The Effect of Gamut Expansion Ratio on Delicious-looking Food under Multi-primary Circumstance

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1. Introduction
Despite of vigorous development in display devices, its display contents had been underestimated and so are multi-primary environments. Recent years, however, as the popularity and development of multi-primary technology, some enterprises had also launched corresponding display devices. There are usually two main techniques to extend color gamut in a display: (1) improving the purity of RGB primaries, (2) adding more color primaries besides RGB. In this study, we use the latter technique to simulate a six-primary environment.

According to previous researches, the appearance of delicious-looking-food usually depends on its color, shape, and surface. Multi-primary techniques would be a powerful tool to show those factors of delicious-looking-food on display images.

The main propose of this study is using a six-primary display based on multi-primary techniques through expanding the ratio of complementary color to explore how it affects the relationships between color enhancement and delicious-looking foods under multi-primary environment.

2. Experiment
2.1 Experimental environment
In this experiment, we used two monitors and three cameras. In the case of monitor, first, we used an Eyeone colorimeter to make a calibration and let the white point close to that of the D65 standard light source. Here, we prepared a SONY monitor corresponding to sRGB color space, and an EIZO monitor corresponding to Adobe RGB color space. Second, we produced some color chips which were composed of three primary colors, red, green and blue, by using Photoshop software to show on the monitors. In order to avoid miss measurement, we generated those color chips in the three kinds of file formats—BMP, JPEG and PNG, respectively.

Then, we prepared three digital cameras: Canon S95, Sony NEX-7 and Sony DSC-T100. Since the brightness on the screen was not uniform, we set cameras at the center of screen and took five pictures at each file by using continuous shooting. Then we put the picture data of each color chip taken by three cameras into computer. After that, we used a Minolta CS-1000 spectroradiometer to measure the chromaticity of each color. The procedure as described above was taking place in a dark room where illuminance was only 1 lx. Figure 1 shows the results in sRGB and AdobeRGB color space.

![xy plot](image_url)

Fig.1. Each camera’s gamut in sRGB(upper) and AdobeRGB (lower) color space
2.2 Experimental stimulus
Here, we used seven brightly colored fruits as experimental stimuli for visual evaluations. They are pineapples, loquats, wax apples, peaches, plums, carambolas, and guavas. In order to prevent influences from background color during visual judgment, all the fruits were placed on a totally white environment including a plate and a table. Since this experiment focuses on the relevance about the color of stimuli and delicious-looking appearance, so we took a picture of each stimulus at its best-looking position to minimize other differences affecting stimulus appearances as low as possible. Light sources with the color temperature 5800K to 6300K were used to make illumination color close to D65 as much as possible.

2.3 Six-primary color space transformation
Here, we generated four kinds of images, produced by the three cameras and a simulated one. The latter was based on the average chromaticity of the three cameras to reproduce standard color that can be captured by all cameras.

After that, we transformed all images into the six-primary color space, as shown in Figure 2. At this time we adjusted the expansion ratio of complementary colors, and then divided those into three types, yellow, cyan and magenta. To determine the order of personal preference for images, with the gamut expansion ratio from 1.0 (original) to 1.5, we used a paired comparison method for making a preference evaluation.

Observers judged which image appeared more delicious based on the color of paired image. Seven observers participated.

At last, in accordance with the result, we were able to mark those ratio points on the chromaticity coordinates and get a contour line that was built by all ratios.

3. Result and Discussion
Figure 3 shows the result of paired comparison experiment. Z-score on ordinates means the degree of preference. Although preference ratings are affected by gamut expansion ratio, there trend is different in hues of stimuli.
A) When transforming into six-primary environment, some pictures are affected by those camera’s color sensitivities and will result in over oversaturated.
B) Some fruits such as loquat would be affected by the memory color of observers, so the expanding effect in chroma would be limited.
C) From the results of psychophysical experiments, we can find that the range of ratio showing delicious-looking is limited.
D) It has more significant effect between the ratios 1.2 to 1.3. This suggests that the gamut expansion ratios that make food look delicious are approximately between these ranges.

4. Conclusion
The result of psychophysical experiment showed the relationships between color enhancement and delicious-looking foods under multi-primary environment. It is also shown that there are a certain degree of correlation between delicious-looking and its own colors. Especially in red, yellow and green colors, after enhancing a certain degree of chroma, the effect is more significant than the other colors.

Fig.2. The example of transforming into six-primary color space

Fig.3. The result of pair comparison

References