Iranian Food Science and Technology Research Journal
Vol. 13, No. 1, Apr. May. 2017, p. 53- 64

نشریه پژوهشهای علوم و صنایع غذایی ایران
جلد ۱۳، شماره ۱، فروردین-اردیبهشت ۱۳۹۶ ص.۶۴-۵۳

Computational estimation of L*a*b* units from RGB using machine vision

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Received: 2015.03.15
Accepted: 2015.05.30

Introduction:.Color is the first quality attribute of food evaluated by consumers, and is therefore an important quality component of food which influences consumer's choice and preferences (Maguire, 1994). Color measurement of food products has been used as an indirect measure of other quality attributes such as flavor and contents of pigments because it is simpler, faster and correlates well with other physicochemical properties. Therefore, rapid and objective measurement of food color is required in quality control for the commercial grading of products (Trusell *et al*., 2005). Among different color spaces, L*a*b* color space is the most practical system used for measuring of color in food due to the uniform distribution of colors in this system as well its high similarity to human perception of color. All of the commercial L*a*b* colorimeters generally measure small, non- representative areas (Pathare *et al*., 2013) while the RGB digital cameras obtain information in pixels. Therefore, this research establishes a computational solution which allows acquiring of digital images in L*a*b* color units for each pixel from the digital RGB image (Fernandez-Vazquez *et al*., 2011). In recent years, computer vision has been used to objectively measure the color of different foods since they provide some obvious advantages over a conventional colorimeter, namely, the possibility of analyzing of each pixel of the entire surface of the food, and quantifying surface characteristics and defects (Mendoza & Aguilera, 2004). The color of many foods has been measured using computer vision techniques (Pedreschi *et al.,* 2011; Lang *et al*., 2012). A computational technique with a combination of a digital camera, image processing software has been used to provide a less expensive and more versatile way to measure the color of many foods than traditional color-measuring instruments. This study used four models to carry out the RGB to L*a*b* transformation: linear, quadratic, support vector regression and neural network. This article presents the details of each model, their performance, and their advantages and disadvantages. The purpose of this work was to find a model (and estimate its parameters) for obtaining L*a*b* color measurements from RGB measurements.

Materials and Methods: The images used in this work were taken with the following image acquisition system (Samsung, SM-N9005 color digital camera with 13 Mega pixels of resolution ,Fig.1). The camera was placed vertically at a distance of 60 cm from the samples and the angle between the axis of the lens and the sources of illumination was approximately °45. Illumination was achieved with 4 natural daylight 150 W lights.

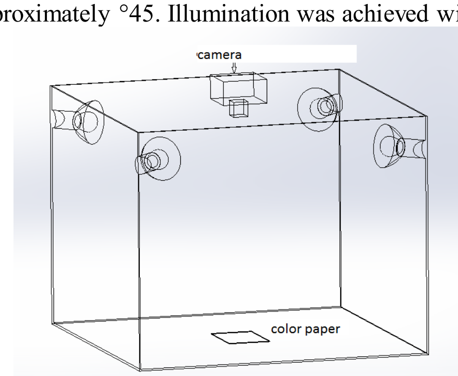

Fig. 1. Schematic diagram of image acquisition system.

In order to calibrate the digital color system, the color values of 42 color charts were measured. Each color chart was

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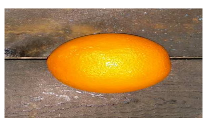
divided into 24 regions. In each region, the L*a*b* color values were measured using a Minolta colorimeter. Additionally, a RGB digital image was taken of each chart, and the R, G and B color values of the corresponding regions were measured using a Matlab program which computes the mean values for each color value in each region according to the 24 masks. In this study four models for the RGB to L*a*b* transformation namely: linear, quadratic, artificial neural network (ANN), support vector regression (SVR) have been used.

Results and discussion: In the evaluation of the performance of the models, the support vector regression and neural network model stands out with an error of only 0.88 and 2.37, respectively. Leon et al. (2004) investigated some models for the RGB to L*a*b* conversion. In the evaluation of the performance of the models, the neural network model showed an error of only 0.93%. In another research Yagzi et al. (2009) measured the L*a*b* values of atlantic salmon fillets subjected to different electron beam doses (0, 1, 1.5, 2 and 3 kGy) using a Minolta CR-200 Chroma Meter and a machine vision system. For both Minolta and machine vision the *L** value increased and the *a** and *b** values decreased with increasing irradiation dose. However, the machine vision system showed significantly higher readings for *L**, *a**, *b** values than the Minolta colorimeter. According to the construction of these models, the correlation between measured and predicted color is well established; therefore, based on the promising obtained results from Computer vision, it is possible to find a L*a*b* color measuring system that is appropriate for an accurate, exacting and detailed characterization of a food item based on a color digital camera. In order to show the capability of the proposed method, the color of an orange was measured using both a Minolta colorimeter and the studied approach. The colorimeter measurement was obtained by averaging 6 measurements in 6 different places of the surface of the orange, whereas the measurement using the digital color image was estimated by averaging all pixels of the surface image. The results are summarized in Fig. 2.



Measurement Method	L*	a*	b*
Minolta colorimeter	58.98	28.32	35.49
Machine Vision (SVR)	61.20	27.30	37.35
Machine Vision (ANN)	60.18	30.19	30.60

Fig. 2. Estimate of L*a*b* values of an orange

Key word: Color, RGB, L*a*b*, ANN, SVR