ZULFAQAR International Journal of
Defence Science, Engineering & Technology

Journal homepage: www.zulfaqar.upnm.edu.my

Preliminary Study on Colour Correction Analysis for Medical Imaging Application

Ahmad Salihin Ahmad Shukeri[a], Nur Diyana Kamarudin[b,*], Siti Noormiza Makhtar[a], Syarifah Bahiyah Rahayu[b], Suzaimah Ramli[c]

[a] *Electric and Electronic Department, Faculty of Engineering, National Defence University of Malaysia (UPNM), Malaysia*
[b] *Cyber Security Centre, National Defence University of Malaysia (UPNM), Malaysia*
[c] *Faculty of Science and Defence technology, National Defence University of Malaysia (UPNM), Malaysia*

*Corresponding author: *nurdiyana@upnm.edu.my*

ARTICLE INFO

Article history:
Received
14-05-2019
Received in revised
12-06-2019
Accepted
19-06-2019
Available online
30-06-2019

Keywords:
Tongue diagnosis,
colour correction,
Gamma Correction,
Polynomial Regression

e-ISSN:
Type: Article

ABSTRACT

This paper presents an effective method to enhance colour correction for tongue diagnosis. Colour Correction means exactly that, correcting the colour in image in the post production process. If the task of correcting an image is not in the workflow, it may be missing out on how great the image could look. It is one of the tasks of being a director of photography to get the best image to the colourist that can be. Understanding the camera's limitation and using that knowledge on set is the first step in getting images that are much easier to correct later in the production workflow. Cameras record three colour responses of Red, Green and Blue (RGB) that are device dependent. In this work, preliminary research on tongue colour correction using polynomial regression algorithm has been implemented on Munsell colour checker for future tongue colour correction and diagnosis. The attained RGB colour space from Munsell Checker image converted to Lab colour space which is device independent colour space based on human visual system that is perceptually uniform. Then, several degrees of polynomial regression method are employed to provide comparative analysis on colour reproduction index to produce good quality of image after colour correction procedure. The experimental outcomes on colour checker show the colour difference is equal to 3.3289, ΔE^*_{ab}=3.3289 which is acceptable in digital image colour reproducibility.

Introduction

Traditionally, human tongue can be observed by medical practitioners based on its colour, texture, shape and features especially used in traditional Chinese medicine (TCM). Colour information data of human tongue has been kept for the further diagnosis. In eastern countries especially in Japan and China, tongue manifestation is a must procedure for patients during clinical inspections. In modern diagnosis, computerized tongue diagnosis system is implemented where we can measure data quantitatively and most of the systems are using machine learning for analysis and diagnosis [1-4]. However, in digital transformation era, some limitations exist in acquisition device where tongue imaging is conducted by using computer-aided tongue diagnosis devices that is not equipped with colour correction procedure for diagnosis. Since then, most of the researches have attempted to solve this limitation by initiating tongue colour correction methods [5]. However, different types and specification of acquisition and display devices rendered different colour measurement.

Several methods have been implemented in colour correction including gamma correction, polynomial regression, *Retinex Theory* and machine learning algorithms. These prominent techniques used regression analysis to determine the correction co-efficient between the target value (sRGB) and the feature values. Gamma correction method provides better contrast enhancement and better brightness preservation. Several authors proposed gamma correction method by introducing adaptive gamma correction using median, min and max values of cumulative histogram [6] and gamma correction with weighting distribution [7][8]. On the other hand, polynomial regression approximates complicated image pattern through continuous improved coefficients based on truth colour checker. In medical, several works have been done on colour correction for human's retinal shading estimation, tongue diagnosis and potential skin cancer imaging [9]. These images are taken in RGB colour space that has poor colour representation of an image. In this work, we used CIELab colour gamut which is one of the device-independent colour spaces with polynomial regression algorithm to enhance colour quality and error measurement in medical images using colour reproductive index, ΔE^*_{ab} .

In tongue diagnosis field, colour often conveys important diagnosis information. In tongue diagnosis colour correction, CIELab colour space is recommended by previous researchers [10-11]. Therefore, to get a meaningful reproducibility of colour regardless of environment and devices specification, tongue images must undergo the process of colour correction. By using digital imaging and processing technology, some physiological information of human body condition can be measured by analysing colour features and colour differences. The quantitative clinical indices extracted from tongue images will be used by the medical practitioners to retrieve physiological conditions of human body.

Methodology

i. Flowchart

Fig. 1 and Fig. 2 show the flowchart and procedure of the colour correction algorithm. Firstly, 24 patches of Munsell colour checker is captured by using TIAS camera, a controlled environment acquisition device for tongue diagnosis. The raw image is used as a test image to attain colour correction co-efficient by comparing the raw values with the ground truth of 24 patches of Munsell colour checker using proposed colour correction algorithm. All the values rendered by the image is in RGB colour space. However, RGB colour space is not a uniform space and inaccurate. RGB operates on three channels: Red, Green and Blue [9]. To analyse the colour in different attributes such as brightness and colour component without affecting each other, RGB colour has been converted into CIELab colour space. Subsequently, the Polynomial Regression Algorithm is implemented on the 24 patches of Munsell colour checker based on CIELab colour.

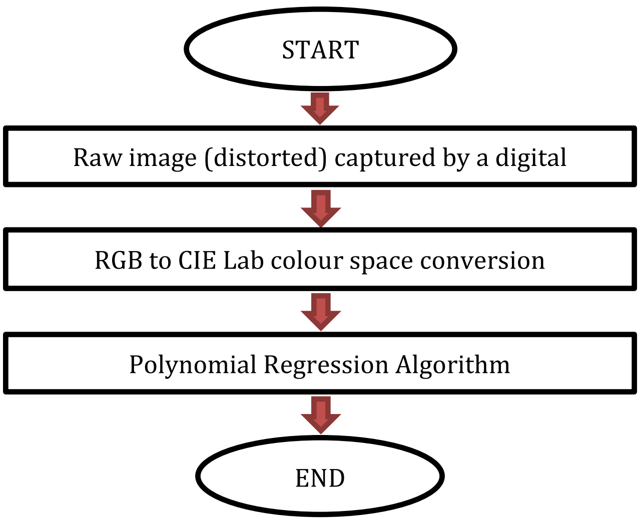


Fig. 1: Flowchart of Colour Correction of Preliminary Work using Munsell Colour Checker

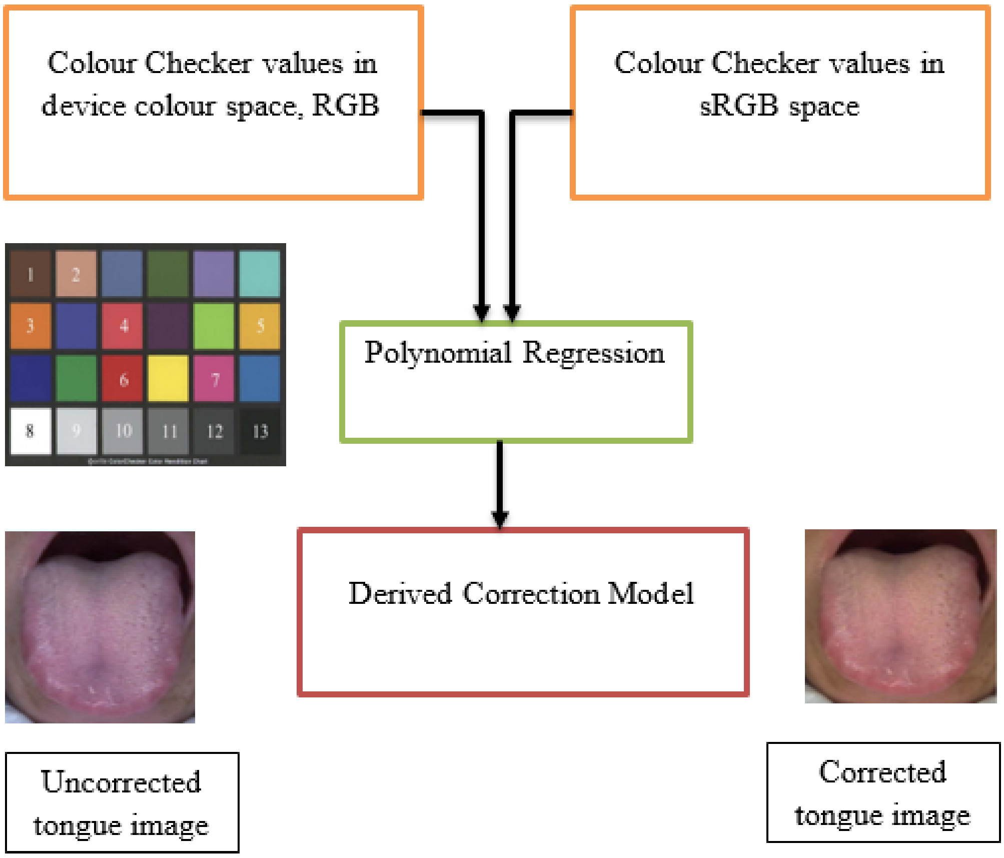


Fig. 2: Flowchart of Colour Correction Proposed for Medical Images (Tongue Diagnosis System)

ii. Colour Correction

In this research, the sRGB colour space is referred to ground truth values for colour correction procedure. The raw image (distorted) of Munsell 24 colour patches captured by the digital camera is in the form of RGB colour space. To enhance the colour representation of an image, it is essential to convert the sRGB colour space to the CIE standard colour space. The transformation of sRGB colour space to CIEXYZ colour space can be proved by equation (1):

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \Phi_{sRGB} \longrightarrow XYZ \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

$$= \begin{pmatrix} 0.4125 & 0.3576 & 0.1804 \\ 0.2127 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9503 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \quad (1)$$

Then, this XYZ colour space will be converted again to CIELab colour space by using equation (2). The colour representation of the target (ground truth) and feature image (distorted image) in colour correction is finally defined using CIELab colour space that is based on one channel for Luminance (Brightness) (**L**) and two colour channels (**a** and **b**). In this equation (2), X_0, Y_0, Z_0 are the CIE XYZ values of the references white point where these attributes can be related to Lab values as:

$$L *= 116f\left(\frac{Y}{Y_0}\right) - 16$$
$$a *= 500\left[f\left(\frac{X}{X_0}\right) - f\left(\frac{Y}{Y_0}\right)\right]$$
$$b *= 200\left[f\left(\frac{X}{X_0}\right) - f\left(\frac{Y}{Y_0}\right)\right]$$

$$f(x) = \begin{cases} x^{1/3} & (x > 0.00886) \\ 7.787x + \frac{16}{116} & (x \leq 0.00886) \end{cases} \quad (2)$$

Finally, the Euclidean distances have been measured between the target (ground truth value) and feature values of Munsell colour checker, (L_1^*, a_1^*, b_1^*) and (L_2^*, a_2^*, b_2^*). It is also denoted as ΔE_{ab}^*, which corresponds to their colour differences or colour reproduction index defined as colour chromatic aberration between images. The formula is defined as in equation (3):

$$\Delta E_{ab}^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2} \quad (3)$$

L^*_1 – the CIE L* values of ground truth colour
a^*_1 – the CIE a* value of ground truth colour
b^*_1 – the CIE b* value of ground truth colour
L^*_2 – the CIE L* value of feature colour
a^*_2 – the CIE a* value of feature colour
b^*_2 – the CIE b* value of feature colour

iii. Polynomial Regression

Munsell colour checker or Xrite colour checker is often used in colour correction and has 24 colour patches [1]. For every patches, the corresponding quantized colour values created by advanced camera can be signified as a vector V: (R_i, G_i, B_i) (i=1, 2, ..., 24), and the corresponding device-independent sRGB tristimulus values are S :(SR_i, SG_i, SB_i) (i =1 ,2, ...,24). If only R, G, and B values are used for mapping from the RGB to sRGB, the transformation is a simply linear transform [1]. In polynomial regression method, the general transformation of a Munsell colour checker image can be signified as in equation (4):

$SRi = a_{11}R_i + a_{12}G_{i+}a_{13}B_i + a_{14}$
$SGi = a_{21}R_i + a_{22}G_{i+}a_{23}B_i + a_{24}$
$SBi = a_1R_i + a_{32}G_{i+}a_{33}B_i + a_{34}$
Where 1,2,3, … ,24 (4)

In equation (3), the sRGB attributes are the value of ground truth that can be extracted via industrial camera whereas the RGBs values are the feature pixels that to be corrected. The aim of every colour correction is to achieve better regression coefficients so that the colour reproducibility of the feature image is higher. Nevertheless, in this experiment, we have observed that; up to certain degree of polynomial regression, it tends to over fit the data.

Results and Discussion

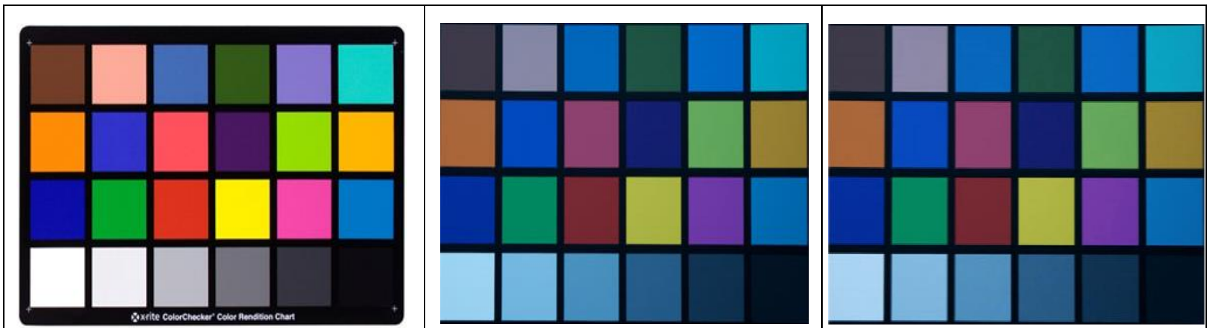
To examine the effectiveness of the polynomial regression algorithm with various degree transformation for colour correction, several experiments have been performed to observe their performances using 24 patches *X-rite* colour checker distorted image with its ground truth value on MATLAB platform. The resulted images after n^{th} polynomial colour correction is shown in Fig. 3 to Fig. 5.

(a) True image	(b) Distorted Image	(c) Corrected Image

Fig. 3: X-rite colour checker 24 patches, (a) true image (b) distorted image (c) colour correction using Polynomial 3

(a) True image	(b) Distorted Image	(c) Corrected Image

Fig. 4: X-rite colour checker 24 patches, (a) true image (b) distorted image (c) colour correction using Polynomial 5



(a) True image	(b) Distorted image	(c) Corrected image

Fig. 5: X-rite colour checker 24 patches, (a) true image (b) distorted image (c) colour correction using Polynomial 7

It has been observed that, polynomial degree 3 attained the greatest performance with the lowest colour difference error, ΔE_{ab}^{*}. The colour correction coefficient of Polynomial degree 3 is shown below;

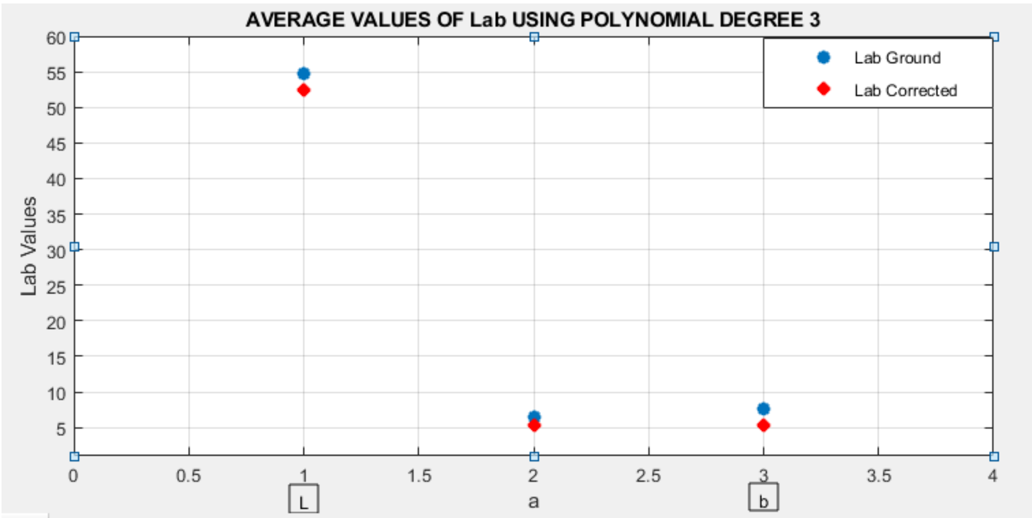
$$Z = \begin{vmatrix} 1.0512 & 0.0662 & 0.0232 \\ 0.1467 & 1.0240 & -0.1228 \\ 0.3578 & 0.1072 & 0.9743 \end{vmatrix}$$

The performance of polynomial degree 3's coefficient is the best compared to others degrees which is Polynomial degree 5 and Polynomial degree 7. Comparison of colour differences index, ΔE^*_{ab} on Polynomial Regression with 3 different degrees are shown in Table 1. Moreover, the comparison of average CIELab colour values and colour pixel distributions between corrected images and ground truth value are depicted in Fig. 6 and Fig. 7. It is shown in both graphs that polynomial degree 3 has the least colour distance compared to its ground truth value which promotes higher image fidelity and quality.

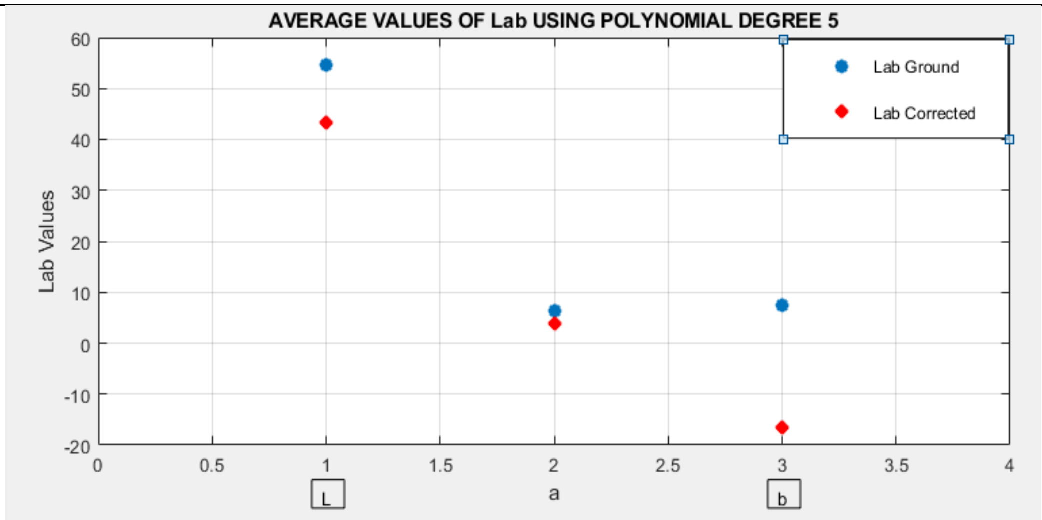
Table 1: Comparison of colour differences index, ΔE^*_{ab} using several Polynomial Degrees

Degree	Delta error			Colour differences index ΔE^*_{ab}
	ΔL	Δa	Δb	
Polynomial 3	-2.2226	-1.1231	-2.2146	3.3289
Polynomial 5	-11.3792	-2.4819	-23.9582	26.6391
Polynomial 7	-11.2481	-1.9955	-23.5859	26.2068

(a) POLYNOMIAL DEGREE 3



(b) POLYNOMIAL DEGREE 5



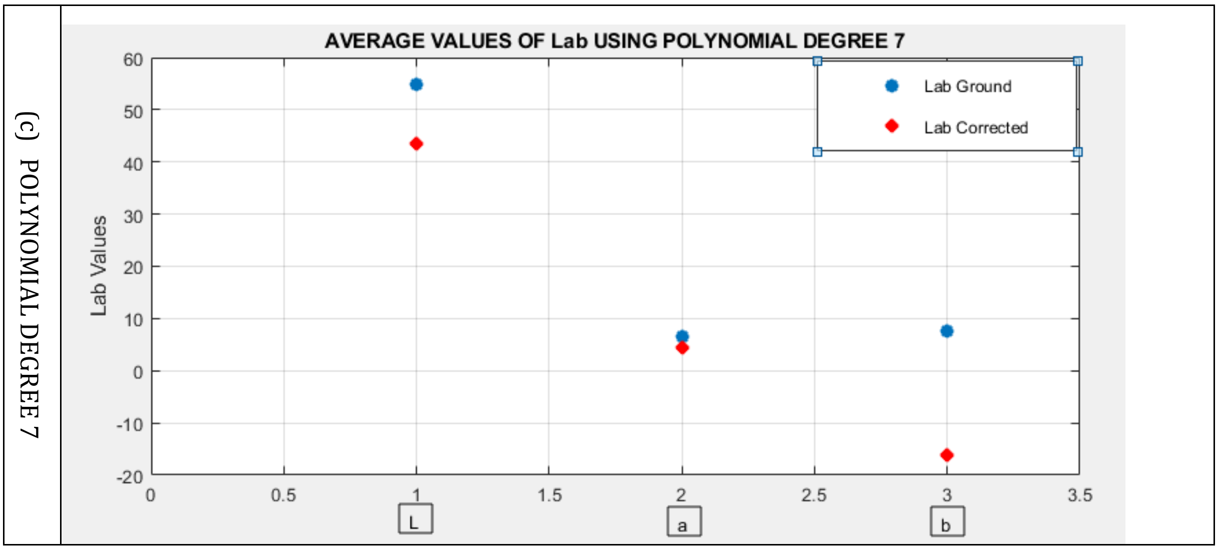
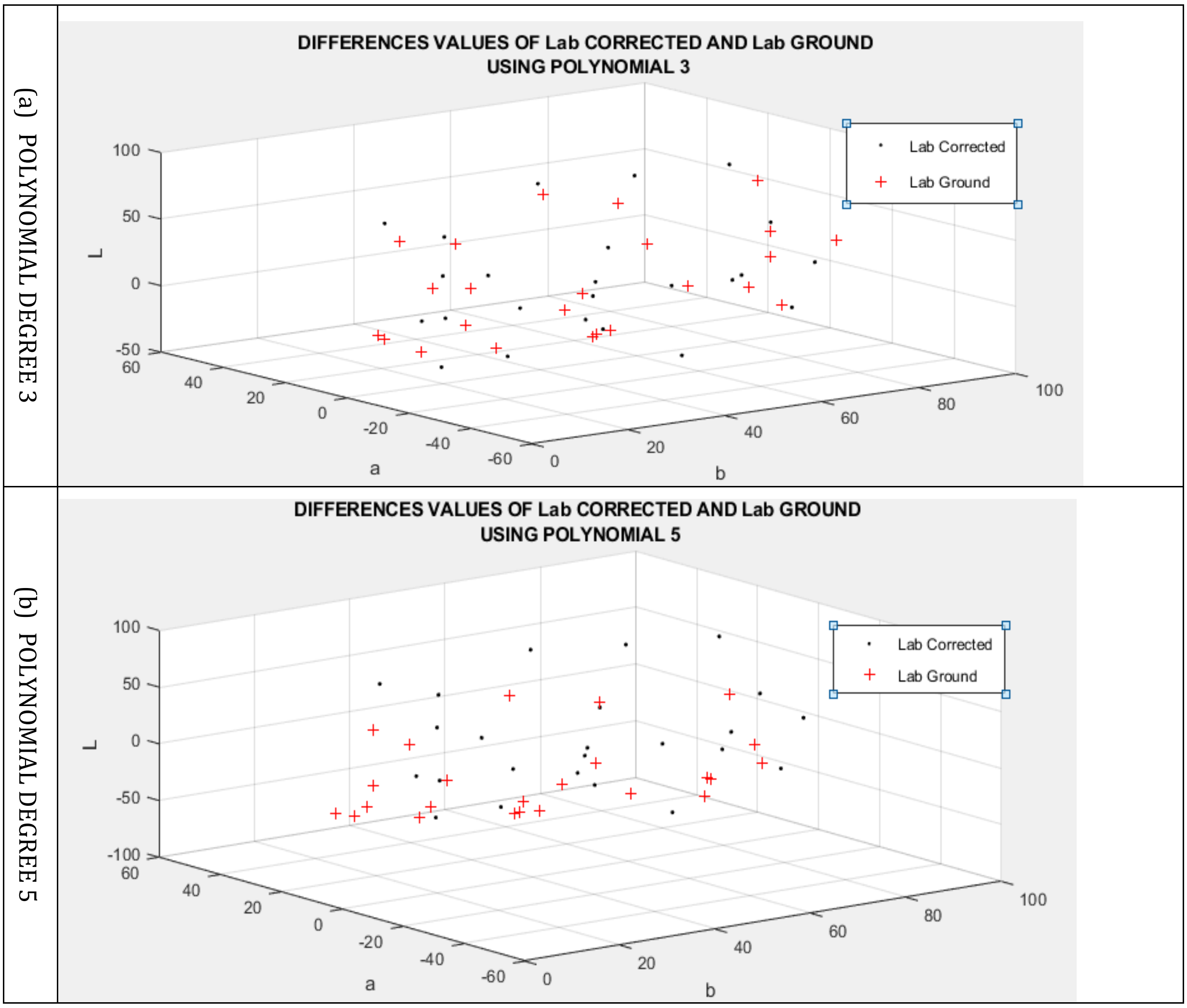


Fig. 6: Comparison of Average Values between CIELab Corrected Image Value and CIELab Ground Truth Value for Polynomial (a) Degree 3 (b) Degree 5 and (c) Degree 7.



(c) POLYNOMIAL DEGREE 7

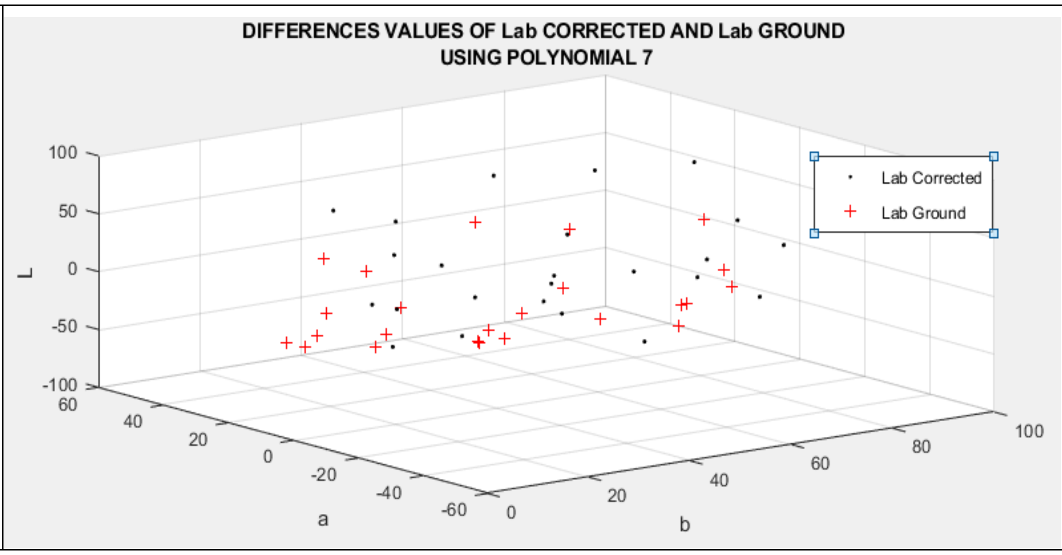


Fig. 7: Pixel Distribution Pattern of CIELab Corrected Image Value and CIELab Ground Truth Value between Polynomial (a) Degree 3 (b) Degree 5 and (c) Degree 7.

Conclusion

This paper presents a preliminary results of colour correction algorithm using polynomial regression algorithm on Munsell 24 patches Colour Checker before it can be implemented on medical images afterward. Based on the experiment, it can be deduced that polynomial degree 3 has the best performance in colour correction compared to other degrees of polynomial. The results of colour difference measurement showed that the colour difference, ΔE^*_{ab}=3.3289 is satisfactory based on previous discussion in [1]. By using similar colour correction coefficient, future works will be implementing a hybrid colour correction scheme with Gamma correction on tongue images. This combination of colour correction method is expected to have greater performance with lower colour differences index using any related medical images (i.e. tongue images, blood and tissue images, magnetic resonance imaging, etc.) in the future.

Acknowledgement

The author wishes to thank the Supervisors, Dr Nur Diyana Kamarudin and Dr Siti Noormiza Makhtar, whose contribution in stimulating suggestions and encouragement for this project. This study is supported by using an academic budget from GPJP Grant UPNM, reference number: UPNM/2018/GPJP/2/TK/1.

References

[1] X. Wang and D. Zhang, "Correction Scheme," vol. 14, no. 6, pp. 1355–1364, 2010.

[2] H. Zhang, "Computer Identification and Quantification of Fissured Tongue Diagnosis," *2018 IEEE Int. Conf. Bioinforma. Biomed.*, pp. 1953–1958, 2018.

[3] Z. Li and Z. Yu, "Tongue image segmentation via colour decomposition and thresholding," 2017.

[4] A. I. Matting, "Automatic Tongue Image Matting for Remote Medical Diagnosis," pp. 561–564, 2017.

[5] C. J. Jung, Y. J. Jeon, J. Y. Kim, and K. H. Kim, "Review on the current trends in tongue diagnosis systems," *Integr. Med. Res.*, vol. 1, no. 1, pp. 13–20, 2012.

[6] S. Karuppanagounder and K. Palanisamy, "Medical Image Contrast Enhancement based on Gamma Correction," no. September, 2014.

[7] S. Rani, "Contrast Enhancement using Improved Adaptive Gamma Correction With Weighting

Distribution Technique," vol. 101, no. 11, pp. 47–53, 2014.

[8] S. Huang, F. Cheng, and Y. Chiu, "Efficient Contrast Enhancement Using Adaptive Gamma Correction With Weighting Distribution," vol. 22, no. 3, pp. 1032–1041, 2013.

[9] G. D. Finlayson, M. Mackiewicz, and A. Hurlbert, "Colour Correction Using Root-Polynomial Regression Title : Colour Correction using Root-Polynomial Regression", no. May 2016, 2015.

[10] X. Wang, B. Zhang, Z. Yang, H. Wang, and D. Zhang, "Statistical Analysis of Tongue Images for Feature Extraction and Diagnostics," vol. 22, no. 12, pp. 5336–5347, 2013.

[11] X. Wang and D. Zhang, "A New Tongue Colourchecker Design by Space Representation for Precise Correction," vol. 17, no. 2, pp. 381–391, 2013.