Estimating the best illuminants for appreciation of art paintings

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ABSTRACT

The visual impression produced by an art painting is influenced by the spectrum of the illuminating light source. The aim of this work was to use hyperspectral imaging data of oil paintings dated from the Renascence époque to compute which from a collection of daylight illuminants produces larger chromatic diversity and, therefore, richer chromatic visual impression. It was found that the number of colours discernible varied significantly with the illuminant and that the maximum number of colours corresponded to an illuminant with the CIE 1931 x value in the range 0.28-0.32, that is, with a correlated colour temperature in the range10,000–6,000 K. The ideal illuminant for these paintings has therefore a correlated colour temperature very different from tungsten halogen lamps or even from SoLux lamps.

1. INTRODUCTION

Art paintings in museums are illuminated by a variety of light sources from natural daylight, tungsten halogen lamps, or light sources that approximate natural daylight, such as SoLux[1,2]. Two factors to be considered in the context of illumination of art paintings are the potential damaging effects of the light on the painting and the visual impression it produces to an observer. The first aspect normally entails using light sources of low intensity and low ultraviolet content; the visual impression is influenced by the spectral profile of the illuminant used, among other factors. Each specific illuminant originates specific luminance and chromaticities distributions and, therefore, a particular visual impression. The aim of this work was to use hyperspectral data of oil paintings from the Renascence époque and models of daylight illuminants to compute which from a collection of illuminants produces larger chromatic diversity and, therefore, richer chromatic visual impression.

2. METHOD

Hyperspectral images of art paintings were taken over the range 400-720 nm at 10 nm intervals. The imaging system was developed from an earlier device[3] and comprised a low-noise Peltier-cooled digital camera providing a spatial resolution of 1344 × 1024 pixels (Hamamatsu, C4742-95-12ER) with a fast-tuneable liquid-crystal filter (VariSpec, model VS-VIS2-10HC-35-SQ, Cambridge Research & Instrumentation, Inc., MA, USA) mounted in front of the lens, together with an infrared blocking filter. A uniform white surface in the same location of the paintings was first imaged by the system and the data used to compensate for spatial non-uniformities of the illuminant and changes in the transmittance properties of the system. Illumination of the paintings was accomplished by three SoLux lamps with correlated colour temperature of 4,700 K.

The performance of system in recovering spectral reflectances of oil painted samples was first tested with uniform test samples painted with several oil paints. The average ΔE_{00}^* over eight test samples was 1.3 and the average spectral difference was 2%.

Hyperspectral images of five oil paintings on wood dated from the Renascence époque were collected at the Museu Nogueira da Silva, Braga, Portugal. Figure 1 shows the setup for collecting hyperspectral data at the Museum and the pictures of the five paintings studied. The spectral reflectance of each pixel of the paintings was estimated from a grey reference surface present in the scene.

The radiance from each painting under daylight illuminants of correlated colour temperatures in the range 40000—3500 K was estimated and the corresponding luminance and chromaticity distributions computed. The illuminant spectra were computed using the CIE method of calculating D-illuminants[4]. In each case, the number of colours discernible was estimated by computing the painting representation in CIELAB space as illustrated in Figure 2 for one of the paintings and by counting the number of non-empty unit cubes in that space[5-7].

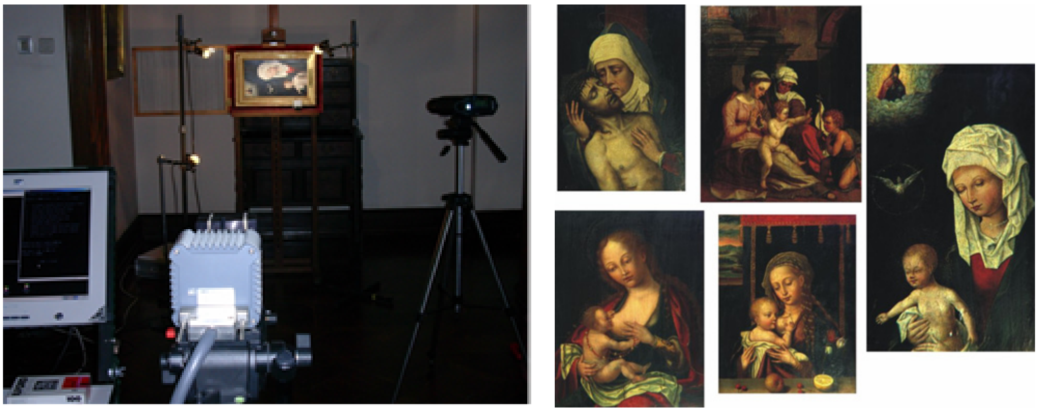

Figure 1: Setup for collecting hyperspectral data from the oil paintings from the Renascence époque at the Museu Nogueira da Silva, Braga (left). Pictures of the five paintings studied (right).

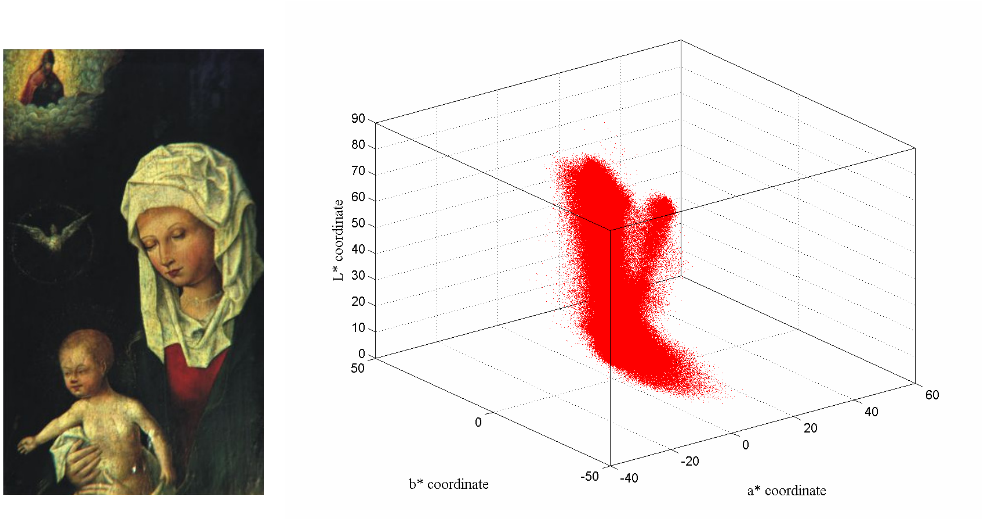

Figure 2: Computed CIELAB colour volume of a painting. The number of discernible colours was estimated by counting the number of non-empty unit cubes in the volume defined by the paintings in that space.

3. RESULTS

The number of colours discernible varied significantly with the illuminant and with the painting. Figure 2 shows the pictures of two of the paintings studied and the corresponding number of colours obtained as a function of the CIE *x* coordinate of the illuminant.

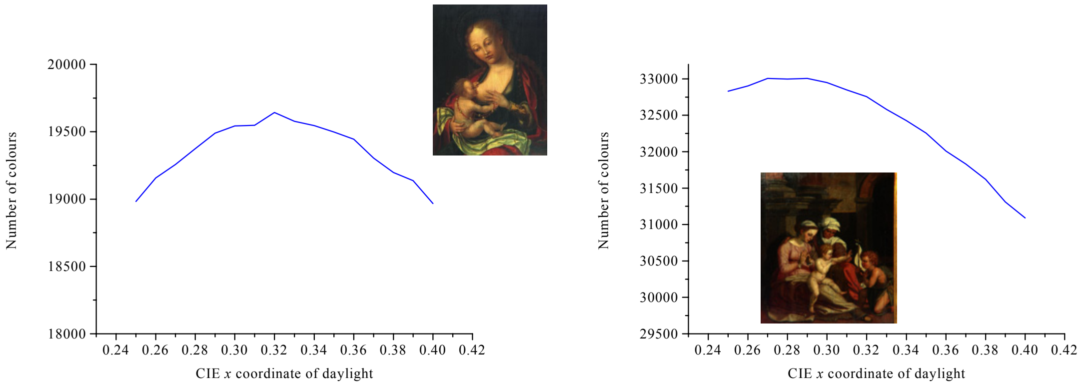

Figure 3: The number of colours discernible obtained as a function of the CIE *x* coordinate of daylight for two of the five paintings studied.

The maximum number of colours corresponded to an *x* value of about 0.28 for one of the paintings and about 0.32 for the other. Results for the other paintings were between the two examples shown. The ideal correlated colour temperature is therefore in the range 10,000-6,000 K, very different from tungsten halogen lamps or even from SoLux lamps, which can be at most 4700 K.

4. CONCLUSIONS

Using daylight illuminants the maximum number of colours for the five oil paintings studied was obtained with an illuminant with CIE 1931 *x* value in the range 0.28-0.32, that is, a correlated colour temperature in the range 10,000-6,000 K. The ideal illuminant has therefore a correlated colour temperature higher than that of tungsten halogen lamps or even SoLux lamps, which can have at most a correlated colour temperature of 4,700 K. Ideal illumination, in the sense of maximum chromatic diversity, for this type of art paintings seems to be best when using light sources of much higher temperature than normally used in museums.

References

1. G. Thomson, "The Museum Environment," 2nd ed. Oxford: Butterworth-Heinemann Ltd (1994).
2. F. Imai, "Simulation of spectra estimation of an oil-paint target under different illuminants," Technical Report, Rochester Institute of Technology (2002).
3. S.M.C. Nascimento, F.P. Ferreira, & D. H. Foster, "Statistics of spatial cone-excitation ratios in natural scenes," Journal of the Optical Society of America A, 19, 1484-1490 (2002).
4. G. Wyszecki and W. S. Stiles, "Color Science: Concepts and Methods, Quantitative Data and Formulae," John Wiley & Sons, New York (1982).
5. M.R. Pointer and G.G. Attridge, "The number of discernible colours," Color Research and Application, 23 (1), 52-54 (1998).
6. J.M.M. Linhares, S.M.C. Nascimento, D.H. Foster and K. Amano, "Chromatic diversity of natural scenes," Perception 33, p65 (2004).

7. J.M.M. Linhares, S.M.C. Nascimento, D.H. Foster and K. Amano, "Effect of coloured sunglasses on the colours of natural scenes," Ophthalmic Research 36, S1 p59 (2004).