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Chromaticity constant: a new ordering for automated extraction of grain-size data from true colour images

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1. Introduction

The grain-size distribution (granulometry) is one of the most traditional morphological applications.It is used to analyze the structures of elements and to identify these elements as well. In many cases, morphological operators on colour and multi-channel images can be treated as an extension of grey morphology, where operators are applied separately on each channel and then recombined. However, this procedure does not work in granulometry [2], due to difficulty in colour ordering. Granulometry produces the appearance of false colour grains when extended directly to *RGB* channels.

The human perception of the colour seems to be more related with its representation as intensity, saturation and chrominance, being intensity changes enough to recognize the majority of objects [3]. The extra information that a colour image carries can then be found in the chromaticity. For this reason, mathematical morphology (MM) of true colour images seems to be a natural extension of grey MM using adequate colour spaces (e.g. *HSV*, *HIS*, *HSL*, etc). However, it is not easy to directly combine the hue channel (H) with the saturation channel (S): the hue is an angular value, varying from 0°to 360°whereas the range for the saturation values is 0-255. Hanbury and Serra [2] define an ordering, called saturation-weighted hue, in the *HLS* space that considers components H and S.

This work defines a metric for the *HSV* colour space that enables ordering, so that granulometries produce the expected results, i.e., without the creation of new colours [3]. The proposed metric is applied to synthetic and real images to illustrate its efficiency.

2. A new metric on *HSV* space

To order the chrome sensation, components of H and S channels are normalized (between 0 and 1) and component V is left out. We remark that, given the nature of the colour space, values 0 and 1 have different meaning in channels S and H. While they represent minimum and maximum saturations in S channel, in the hue channel they represent a same colour ($0° = 360°$), as shown in Figure 1. Due to this fact, a function called hue distance is defined as being the smallest angle between two hues. Then, the biggest possible distance between any hue values is 180°. With hue and saturation being represented on same scale, we can reduce them to one value. The proposed metric maps these two values into only one scalar value called chromaticity constant. The chromaticity constant is defined as being the maximum distance between saturation and hue. In [3] it was demonstrated that this is a metric for the *HSV* space, and then it can be used for ordering in this space.

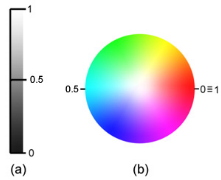

Figure 1. Normalized (a) saturations and (b) hues.

Figure 2 shows the geometric representation of *HS* plane covered by the proposed metric, considering red as the lower possible colour. In this example, only the colour of maximum intensity value is considered, because the proposed metric does not consider the V component. Region (**a**), in Figure 2, shows all the colours that presents the chromaticity constant equal or less than $1/4 = 0.25$ in relation to the minimum colour. Region (**b**) shows the colours where this new component is equal or less than $1/2 = 0.5$, and so on. Moreover, this minimum colour can be defined in each case. For granulometries this must be the background colour.

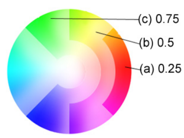

Figure 2. *HSV* colour space covered by the proposed metric with maximum intensity and red on initial position.

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3. Examples

For each image in the following examples, the colour of background is chosen as the minimum colour of the space. Initially synthetic images had been used as tests of the proposed metric on different minimum colour (background). Figure 3 is a controlled experiment, where the amount and size of the grain are known. The only difference among these images is the colour of the background and of some grains, which changes at random in each one. Grains compositions and areas are described in Table 1.

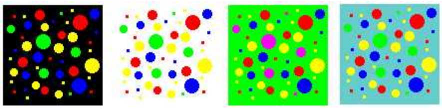

Figure 3. Synthetic images used as tests.

Table 1. Number of grains and occupied area.

Size of grains	*Numbers of grains*	*Grain area*
3	23	207
5	10	520
7	10	800
11	4	708

The resulting pattern spectrum of opening granulometries and opening granulometries with reconstruction, shown in Figure 4, is the same for all the images in Figure 3. The results with reconstruction (also called conditional granulometries) correspond to the true values in Table 1.

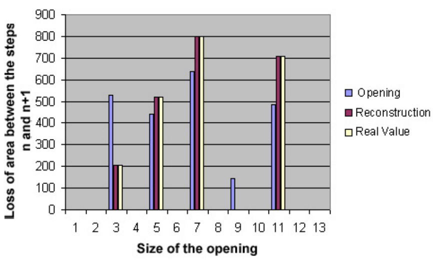

Figure 4. Pattern spectrum for the images in Figure 3.

The proposed metric was also tested on images with real grains. In the images shown in Figure 5, there are 6 grains of pea, 7 grains of corn, 4 white bean grains, 8 grains of rice and 5 black bean grains. Two background colours are considered and the contrast is better for the left image. Figure 6 shows the results of opening granulometries with reconstruction. Due to the low resolution of the image, the true size distribution is not obtained as in the previous example.

Figure 5. A real image of grains, with different background colours.

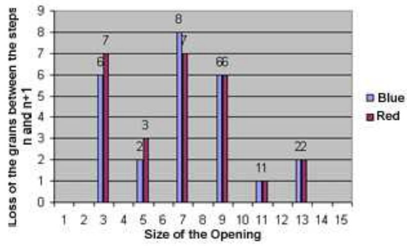

Figure 6. Pattern spectrum of the granulometries by reconstruction of the images presented in Figure 5.

4. Conclusion

Tests on synthetic and real images showed that the proposed metric produces good results. The same occurred in the comparative tests with other works [3]. False colours are not detected in the experiments. For real images with transparent grains (as the rice ones), the background colour and the contrast and regularity in the chromatic sense (the luminance does not present influence), is an important aspect for the result. An opening could be applied to eliminate small chromatic variations [3].

References

[1] J. Serra, *Image analysis and mathematical morphology*, Academic, London, 1982.

[2] A. Hanbury and J. Serra, *Mathematical Morphology in the HLS Colour Space*, Proceedings of British Machine Vision Conference-BMVA, 2001, pp. 451–460.

[3] E. P. Calixto, *Granulometria morfológica em espaços de cores: estudo da ordenação espacial*, UFF, Rio de Janeiro, 2005. M. Sc. Dissertation, 2005 (in portuguese).