Chromaticity constant: Introducing a new ordination for automated extraction of grain–size data from true colour images

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1. Introduction

The grain-size distribution or granulometries is one of most traditional mathematical morphology (MM) applications since the MM development in the 1960´s by G. Matheron [1930-2000] and J. Serra **[1]**. It is used to analyze the structures of elements and to identify these elements as well. Widely explored in bi level and grey scale, the morphology of true colour images presents aspects for deeper researches. Colour and multi-channel MM in many cases can be treated as extension of grey MM, where its operators are applied separately on each channel and then recombined. However, this procedure does not work in granulometry **[2]**. Difficulty in colour's ordinations is the main reason. Granulometry produces the appearance of false colour grains when extended directly to *RGB* channels. This work addresses this problem. It defines a metric for *HSV* colour space that enables ordination, 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. Colour spaces x granulometries

It is difficult to imagine an order or rank in the RGB colour space. 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 loads can then be found in the chromaticity. For this reason, MM of true colour images appear to be a natural extension of grey MM using adequate colours spaces (e.g. *HSV*, *HIS*, *HSL*, etc). However, it is impossible to combine directly the hue channel *(H)* with the saturation channel *(S)*: The hue is an angular value, being able to change between 0° and 360° whereas the saturation values range is 0-255. Hanbury and Serra **[2]** define an ordinance in space *HLS* that considers components *H* and *S*. Their ordinance is called **saturation-weighted hue**: it computes e new H value for each vector on HLS. Then such vector is computed from this new H element with L and S. After the achievement of the *sup* and *inf* values, the original hue is restored to avoid the appearance of false colours. The main feature of this metric is that maximum chrome or purity colours present greater probability to be on the limits of the process. The here presented work considers this problem on HSV colour space and the use of other metric.

3. Considering a new metric on *H and S* channels

First of all, the objective is to order the chrome sensation. The *V* component will be left and *H* and *S* channels are normalized (between 0 and 1). Although, given to the nature of the colour space, values 0 and 1 have different meaning in each case. They represent maximum and minimum saturations, but for the hue channel they represent the same colour (0° = 360°), as shown in **Figure 1**. Due to this aspect, a function called **hue distance** is defined. This represents the smaller angle between two hues, a form of **minimum hue**. With this, the biggest possible distance between any hue values is 180°. Then, with hue and saturation being represented on same scale, we can reduce them to one value. The proposed metric transforms these into only one scalar 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 *HSV* space, and then can be used for ordination in this space.

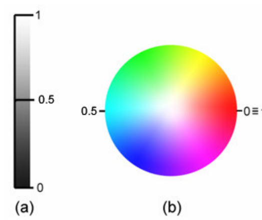

Figure 1. (a) Normalized saturations. (b) Normalized hues.

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 proposal 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 ¼=0.25 in relation to the minimum colour. Region (b) shows the colours where this new component is equal or less than ½=0.5, and so on. Moreover, this minimum colour can be defined in each case. For granulometries this must be the background colour.

4. Examples

After the colour space ordination, grain-size distribution can be considered. For each image on 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 between these images is the colour of the background and colour of some grains, which changes at random in each one. Grains compositions and areas are described in **Table 1**.

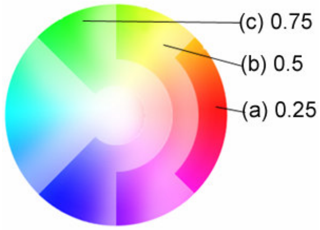

Figure 2. *HSV* colour space covered by the proposed metric with maximum intensity and red on initial position.

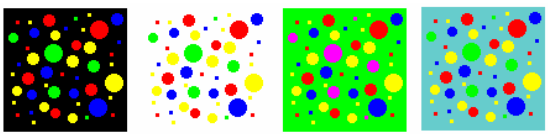

Figure 3. Synthetic images used as tests.

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

Figure 4 presents the resulting pattern spectrum of opening granulometries and opening granulometries with reconstruction for every image (**Figure 3)**. All images produce same results. Observe that the results with reconstruction (also called conditional granulometries) presented in **Figure 4** correspond to the values in **Table 1.**

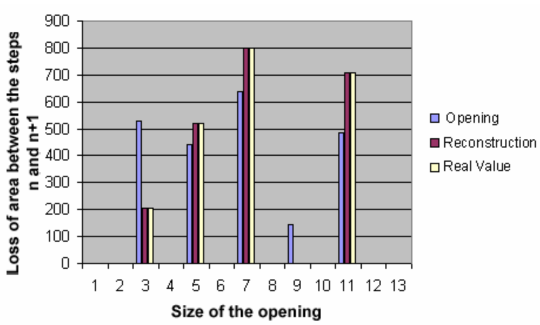

Figure 4. Pattern spectrum for the images in **Figure 3**.

In the next examples, this metric is applied to the real grains presented in **Figure 5**. There are 6 grains of pea, 7 grains of corn, 4 white beans grains, 8 grains of rice and 5 black beans grains. In each case two background colours are considered. The contrast is better for the left image. **Figure 6** shows the results. In these results only opening granulometries with reconstruction are considered. They now change quite a little. The images used have low resolution; since the tool used for tests is not concerned with this point to improve the speed of the process the errors occurred in the measurement phase is related with this low definition.

5. Conclusion

Synthetic and real images tests showed that the proposed metric produces excellent results. The same occurred in the comparative tests with other works **[3].** False colours are not detected on the experiments. However, the background of the images is important on the result with real and transparent grains (as the rice ones), specially its contrast and regularity in the chromatic sense (the luminance does not present influence). To minimize this, a first opening operation in the image can be made to eliminate small chromatic variations [**3**].

Figure 5. Real image composed of same grains but with difference is the colour background of each case.

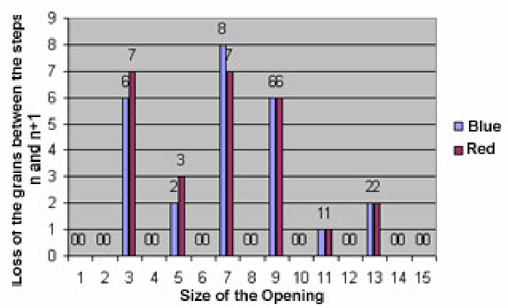

Figure 6. Pattern spectrum of the granulometries by reconstruction of the images presented in **Figure 5**.

References

[1] J. Serra, *Image Analysis and Mathematical Morphology Volume 2: Theoretical Advances,* Academic Press Inc., 1988.

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