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Colour Characterization for Scanners: Validations on Textiles & Paints

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Abstract—Ppreviously, we have studied the characterisation of different scanners by look up table, neural networks and polynomial regression models exclusively for various ASTM illuminant and observer along with color coordinates and DPIs. RGBL*a*b* color coordinates shows better results for both polynomial and neural network. . Polynomial regression method found to be more suitable and robust. T heir validation results for textiles and paint substrates based on polynomial regression and neural network were investigated and discussed here.

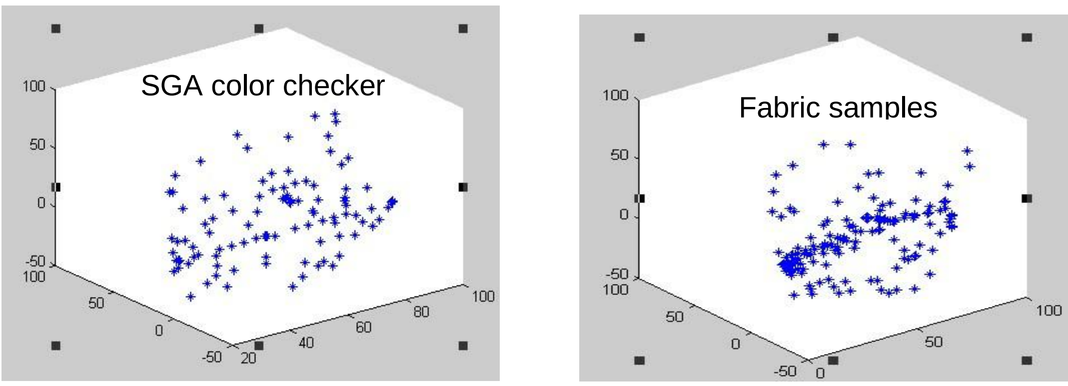
Keywords— Tristimulus values, Color matching function , Color characterization, Polynomial regression, CIE illuminant and observer ,back propagation, neural network

I. Introduction:

Many imaging applications and analysis demand human perception and it requires device dependent colour space to independent colour space transformation such as RGB to CIE L*a*b* standard. If image acquisition will be standardised well and they are characterised ensuring that they are calorimetrically accurate, potentially it can be best economic and flexible system for non-evasive testing of materials and colour appearance. The color characterization of digital systems often uses standard charts containing uniform solid Color samples. The GretagMacbeth ColorChecker and GretagMacbeth ColorChecker DC charts are widely being used as targets for color characterization tasks. ([1]-[3]). Characterization charts such as the Gretag Macbeth Color Checker, the Gretag Macbeth ColorChecker DC and the ANSI IT8 charts are designed to be used in a color management process with the aim to allow a system to reproduce colors with acceptable tolerance. Some work has been reported to investigate which characterization target is optimum for the characterization process ([4]-[5]).The colorimetric characterization methods like polynomial regression, ([6]–[10]) neural networks ([11]–[12]) and look-up tables ([13],[14]) most commonly reported for scanners and cameras ([15]-[17]. In our previous work [18] various scanners were experimented for Color characterisation based on X-rite 140 Colorchecker and it has been observed that the colorimetric characterization constrained to specific combinations of illumination and observer functions. There is only a few work that has been investigated elsewhere about the validation results, which is essential for real world applications. We validated these characterisation models for textile and paint samples further.

II. Experimental:

Typically, 153 solid color fabrics (fig.2) were carefully chosen such that it had the approximately same L*,a*,b* distribution as of X-rite 140 colour checker to predict over the entire color gamut. These solid colored textile samples were scanned in Fabric Eye D-2000. The 3D plot of CIEL*a*b* distribution of 153 fabrics and X-rite 140 Color checker has been given in fig.1. The textile samples did not include any transparent, glossy, optical brightener treated or having complicated surface profile. All the precise measurements were carried as per the previous study [18].

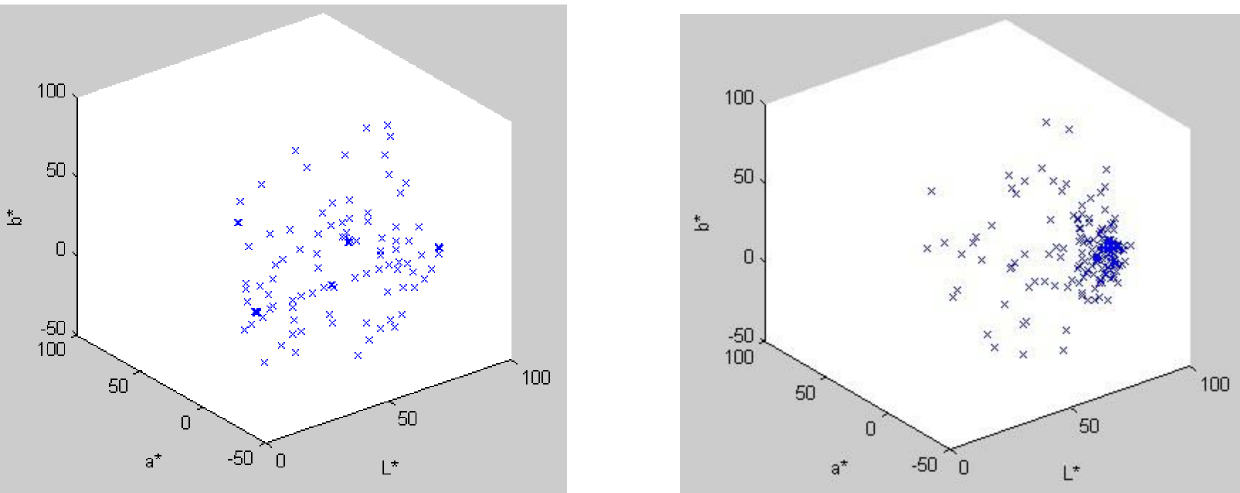


[Fig. 1 CIE L*,a*,b* Distribution of SGA and 153 FABICS at D65 64]

[Fig. 2 some fabric images out of 153 fabrics]

Same way, 165 paint samples were scanned (Fig.3) and their CIEL*a*b* color gamut distribution were given in fig.4

[Fig. 3 Scanned image of some paints samples out of 165]



[Fig. 4 CIE L*,a*,b* gamut of color checker and 165 Paints at D65 64]

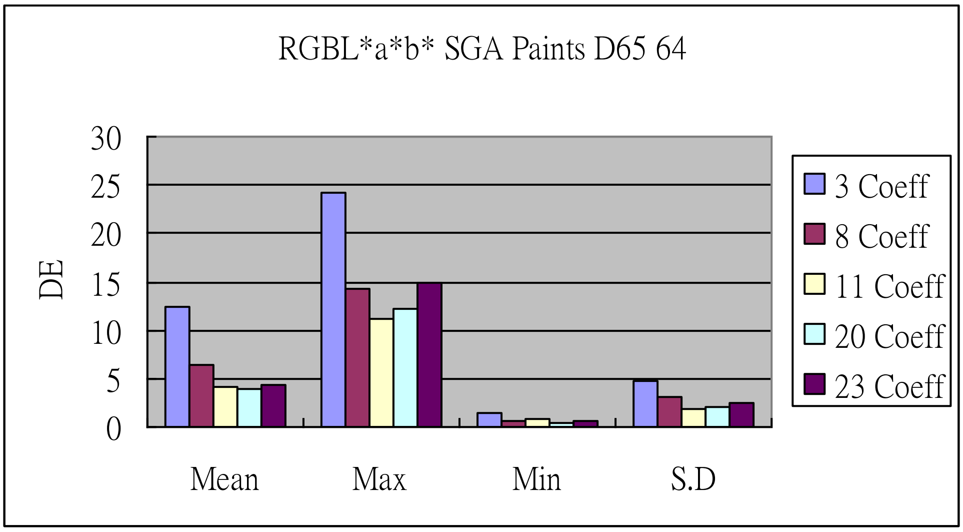
III. Results and Discussion:

The predicted values are obtained by the polynomial regression model as obtained from characterizing color coordinates by taking SGA color checker 140 with Spectrophotometer. The experimental results based on best characterised polynomials of 3^{rd}, 8^{th}, 10^{th}, 20^{th} & 23^{rd} arguments were shown on the table 3 below.

[Table 1. Validation results for 153 textile samples based on polynomial regression model of SGA Colorchecker]

RGBLAB	3^{rd}	8^{th}	A 64 10^{th}	20^{th}	23^{rd}			A31		
DE Avg	7.7334	7.85	7.6476	7.6457	7.6085	7.7873	7.8547	7.646	7.6522	7.6082
DE Max	32.891	28.128	25.129	25.14	25.128	34.538	29.867	26.236	26.4332	26.4253
DE Min	0.9818	0.6482	1.5623	1.4916	1.6742	0.9304	0.7346	1.4909	1.5426	1.3884
DE Std	4.5647	3.9415	3.7028	3.7345	3.7188	4.6579	4.1161	3.7508	3.8002	3.7756
RGBLAB			C 64					C31		
DE Avg	7.8091	7.9962	7.9222	7.9095	7.8579	7.8838	7.9075	7.8925	7.8606	7.8063
DE Max	27.901	24.402	23.436	22.25	22.14	29.879	26.125	22.868	23.4847	23.3724
DE Min	0.6149	0.9926	1.6901	1.4256	1.5603	0.9144	1.1017	1.5529	1.42	1.6251
DE Std	4.5206	3.8533	3.7708	3.7712	3.7877	4.7797	3.9993	3.7864	3.8106	3.8058
RGBLAB			D50 64					D50 31		
DE Avg	7.6909	7.937	7.8261	7.8123	7.7629	7.7065	7.8548	7.7916	7.7643	7.7137
DE Max	29.732	25.9	22.929	23.455	23.372	31.7	27.743	24.288	24.8166	24.7334
DE Min	0.4225	1.0605	1.6466	1.4572	1.6113	0.2854	0.7842	1.6374	1.4766	1.684
DE Std	4.4164	3.7998	3.703	3.7196	3.7258	4.5879	3.9675	3.7336	3.7831	3.7664
RGBLAB			D55 64					D55 31		
DE Avg	7.7175	7.863	7.8619	7.8464	7.795	7.7434	7.5018	7.8274	7.7961	7.7433
DE Max	29.029	25.465	22.405	23.042	22.948	31.023	22.338	23.786	24.3934	24.2986
DE Min	0.4384	0.8784	1.6613	1.4464	1.5885	0.4474	0.8021	1.6327	1.4562	1.6599
DE Std	4.4253	3.9544	3.7158	3.7262	3.737	4.6181	3.4667	3.7407	3.7826	3.7708
RGBLAB			D65 64					D65 31		
DE Avg	7.7874	8.0195	7.9309	7.9107	7.8574	7.8368	7.9297	7.898	7.8594	7.8043
DE Max	27.891	24.468	23.244	22.381	22.273	29.907	26.266	22.938	23.6941	23.5838
DE Min	0.5937	1.1063	1.6235	1.4357	1.5577	0.7714	0.9059	1.4341	1.4274	1.625
DE Std	4.4813	3.8189	3.75	3.7508	3.7682	4.7132	3.9673	3.7662	3.7939	3.7897
RGBLAB			D75 64					D75 31		
DE Avg	7.8607	8.0783	7.9911	7.9663	7.9127	7.9903	7.6693	7.9641	7.9152	7.8579
DE Max	27.394	24.04	24.29	21.912	22.213	29.251	21.107	22.421	23.1945	23.0753
DE Min	0.7692	1.1437	1.716	1.433	1.5398	1.0504	0.7473	1.5262	1.4071	1.6025
DE Std	4.558	3.8561	3.79	3.7831	3.8046	4.8492	3.7114	3.8014	3.8167	3.8179
RGBLAB			F2 64					F2 31		
DE Avg	7.2893	8.4081	7.6438	7.6954	7.6262	7.3425	8.181	7.6585	7.6964	7.6259
DE Max	21.493	30.375	21.102	18.48	18.388	23.339	27.25	19.29	19.761	19.6691
DE Min	0.2108	1.1585	1.4338	1.2009	1.2024	0.5446	1.0204	1.4496	1.1808	1.2013
DE Std	3.9373	4.7184	3.6292	3.6387	3.6234	4.1205	4.3595	3.619	3.6538	3.6258
RGBLAB			F7 64					F7 31		
DE Avg	7.7343	7.9952	7.9432	7.9394	7.8824	7.8229	7.8091	7.9383	7.915	7.8566
DE Max	26.304	25.084	23.54	21.287	21.166	28.268	22.004	21.893	22.5511	22.4252
DE Min	0.5885	1.0131	1.6441	1.381	1.517	1.0097	0.6611	1.5152	1.3743	1.5709
DE Std	4.468	3.855	3.7661	3.7626	3.7789	4.7526	3.6304	3.7803	3.7974	3.7955
RGBLAB			F11 64					F11 31		

DE Avg	7.4955	7.5978	7.761	7.7607	7.6866	7.5266	7.4405	7.802	7.7808	7.7074
DE Max	29.05	22.769	22.747	21.971	21.903	29.983	19.438	23.54	22.94	22.8725
DE Min	0.15	1.1779	0.9175	0.6397	0.7008	0.6751	1.2608	0.4286	0.352	0.567
DE Std	4.3409	3.4751	3.8933	3.86	3.8395	4.4635	3.3116	3.8853	3.866	3.8341



[Fig. 5 FABRIC EYE D2000 RGB L*a*b* (D65 64) higher argument model for paints]

It has been observed that the overall validation results are bad and may not be useful for real world colorimetric applications in both cases of textiles and paints though their characterisation results were apparently acceptable. Here the predicted perpetual CIEL*a*b* color difference (DE) values are higher enough to be detected by human eye. In addition, we noticed that through the minimum, maximum and standard deviation of DE decreasing with the increase in polynomial arguments in case of craterisation, their average DE values did not show much improvements for all the combinations of Illuminant and observer pairs (illuminants A, C, D50, D55, D65, D75, F2, F7, F11 for 2Deg & 10Deg observers) and Validation has shown no substantial improvement. Neural net models have shown much higher outliner as compared to polynomial regression and the case is worse for paints rather (Fig.4). It is expected that the characterization results depend upon the material and dye inheriting properties of light absorption and reflectance, partial exposed area (blurring) and interlacing points exposure for textiles , i.e. geometric texture ; the case is rather simple for solid color paints so as the color checker. Hence it is a crystal clear fact that the substrate characteristic and the colouring material's surface reflection properties of various random selections affecting the validation results. We tried further to take domain based characterisation i.e. selecting these 153 fabric samples instead of SGA color checker and validate next 54 samples. The summary of results was given in the table below. It has shown improved results in validation.

[Table No. 2. Summary of results]

***Fabic EyeD2000**	**X-rite SGA 140 based 23 arg. Polynomial Chtz. model**	**153 samples Validation**	**RGBLab 23 poly argument Predicted from 153 real fabric chtz. Model**
DE Avg	1.749	7.9081	***1.7244***
DE Max	9.325	14.3899	***4.0544***
DE Min	0.221	1.1707	***0.1538***
DE Std	1.528	2.7313	***0.9001***

IV. Conclusion:

The validation study on textile and paints clearly indicate the significant contribution of surface reflection and irradiance properties of varied material and texture properties in imaging domain. The overall validation results were found to be bad enough to be applied for real world colorimetric applications, though their characterisation results based on colour checker were apparently acceptable. The color characterization of scanners not only depends upon the device dependent illuminant source and type of model mapping , but also the domain knowledge of substrates and colorant , which has its own unique absorption, transmission and surface reflection characteristics . Thus, the mapping model performance methods need to be formulated considering their own domain model, not the color checker based characterisation. Hence it may lose their colorimetric accuracy and best generalization capability. However, their performances need to be validated extensively and careful consideration should be made so that it could represent a wide color gamut and the substrate based texture and color.

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**** Fabric Eye TM : Developed in GAMALAB,** Copy-right scanner of HKRITA and the Kong Kong Polytechnic University. The dataset can be found at https://www.researchgate.net/profile/Asimananda_Khandual/

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Prof. George Baciu holds a PhD degree in Engineering and a B.Math degree in Computer Science and Applied Mathematics from the University of Waterloo. He has been a member of the Computer Graphics Laboratory and the Pattern Analysis and Machine Intelligence Laboratory at the University of Waterloo and subsequently Director of the Graphics And Music Experimentation Laboratory at The Hong Kong University of Science and Technology in Hong Kong. Currently, Dr. Baciu is Director of the Graphics And Multimedia Applications (GAMA) Laboratory in the Department of Computing at The Hong Kong Polytechnic University. His research interests are primarily in computer graphics, physically-based illumination, rendering and motion synthesis with specific problems of interest in topological analysis of structures for multi-body dynamics, motion design for character animation, collision detection and response, constraint-based synthesis of large-scale virtual environments and entropy optimization methods for data segmentation, object classification, mesh generation and rendering, Color modeling and machine vision.

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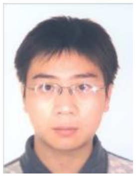

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