∆E	Spectrometer Technique	LAB space model	Difference ∆E
Pair 1	4.723	4.1231	0.5999	3.756	3.2349	0.5211	2.862	2.5854	0.2766
Pair 2	9.973	10.677	-0.704	8.210	8.6681	-0.4581	5.462	6.0947	-0.6327
Pair 3	10.924	10.826	-0.102	9.546	10.364	-0.818	5.568	6.2037	-0.6357
Pair 4	12.102	12.349	-0.247	10.752	11.2037	-0.4517	5.765	6.2741	-0.5091

Chart of Colour Strength Measurement

*As shown in Fig. 5, for the image samples used Section V.A measurement of colour strength using HSI model is carried out. Firstly resize the input image in to 512*512 pixels. Convert this image to HSI model using (16),(17) and (19). Using HSI model Calculate 'I' parameter using (19)which is known as colour intensity.*

Table II show the results of the difference between traditional and our HSI method where a minimum is 0.063for intensity measurement is achived.

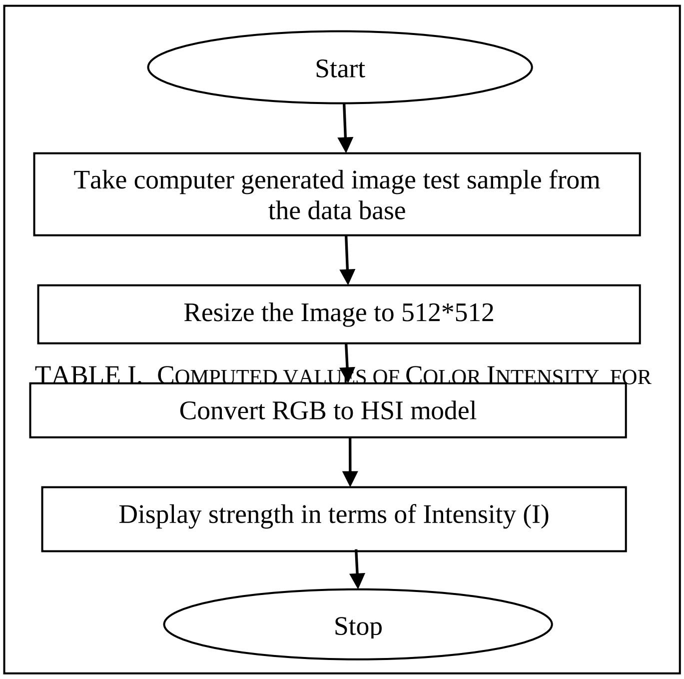

Fig.5. Measurement of Colour Strength

TABLE I. COMPUTED VALUES OF COLOR INTENSITY FOR

Sample image pair	Intensity-I		Difference
	I1: Computed From Lab Spectrometer Technique	I2: Computed from HSI space model	I1- I2
Pair 1	0.332	0.397	0.065
Pair 2	0.461	0.531	0.07
Pair 3	0.66	0.901	0.241
Pair 4	0.724	0.789	0.063

Conclusion

In this paper an automatic image processing method based on LAB space model for determination of the variations in color strength and shade of single uniform color without any manual help for interpretation is presented. The absolute difference of ∆E obtained by these three methods CIE76, CIE94 and CMC l:c are 1.304, 1.330 and 0.90 respectively. This indicate that, the CMC 1:c model works more accurately compared to CIE76 and CIE94 for color shade variation measurement. The maximum error for intensity measurement obtained is 0.241. This indicates that that there is a need for modification of the algorithm to improve the accuracy of color intensity measurement.

FUTURE SCOPE

Future scope would be to algorithm of LAB colour model this algorithm on the other samples with lesser % variation in color shade than the test samples under consideration and also for other colours. Next step would be testing this method on real dyed samples with uniform color. The maximum error for intensity measurement is 0.234. This indicates that that there is a need for modification of algorithm to improve the accuracy of color intensity measurement.

Acknowledgment

We are very much thankful to Textile chemistry lab of Textile and Engineering Institute for their support and valuable guidance. Also we thank principal Dr. P.V. Kadole of this Institute, for his kind permission and support.

Reference

1. George Paschos, “Perceptually Uniform Color Spaces for Color Texture Analysis: An Empirical Evaluation”, IEEE Transactions on Image Processing, vol. 10, no. 6, JUNE 2009.
2. Robertson, AlanR. “Historical Development of CIE Recommended Color Difference Equations”, Color Research and Application 1990 15(3) pp.167-170.
3. Sharma Gaurav, “The CIEDE2000 Color Difference Formula: Implementation Notes, Suplementry Test Data, and Mathematical Observations”, Color Research and Application 2005, 30(1) pp.21-30.
4. Manual of “QTEX 2.0”, of Spectrophotometer cm-3600d
5. Gonzalez R. C. and Woods R. E., “Digital Image Processing”, Prentice Hall Publication
6. Abdel Salam, “Online Fabric Inspection by Image Processing Technology”, Doctoral School ED 494 Jean Henri Lambert 2012.