

Color calibration via natural food colors

Brian FUNT, Milan MOSNY
School of Computing Science, Simon Fraser University, Canada

ABSTRACT

Color image calibration is usually done with the aid of a color chart such as the Macbeth ColorChecker containing a set of carefully produced color patches. However, in many consumer applications such as Internet shopping, for which the correct reproduction of color can be very important, most users will not have a color chart readily available, and probably are not interested in purchasing one in any case. We propose using the colors of the fleshy interior parts of oranges, lemons and limes, along with cooked egg white as a means of creating a simple color ‘chart’. A sample of oranges, lemons and limes from North America and Australia has shown their color to be quite consistent, and therefore potentially suitable as a set of reference colors for color image calibration. Figure 1 shows one of the images used in measuring the colors of the fruits and vegetables. In the case of Internet sales, a seller photographing color-sensitive merchandise, such as clothing, could simply include one or two of these foods in each picture. This would provide an immediate point of reference for the purchaser as to whether or not the image colors are correct. Clearly, if the food colors do not look right, neither will the merchandise when it is delivered.

1. INTRODUCTION

We investigate whether fruit colors are stable enough to be used as a form of color chart for ensuring that the colors in an image are correct. Consider the situation of web-based clothes shopping. It is important that the colors the shopper views from the vendor’s web page accurately represent the colors of the item to be purchased. However, the problem is not all the vendor’s responsibility. The vendor may present images in sRGB space expecting the shopper to be using an sRGB calibrated monitor under standard viewing conditions, however, the user may have adjusted the brightness and contrast controls of his/her monitor which can significantly affect the colors it displays. As well, the monitor may be being viewed in lighting conditions that are far from those specified in the sRGB standard.

The typical web shopper is likely to be unaware that displays require calibration, that adjusting the contrast and brightness controls will affect the colors, and that the viewing conditions matter. Even if the shopper does realize these problems, it is difficult to deal with them directly. The shopper could purchase a calibration kit (e.g., X-Rite i1Display LT) but it seems unlikely that many people will do this. Even having a simple color chart such as the Macbeth ColorChecker handy would seem to be too much to expect. If all users did have a standard color chart available, then the vendors could include it in all of their images as well. By comparing the real color chart to the vendor’s image of it, the shopper could be reassured, assuming the colors match, that the colors of the merchandise will match too.

Since it is unlikely that the typical web shopper will have a color chart available, we consider whether or not the colors of some standard objects could be used for comparison instead. The question is, though, what objects are both readily available and more or less guaranteed to be of a color? Although colors such as Coca-Cola red, or those of some

currencies (e.g., the light blue of the 20 Euro note), may be relatively stable, they are not guaranteed to be so and are certainly subject to change. Metals such as gold and silver are another possibility, but the color of gold varies with its purity, and shiny silver is less a color than the reflection of its surrounding colors. In terms of natural objects, many, such as the green of leaves, would appear to be too variable. However, our hypothesis is that the fleshy interior of many fruits, and perhaps some vegetables, may be sufficiently stable to use as reference colors. If so, then a collection of a few fruits or vegetables might suffice as a simple color chart. This ‘chart’ could then be used by the shopper to validate the vendor’s colors.

2. EXPERIMENTAL SETUP

The colors of fleshy parts of navel oranges, limes, lemons, beets, carrots, parsley, and egg whites were measured. Various kinds of paper were added for reference. The fruit, vegetables and eggs were purchased from 5 different stores in the Vancouver area. Both ripe and greener foods were selected. Fruits and vegetables originated from the USA, Mexico, Canada and Australia. The ‘white’ papers included a paper towel, tissues, printer papers and a selection of business cards of varying quality.

The fruits, paper samples, and a small Macbeth Color Checker were arranged together as shown in Figure 1 and photographed under two incandescent and two fluorescent lights. A Nikon D700 digital camera using 14-bit raw mode was used to obtain the images, and then dcrw (Coffin 2010) was used to convert the Nikon NEF linear images into 16-bit sRGB gamma-corrected TIFFs. Variations of the TIFF images were generated using Nikon ViewNX™ version 1.5.2, an image-editing program. All variations started from the images taken under the cool white fluorescent. Each image was brightened using a setting of 35, and then color boosted with settings 33 and 66, contrast enhanced with settings -25, -50, +25, +50, or shadow protected using settings of 25 and 50. Altogether 8 variations of each brightened image were produced. Figure 1 shows a brightened image with no other variation and the corresponding brightened image with color boost set to 66 displayed on an LCD monitor and then re-photographed with the camera. The LCD was not specifically calibrated, but is believed to be fairly close to the sRGB standard. The pictures of the monitor were taken in a fairly dark room illuminated by early morning cloudy sky.

Using an image annotation program, rectangular image areas were selected from the fleshy part of each food and paper sample, as well as the lower left, lower right, and upper left ColorChecker patches. The positions of the remaining ColorChecker patches were inferred. Linearized sRGB values from each of the rectangle areas were collected and the median R, median G and median B values were taken to represent the color of the sample. This was done to reduce noise, and to remove outliers created by the specular reflection. The median linearized sRGB values were converted to CIE XYZ via the standard 3×3 matrix.

The brightness of samples of the same food may vary between images and also within an image due to varying distance from the light source, changing angle of incidence, and to some degree, due to variations between the samples. In order to focus on the distribution of chromaticities of the samples independent of their brightness, we normalized each food sample, paper sample and Macbeth ColorChecker patch to a Y value computed as the average Y under the cool white fluorescent of the samples of the same type. The normalized XYZ values were then converted to CIELAB space. The white patch of the ColorChecker was used as the reference $X_n Y_n Z_n$ white. Note that the L^* , a^* , and b^* values depend only on the ratios X/X_n , Y/Y_n , and Z/Z_n . Here, X, Y, Z are the values of the measured rectangular area and X_n , Y_n , and Z_n are the values of the white of the color checker. Hence, converting the colors to

CIELAB space effectively color corrects all images via a von-Kries-type (i.e., diagonal matrix) transformation in the CIE XYZ space.

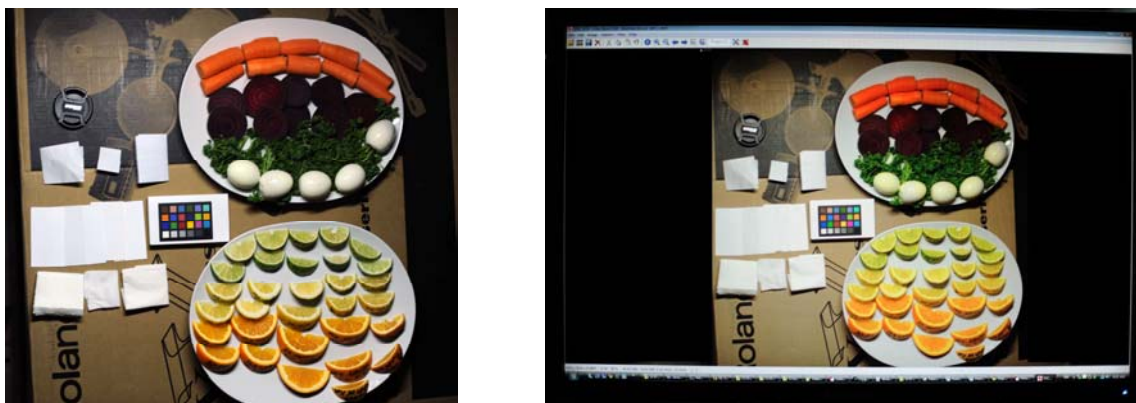


Figure 1. Left: TIFF image of food and paper samples showing the layout. Right: photo of the LCD displaying the image from the left after color boost has been applied. It is easy to see that the fruits on right appear too intense and more saturated, while the eggs are a bit green. The colors differ despite both images being white balanced so $R=G=B$ for the white patch.

3. RESULTS AND CONCLUSIONS

Figure 2 shows the distribution of a^* and b^* values (normalized Y, hence L^* too) of the different fruits in a single image. The a^*b^* values of each type are fairly well clustered, comparable to the clustering of the white papers. Hence, it would appear that they could be useful for color calibration.

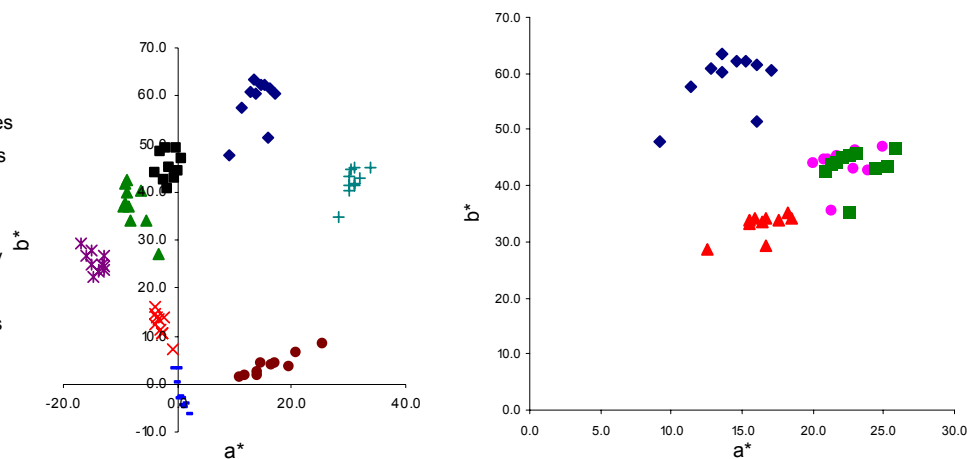


Figure 2. Left: plot of a^*b^* chromaticities of food and paper samples from a single image illuminated by cool white fluorescent. Right: plot of a^*b^* chromaticities of the oranges from four images of the same scene under four different illuminants. Each symbol type represents multiple samplings within a single image.

The next issue is whether white balancing (Lee 2005, Finlayson et al. 2005) affects the fruit colors and the ColorChecker colors comparably. Since white balancing makes whites white in the image, one might assume that all the other colors would follow and be correct as well; however, this is not necessarily the case. The von Kries scaling is far from perfect, and in addition many of the image-enhancement operations found in programs like Adobe Photoshop that are often used to make an image look more appealing often change the

chromaticity of non-white colors. For example, an operation that increases the vividness of an image may well be changing the saturation of the colors without having any effect on white. In order for the fruits to be useful as a color chart, it is important that their colors migrate in the same way as the ColorChecker's colors do. That they do is illustrated in Figure 3 where on the left is shown that the colors move together very closely under illuminant change, and on the right that the colors also move together under image enhancement, although less linearly.

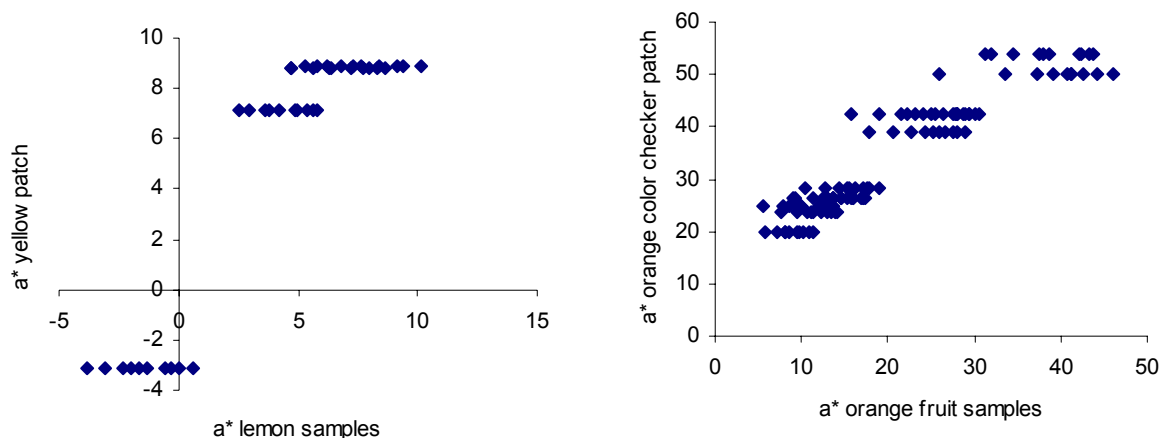


Figure 3. Demonstration of the correlation between the fruit colors and the ColorChecker colors across both illuminant change (left) and image enhancement operations (right). Left: plot of lemon sample a^* values vs. ColorChecker yellow patch a^* values under four different illuminants after white balancing (left). Right: plot of a^* values of the orange fruit samples versus the orange ColorChecker patch a^* values (after white balancing) for the eight image enhancements, the images of the LCD, and the original image taken under cool white light.

The results shown in Figures 2 and 3 demonstrate that it is possible to use a fruit-based color chart to determine when image colors are incorrect, as in the example of Figure 1 (right).

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Address: Brian Funt or Milan Mosny, School of Computing Science, Simon Fraser University,
 8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6
 E-mails: funt@sfu.ca, mмосny@sfu.ca