

Studying art paintings through a multispectral imaging system composed of light-emitting diodes covering the spectral range from 370 to 1600 nm

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Abstract

In this work we present the use of a multispectral imaging system covering a wide spectral range for the study of the wall paintings attributed to the painter Ferrer Bassa decorating Saint Michael's cell at the Royal Monastery of Pedralbes (Barcelona), which are an exceptional masterpiece of the Catalan Gothic painting scene. The system used in this study was based in two monochrome digital cameras: firstly a CCD camera with spectral response from 350 to 950nm and spatial resolution of 1392×1040 pixels; and secondly an InGaAs camera with spectral sensitivity over the wavelengths comprised between 900 and 1650nm and spatial resolution of 320×256 pixels. A multiplexed light source composed of 23 light-emitting diodes (LED) with different peak wavelengths and spectral bandwidths was developed to uniformly and diffusely illuminate the analyzed scene. The capturing and illumination systems as well as the processing of the information were computationally controlled using specific implemented routines. From the 23 different images of the scene sequentially acquired by means of the multispectral imaging system, the spectral information over the mentioned range as well as the colorimetric values were extracted pixel by pixel. Calculations of spectral information were achieved by using two different mathematical algorithms: a direct interpolation from the digital responses of the imaging sensors, and through a process of preliminary training of the system and spectral estimation by means of the pseudo-inverse method. In the case of the interpolation results, accuracy was sacrificed for sake of simplicity due to the fact that no training process was required. On the other hand, several color patches containing the basic pigments originally employed in the wall paintings were produced to be used as a preliminary training basis of the system. They were deposited on a lime and plaster substrate, emulating the fresco technique used by the author. These patches included pigments such as indigo, venetian red, ivory black, red ochre, white lead, burnt brown among others. All them were characterized by means of a conventional spectroradiometer as well as using the multispectral imaging system, with the final goal to obtain the proper transform from digital levels to colorimetric and spectral information for the posteriorly running measurements at the Royal Monastery of Pedralbes. Results of simulations and real measurements are presented providing access to spectral and color information of the paintings pixel by pixel. The accuracy of the system in spectral and colorimetric terms is also discussed. The results of this study as well as the methodology proposed can be a powerful tool for art conservators and restorers, since a lot of information related to the original colors and pigments is provided. Moreover, complementary information such as author's underlying drawings are also provided from the multispectral infrared images, which otherwise would remain hidden.