Image Dependent Gamut Mapping Based on Color Variations at Each Segmented Region

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Abstract

This paper proposes an image-dependent gamut-mapping algorithm for cross media color reproduction. Since every color device has a limited range of producible colors, the colors reproduced by a destination device will be different from those of the original device. Therefore, to compensate for this color difference, the proposed method considers the color spatial characteristics in an image. First, a region segmentation method is used to create regions in the image domain. Then, different mapping methods are applied according to the image characteristics. If the color variation in a region is significant, a color rearrangement method is used to preserve the color contrast. Otherwise, a clipping method is used to reduce the color difference. Psychophysical tests demonstrated that the proposed method enhances the lightness contrast and chrominance in an image. Consequently, the output image is highly consistent with the input image.

1. Gamut Mapping Based on Color Variations

An image-dependent gamut-mapping method[1] is proposed that considers the color variations in an image. Figure 1 shows a flowchart of the proposed method. In the first step, the device-dependent color space is converted into a device-independent color space using tetrahedral interpolation. The lightness image L is then segmented using morphological tools and a watershed. Next, a local histogram is calculated for each region at a constant hue plane. The color distribution of each region is then compared with that of the device gamut. Finally, the values of the input pixels are adaptively determined according to the color variations in each region. If there are many out-of-colors in a particular region, a color rearrangement method is used to the preserve color variations. Otherwise, out-of-colors are clipped to the gamut boundary to reduce the color difference, thereby preserving the gradation of the image.

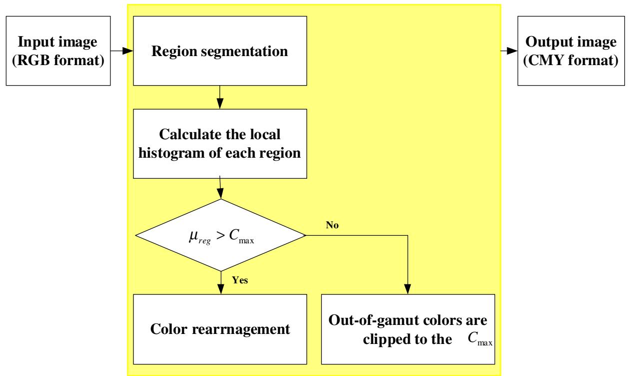

Figure 1. Block diagram of the proposed gamut mapping.

2. Image Segmentation

To segment the image, morphological filters and a watershed algorithm are used. Morphological transforms are a geometrical approach to signal processing and easily deal with criteria such as shape, size, and connectivity. A large number of morphological tools rely on two basic sets of transformations, known as erosions and dilations, which are used to simplify the image. Then, a marker extraction technique is used to identify the flat regions in the simplified image. The interior of each homogeneous region is marked by a label, a constant lightness level value, that is unique for each region. Once these markers have been defined, decisions can be taken by the watershed algorithm.

3. Color Distribution at Each Region

After the regions are determined, chroma histograms are computed. Figure 2 shows the compression region in the device gamut, which is 70% of the maximum values. The distribution of the out-of-gamut values is adaptively changed according to the distribution of the in-gamut values. To determine which method is used to arrange the histogram distribution of the out-of-colors, the mean μ_{reg} of the population of pixels within the region is computed. If the mean is larger than $C_{\max}$, which indicates many out-of-gamut colors in a region, the distribution of colors is stretched to $[\mu_{reg} - \kappa\sigma_{reg}, C_{\max}]$[2]. Otherwise, the out-of-gamut colors are clipped to the gamut boundary. This can be expressed as follows:

$$[i_{\min}, i_{\max}] = [\mu_{reg} - \kappa\sigma_{reg},\ C_{\max}],\ \ if\ \ \mu_{reg} > C_{\max}, \qquad (1)$$
$$C_{\max} = Out - of - gamut\ colors,\ \ otherwise$$

The proposed method considers the color variations in each region based on the input color distribution. This method not only preserves larger color variations in a region using color rearrangement method, but also reduces the color difference in a region that only has a few out-of-colors.

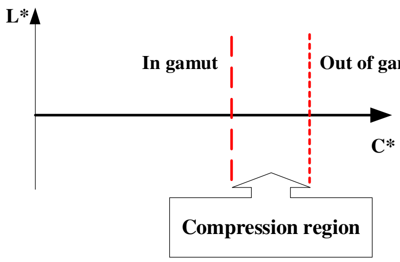

Figure 2. Compression region in the divice gamut.

In Figure 3, the method to arrange the input color distribution is explained. Figure 3(a) is the method to rearrange the input histogram, when many out-of-gamut colors are existed in the region. Figure 3(b) shows the clipping method, as a few out-of-gamut colors are existed in the region. In each region, the out-of-colors are redistributed according to the input color distribution.

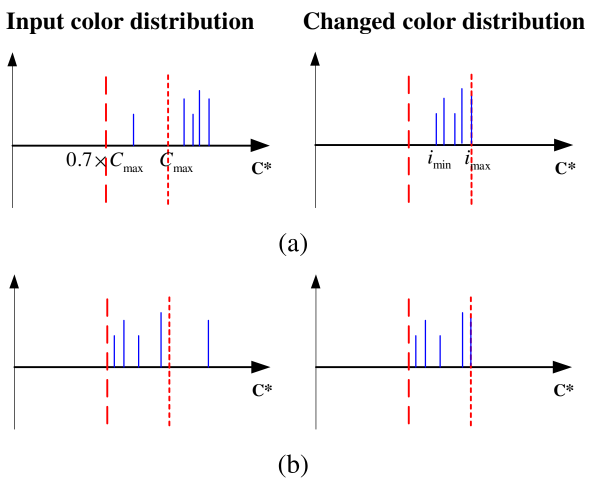

Figure 3. Input and changed color distribution; (a) color rearrangement method, (b) clipping method.

4. Experimental Results

To determine the gamut of each device, 9×9×9 color samples were generated in RGB space for a monitor (LG Flatron 775FT) and printed in CMY space using a printer (HP 895cxi). To measure the sample colors displayed on the monitor and printed by the printer, a Minolta CS-1000 and Minolta CM-3600d were used. The 'Parrot' image was chosen to test the general performance of the proposed gamut mapping. Figure 4 shows the images printed by error diffusion using the variable anchor points method[3] and the proposed method. In a psychophysical test, the results from the proposed method were preferred over those from the variable anchor points method.

(a) (b)

Figure 4. 'Parrot' image; (a) variable anchor points method, (b) Proposed method.

5. Conclusion

This paper proposed gamut mapping based on color variations within segmented regions. Since the proposed method adaptively considers the local color variations in each region, the gradation of the image can be preserved.

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