Mosaic Image of Dominant Color useful for Analysis of Color in Painting Arts

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ABSTRACT

Segmentation of an image into mosaic is an effective method for analyzing color feature of painting arts. A mosaic image generated by the dominant color in each segment is better than a mosaic by average color, because a dominant color mosaic can keep the original color and the color difference between two adjacent colors. The advantages of dominant color mosaic are discussed through the results of several experiments.

1. INTRODUCTION

Analysis of color features of painting arts through computational approach is one of our major subjects of studies. We have devised several mathematical tools and implemented a specifically designed software system for revealing color features of images [1, 2, etc.].

Segmentation of an image into mosaic is an effective method for reducing the number of constituent colors as well as for representing an approximated or abstracted image of the original image. A usual mosaic image, produced by image processing software such as Photoshop, is computed by the average color in each segment. Another idea of ours is to apply the dominant color which occupies the largest area in the segment.

In our previous study the dominant color mosaic was used for the analysis of spatial color variation in painting arts[3]. In this study the advantages of our method are discussed.

2. MOSAIC IMAGE OF DOMINANT COLOR

2.1 Algorithm and its characteristics

The mosaic image of dominant color is computed by the following algorithm :

1. quantize all colors in an image by means of uniform quantization in a color space
2. divide the image into several square segments,
3. for each segment, the most frequent color, dominant color, is chosen as a representative color of the segment.

Suppose that an image is regarded as a piecewise continuous function with finite gaps. The above algorithm keeps the color difference between two adjacent colors. On the other hand, the average color mosaic generates false color at the border of continuous color region, so that the color difference cannot be reserved.

The approximated images obtained by both dominant color mosaic and average color mosaic converge to the original color image as the number of division approaches to infinity. However, the color distribution generated by average color mosaic generally does not converge to the original color distribution, whereas the color distribution generated by dominant color mosaic always converges to the original distribution.

The adequate number of division depends on the purpose of the analysis. For instance, in order to extract the accent color occupying a small area, the size of a mosaic segment must be smaller than the area of the accent. In order to examine rough composition of color regions, neglecting fine touches, the number of division can be decreased.

2.2. Necessary and sufficient resolution of discrete image

For practical computational processing, an image is not continuous but discrete, sampled by a digital camera or a scanner. A necessary and sufficient resolution of the image is determined by the spatial acuity of visual discrimination. For example, if we look at an object from the distance of 50cm, the resolution is roughly equal to 180 dpi (derived from the fact that the viewing angle of standard visual acuity is 1/60 deg.).

When the source image for analysis is a printed material composed of dots of insufficient resolution, e.g. 150 dpi, a kind of smoothing algorithm to remove the influence of dots should be performed before analysis. The source images used in this article are cited from some art catalogues, and the frequency of dots was 150 dpi, so we were obliged to reduce the resolution to 96 dpi instead of the original 150 dpi.

3. EXPERIMENTS AND RESULTS

Through several examples, dominant color mosaic is compared to average color mosaic from the point of view of color distribution in a color space.

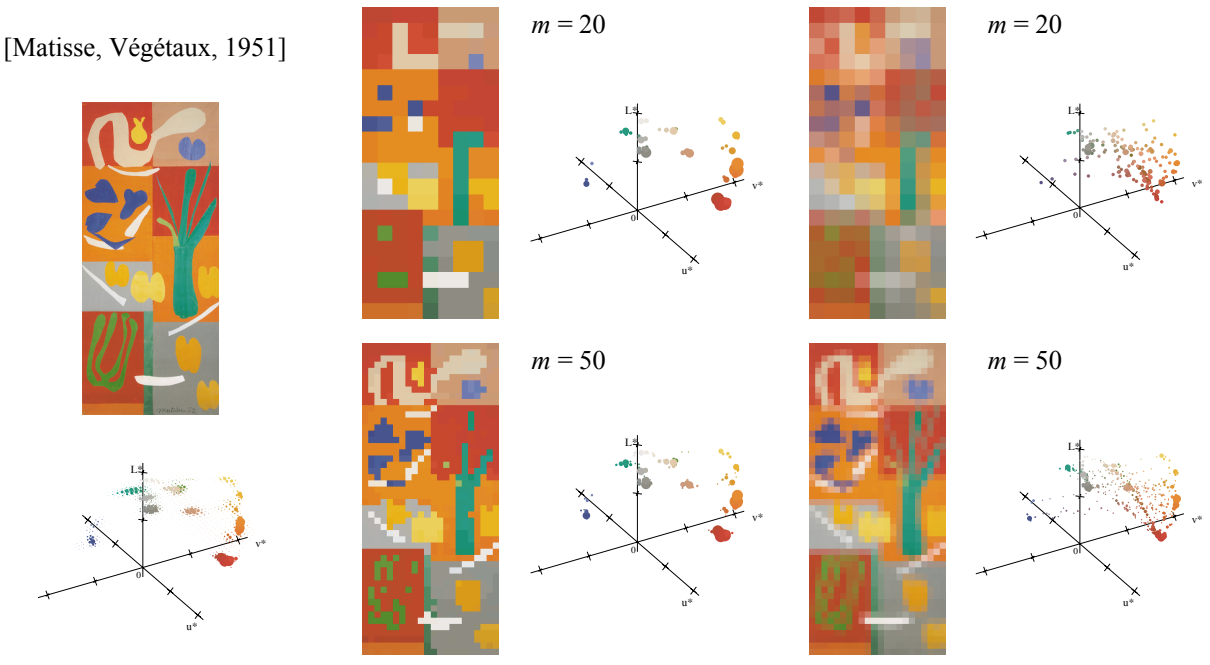
Representation of sharply-delimitated colors

Fig.1 (H.Matisse: Végétaux, 1951, 175×81) shows an example of an image composed of several colors sharply-delimitated. The number of colors of the image is roughly 13. The color distribution of the original image is plotted in CIELUV color space. The image is mosaicked by dominant color, where the number of division of the longer side m is 20 and 50 (Fig.1b). For either division, its constituent colors plotted in CIELUV space well reflect the original color distribution.

In contrast, the mosaic image by average color (m = 20) includes many false intermediate colors between red and the other colors. If the number of division is larger (m = 50), false colors increase.

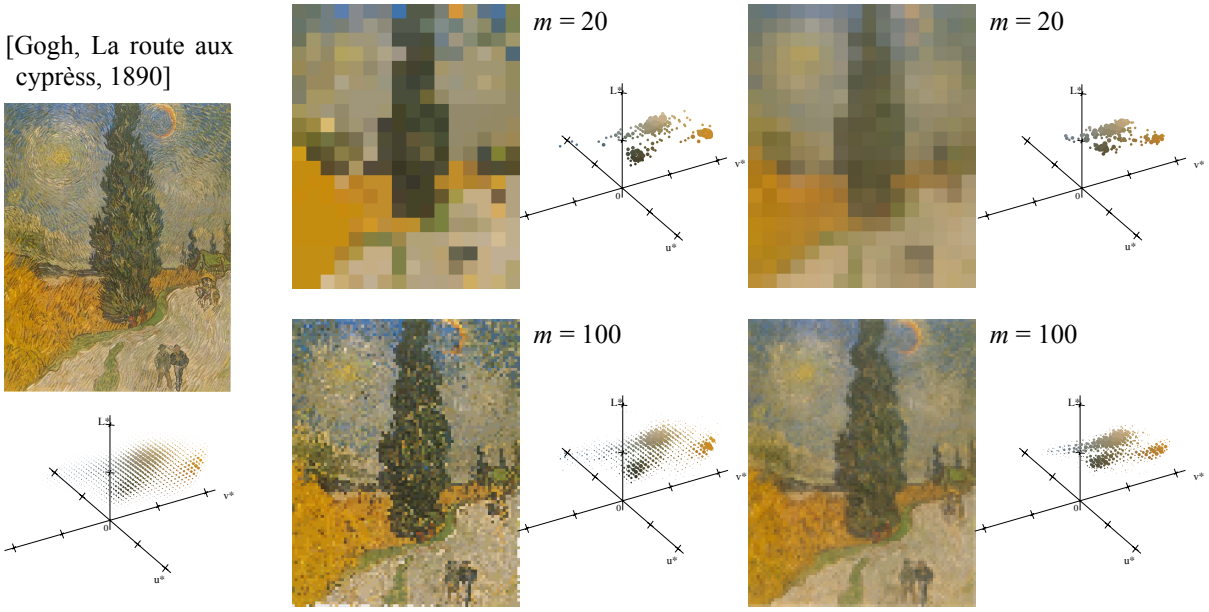
Representation of high chroma and accent colors

In case of an image without sharp boundary between colors or an image with gradation, the difference between a dominant color mosaic and an average color mosaic is not so apparent because the constituent color of the original image is not limited to a small number of colors. However, a dominant color mosaic has some advantages.



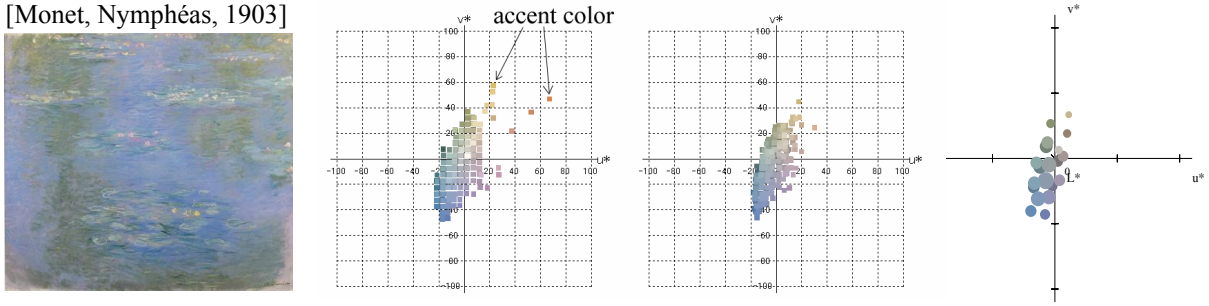
(a) original image (b) dominant color mosaic (c) average color mosaic

Figure 1: An example of image with sharply-delimitated colors



(a) original image (b) dominant color mosaic (c) average color mosaic

Figure 2: An example of image with fine touch



(a) original image (b) dominant color (c) average color (d) quantized color by *K*-means

Figure 3: Representation of accent colors (Fig3 b,c do not reflect the proportion of area)

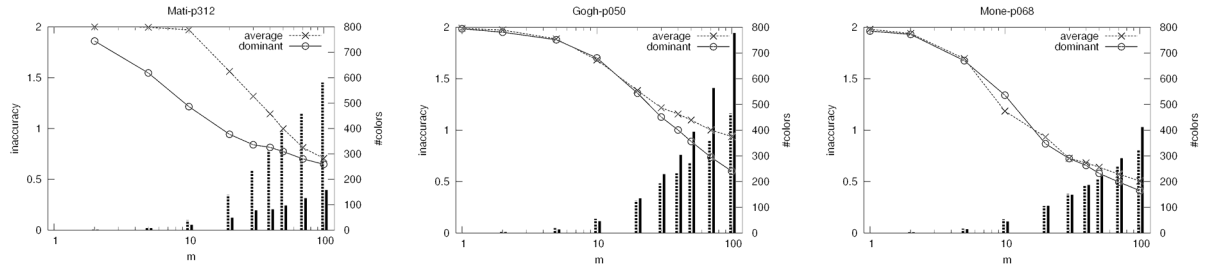


Figure 4: Inaccuracy of color distribution of the mosaic images compared with the original image. The line chart with circle is dominant color, and the line chart with cross is average color. The bar chart is the number of colors.

Fig.2 (V.Gogh: La route aux cyprèss, 1890, 92×73) is an example of image characterized by fine strong touch with high contrast, e.g. yellow, blue and dark green, which is clearly represented by the dominant color mosaic. The color distribution of dominant color mosaic keeps chroma higher than the average color mosaic.

Fig.3 (C.Monet: Nymphéas, 1903, 89×100) is an example of image having fine touch but weak contrast. The color distributions are plotted on u^*-v^* plane. The accent colors, yellow and pink of water lilies, are better expressed in the dominant color mosaic (Fig.3b) comparing to average color

mosaic (Fig.3c). Increasing the number of the segments, the average color mosaic will also have the accent colors, however unnecessary false colors will increase. The *K*-means method, useful for quantization by representative colors, has the same problem of lack of accent colors (Fig.3d).

Difference of color distribution between mosaic image and original image

The inaccuracy of color distribution of mosaic images compared with the original image is quantitatively evaluated. The three line charts in Fig. 4 shows that the dominant mosaic has less inaccuracy than the average mosaic.

4. APPLICATION

As an application of mosaic image of dominant color, the color difference image was calculated by the following expression, which represent the degree of distinctiveness of each segment.

Fig.5 illustrates distinctiveness of a segment 0 defined by

$$\overline{\Delta E_0^*} = [(\Delta E_1^{*2} + \Delta E_2^{*2} + \Delta E_3^{*2} + \Delta E_4^{*2})/4]^{1/2} \quad (1)$$

where ΔE_i^* is the CIELUV color difference between 0 and surrounding segment i (i = 1,2,3,4).

For each color component, replacing ΔE^* in the above expression by ΔL^*, Δu^*, Δv^*, ΔC^*, and ΔH^*, the image of component color difference can be defined similarly. Then, the following relation holds :

$$\overline{\Delta E_0^{*2}} = \overline{\Delta L_0^{*2}} + \overline{\Delta u_0^{*2}} + \overline{\Delta v_0^{*2}} = \overline{\Delta L_0^{*2}} + \overline{\Delta C_0^{*2}} + \overline{\Delta H_0^{*2}} \ . \quad (2)$$

Fig.6 shows six color difference images derived from Fig.1. The degree of distinctiveness is visualized by gray scale. The $\overline{\Delta H^*}$ image has the strongest distinctiveness and the $\overline{\Delta L^*}$ the weakest, which means this painting uses strong contrast in hue with very weak contrast in lightness.

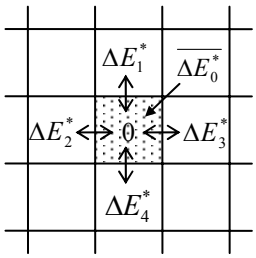


Figure 5: Calculation of distinctiveness of segment

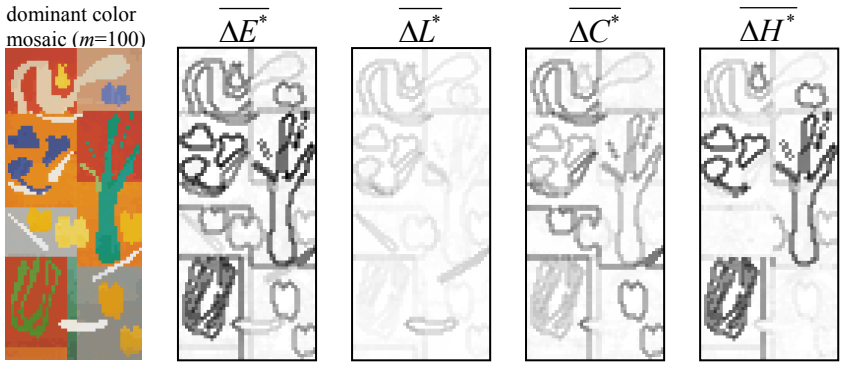


Figure 6: Color difference images. Dark part means strong distinctiveness.

5. CONCLUSION

This study shows mosaic image of dominant color is useful for analysis of color in painting arts, because the algorithm reflects the original color distribution in a color space better than average color mosaic.

References

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