Characterization of heritage objects with NIR hyperspectral imaging

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Numerous analytical methods might be implemented to study art objects’ authenticity, composition and conservation state. However, most of these are time consuming, expensive or destructive. The implementation of alternative techniques having high reliability and non-destructive character is, therefore, within great interest for restorers and researchers. This work demonstrates the implementation of hyperspectral imaging (HI) for cultural heritage object evaluation. Five hyperspectral cameras produced by SPECIM (Oulu, Finland) that operate in different spectral ranges were used for scanning a beehive panel painting that was obtained from the collection of the Slovene Ethnographic Museum. All cameras were operating in push broom mode, allowing line by line spectral measurement. White (spectralon) and black (detector noise) reference backgrounds were measured before each scanning of the panel. Halogen lamps were used as a light source for VNIR, NIR and SWIR cameras, while heat radiation was used as a source for the MWIR and LWIR systems. Evince software by Prediktera (Umea, Sweden) was used for analysing and exploring the hyperspectral images. Standard normal variate (SNV) and mean centring were applied as pre-processing prior to PCA modelling.

Precise and fast methods, such as HI, provide information related not only to certain pigments and binders used but also allow for their mapping on the entire object. The obtained score plots, in the form of spatially resolved pixels, also contain information regarding similarity, groupings and trend patterns that characterize the object. Analysis of loadings allows identification of spectra where specific wavelengths regions contributed to high variance in certain PCA models. In our study, HI scanning was also compared with other spectroscopic methods, such as Raman and FT-IR spectroscopy, which are commonly used for the identification of pigments and binders of the investigated objects (Retko et al. 2019). Therefore, the merging of HI with other reference methods results in the generation of a rich database that allows for a precise identification of original artist materials as well as various additives that were possibly applied later (e.g., during conservation campaigns).

**Keywords:** hyperspectral imaging, cultural heritage, painted beehive panels

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