Computer Aided Colorimetric Analysis of Fine Art Paintings

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The purpose of our study is twofold. First, we propose a methodology for using a computer to assist with the colorimetric analysis of fine art paintings. This analysis provides valuable information about the colours in a painting, their distribution, the techniques used by the artist etc. Then we apply this methodology to a set of paintings from different epochs.

1 Introduction

In order to analyse paintings, specialists use many different techniques exploring different parts of the electromagnetic spectrum: near infra-red, ultra-violet, X-rays, etc. But surprisingly, the visual domain has rarely been analysed, probably because colour perception is a very complex domain, being rather difficult to analyse adequately by means of automatic techniques. Our visual sensations are the results of three different processes: physical, neuro-physical and psychophysical. Colorimetry is based on the evidence of trichromacy and the definition of a reference observer. It allows the measure of colours as luminous stimuli. For fine arts, it provides a way to quantify the paintings and their reproduction.

The colours of a fine art painting is indeed a very important property of the painting. Traditionally, the colours have mostly been evaluated qualitatively by observing the painting. Besides the obvious uncertainty steming from the qualitative analysis, another important drawback with such methods is that it requires the curator or art historian to be located physically close to the painting.

To perform a quantitative analysis of the colours of a painting, colour measuring devices such as colorimeters and spectrophotometers can be used. But, such equipment have a very poor spatial resolution, making it difficult to analyse the painting as a whole. We propose thus to apply digital image processing techniques to analyse the painting [1, 2, 3, 4]. However, to analyse and evaluate the colours in a painting it is important to be able to quantify them properly, in particular to make sure that the analysis is independent of the image acquisition device.

In the next section, we present briefly a methodology that enables us to capture high-quality colour-calibrated device-independent images. Then, in Section 3, we proceed to the colorimetric analysis of three paintings.

2 Image acquisition

Traditionnally, the image acquisition process is quite complex and it is difficult to control how colour is being processed in the different steps, see Figure 1.

The proposed digital image acquisition process is performed directly from the painting, without a photographic intermediary, using a high resolution CCD camera, see Figure 2. The

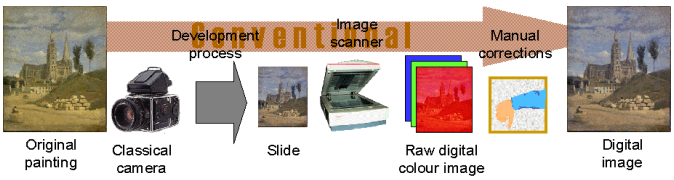

Figure 1: *Traditional image acquisition process using classical photography.*

original methods which have been developed [5, 6] allows a perfect spatial resolution and an excellent colour fidelity. The acquisition is therefore independent of the light source and the acquisition equipment. The process of colorimetric characterisation of the camera provides the transformation from the RGB values of the camera to the device-independent CIELAB colour space, using spectrally calibrated colour targets [7, 8].

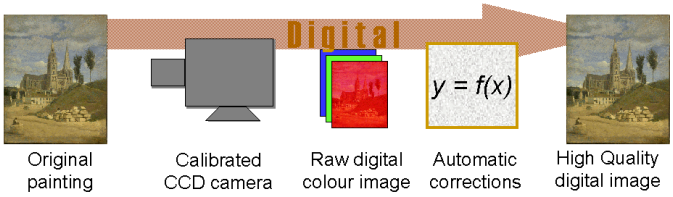

Figure 2: *Entirely digital image acquisition process using a CCD camera.*

These techniques have been applied to the acquisition of paintings shown during recent exhibitions in Paris, in particular for the making of a CD-ROM on Corot in collaboration with the French Museums Research Laboratory (LRMF) [5, 6].

3 Colorimetric analysis

Disposing of a colour-calibrated digital image representing the painting, we project every pixel of the image to its corresponding position in the 3-dimensional CIELAB space, thus obtaining a cloud of points representing all the colours used in the painting, the colour distribution. We perform a segmentation of the CIELAB space into different regions, such as light and dark colours, pastels and saturated colours etc. This segmentation in CIELAB space also provides a segmentation of the painting itself. We can then perform a colorimetric analysis of the resulting regions separately, and extract several properties, such as the precision of the nuances, colour harmonies, principal colours etc. We can also perform statistical analyses of the colour distributions.

Furthermore, the colorimetric analysis allows the demonstration and evaluation of different effects, such as the simultaneous contrast, known from the theories of colour appearance,

that the painter has used to obtain the desired impression.

The described methodology has been applied to perform a comparative analysis of three paintings, *"Le Souffleur à la pipe"* by Georges de La Tour (1593-1652), *"Le ballon aérostatique"* by Francisco de Goya (1746-1828), and *"Le Forum, vu du Jardin Farnèse"* by Jean-Baptiste Camille Corot (1796-1876). The colour distributions in CIELAB space show that each painter has his own way of treating colours. We resume here some of the information we have drawn from our analysis.

In his *"Souffleur"*, La Tour uses fully the technique of light/dark contrast *(chiaroscuro)*, allowing here to amplify the contrast between the bright and colourful red colours (the incandescence of the brand illuminating the scene) and the dark nearly neutral colours of the background. Very often, in La Tour's paintings, all the colours are situated in the region between reds and yellows. Goya's painting is more colourful. In *"Le ballon"* the colour cluster seems to twirl around the neutral axis. Nevertheless, it is possible to segment the colour cluster in three parts by considering the hue and lightness distribution: the white cloud, the balloon and the far horizon, and the hilly countryside. The colour distribution of the *"Forum"* seems unique, parting from bluish greys, passing the neutral axis, towards the oranges (see Figure 3). A partition of this cluster by a vertical plane in CIELAB space, permits to separate in a bright greyish cluster corresponding to the sky, and another cluster of saturated yellows. The greyish cluster is composed of two complimentary hues (yellow-blue) of inequal proportions, illustrating the phenomenon of chromatic adaptation. The yellow cluster is thin and vertical, steming from one single pigment. However the dark colours becomes more orange (Bezold-Brücke effect). This effect allows Corot to transcribe the progressive reddishness of the evening light on the bricks of the *"Forum"* (see Figure 4).

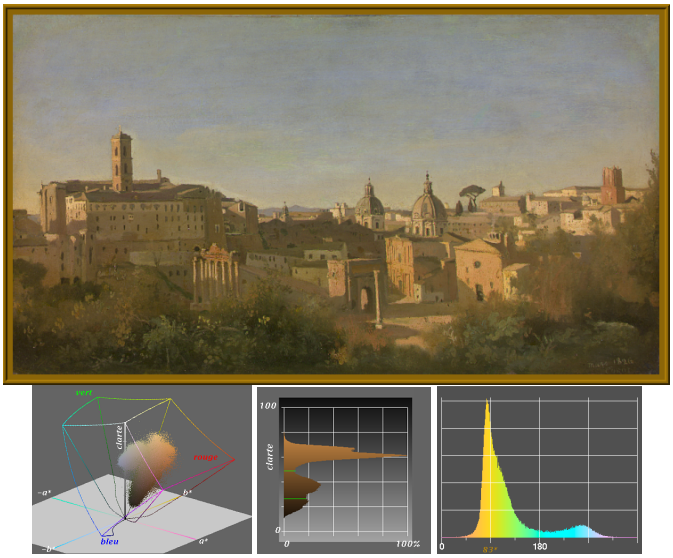

Figure 3: *Colorimetric analysis of "Le Forum" by C. Corot. The colour distribution in CIELAB space, the lightness histogram, and the hue histogram of the blue/yellow sky.*

4 Conclusion

The computer aided colorimetric analysis of paintings can provide curators and art historians with valuable information, both quantitative and qualitative, regarding the colours that the painter has created on his palette in the realisation of a masterpiece. It is however evident that a computer will never replace man in the appreciation of a painting, but we think that it may be a very efficient tool.

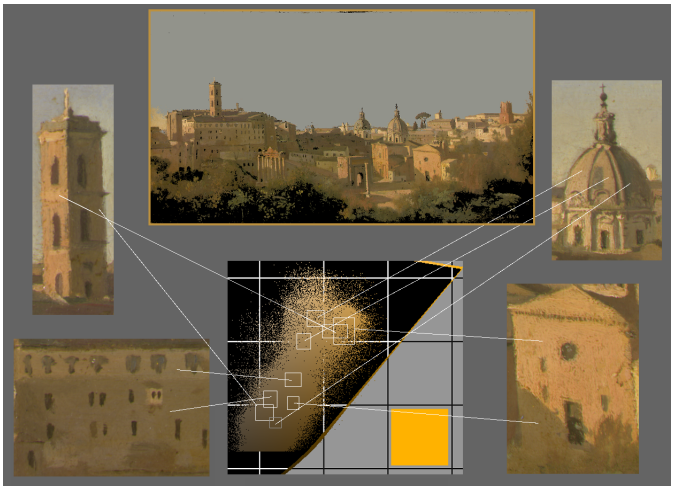

Figure 4: *Correspondences between the nuances of constant hue (584 nm dominant wavelength) and details in the painting.*

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