



Feature Extraction from Paint Layer EDXRF Spectra Using Pattern Recognition Techniques

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Abstract

Attribution is common practice in the cultural heritage examinations, whether it is a provenance study of the ceramic findings or attribution to the particular author/forgery identification. Most of such processes are based on well established procedures supported by pattern recognition techniques.

This research was performed to explore the possibilities of EDXRF analysis in the process of attribution of an art objects made by unknown authors compared to the known provenance groups. PCA analysis has been used to explore informativeness of EDXRF spectra of the paint layers in the process of attribution, and to extract the carrier of the most important information for that purpose.

The result shows that PCA can be used as efficient tool to extract the informative features. The process of attribution by PCA analysis was successfully performed on 18th century icons from the Krušedol Monastery.

Introduction

The Krušedol Monastery, founded in 1509, and represents a monument of exceptional significance for Serbian heritage, due to its historical importance and artistic value. The iconostasis of the monastery church comprises icons from different historical periods – from the 16th to the 19th century. These icons have been painted by various masters: Walachian icon painters, South Balkan masters, Ukrainian Baroque painters as well as Serbian icon painters. Measured spectra of four 18th century icons: *Mother of God with the Christ*, *St John the Baptist*, *Annunciation with the Serbian saints* (throne-tier icons) and *St. Prophet Solomon* (small icon from the north royal door) were analysed by pattern recognition techniques. The throne-tier icons are attributed to the Master Jov Vasilijevic and there is good assumption that they were painted in the same period, presumably in 1745. Together with the statistically important number of measuring points this can be treated as representative dataset. The latter icon is also attributed to the middle of the 18th century, but to the unknown Jov Vasilijevic follower and consequently has been chosen as representative control dataset [1].

Different pattern recognition techniques are proven to be efficient as tool for generating conclusions based on the analytical results that are archaeologically/artistically meaningful [2]. Among them, PCA is of special efficiency in the processes of attribution. The possibilities of using PCA to extract the features carrying information that allows attribution (similarities and differences) were examined.

Materials & Methods

The analysis of the complex structure of icons (painting on a wooden panel) was done using pEDXRF spectrometry technique, establishing elemental composition of the selected spots.

Portable in-house developed EDXRF spectrometer was used for the non-invasive and non-destructive analysis of the selected icons. The spectrometer consists of an Oxford X-ray tube, compact X-ray spectrometer (X123, Amptek Inc.) with Si-PIN detector mounted on the motorized platform which enables movement along all three directions. Proper positioning of the excitation beam on the analyzed surface is enabled by using two laser pointers for alignment. Measurement setup was same for all spectra acquired. Only qualitative analysis was performed. Analyzed points were

selected to represent areas of different colours present on the surface layer of the icons. Total of 72 EDXRF spectra were used for further analysis by PCA. The range between 150th and 1600th channel (total of 1451 data) was used as features of each spectrum, forming 72x1451 dimensional dataset [3].

The data were not additionally pre-treated prior PCA analysis, but raw spectra were processed through the procedure for processing huge amount of spectra which has been developed under the project [4].

Results

The PCA was used to analyse the whole 72x1451 dataset. It was shown (Fig 1a) that all spots analysed on the icon attributed to the Jov Vasiljevic studio are clearly distinguished from those attributed to Jov Vasiljevic himself. Following the trend noticed in the Fig 1a and Fig 1b, the input dataset was restricted to the spectral data of particular colour. The results of the PCA analysis of such datasets has been shown in Fig 1c and Fig 1d, and were compared to those previously obtained in the process of pigments identification (by EDXRF spectrometry and UV and IC imaging techniques) [1]. The identification has been confirmed.

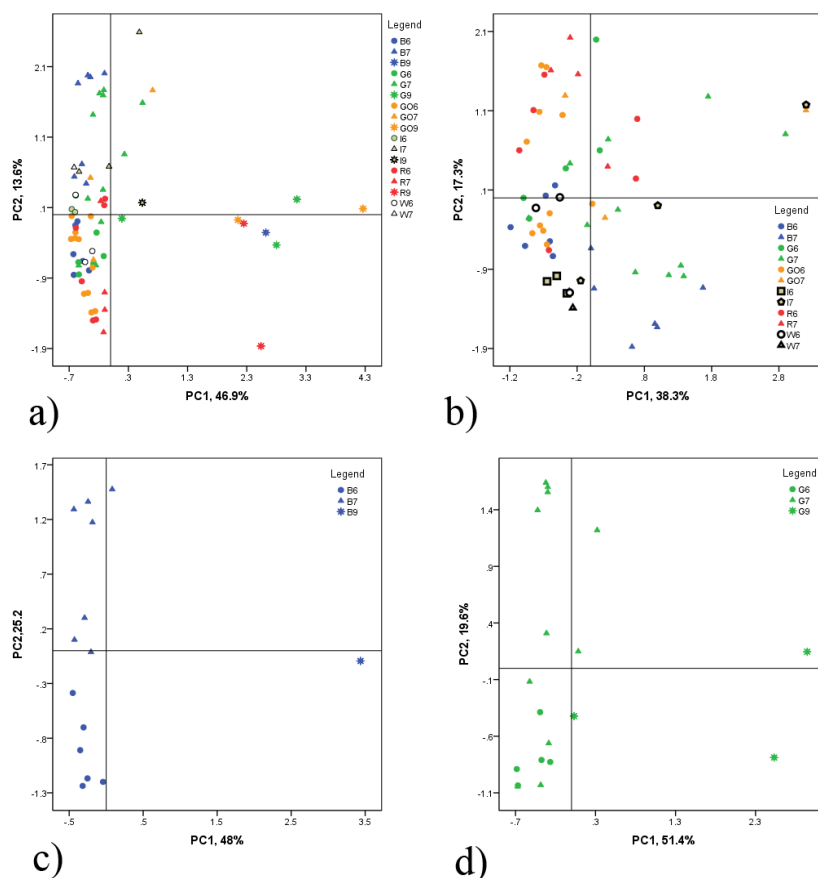


Fig. 1; Results of the attribution based on PCA analysis of the EDXRF spectra dataset. The measured points in blue, green, red, white, flash tones and gold areas of the paint layer were labelled as B, G, R, W, I and GO, respectively. Associated number denotes corresponding icon

Conclusions

The proposed procedure of using raw EDXRF spectra data in the PCA analysis allows feature extraction that carry important information. The characteristic pigment mixtures can be distinguished and used in the process of attribution of an art work of unknown master by comparison to the similar data of well known authors.

References

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