VIS-NIR REFLECTANCE SPECTRA CLASSIFIER FOR PIGMENTS IN THE MOBARTECH PROJECT

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The present work presents the preliminary outcome of one of the tasks inside the MOBARTECH project; in detail, the creation of the prototype for a compact FORS spectrophotometer capable of automatically identifying pigments and dyes.
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1. Introduction

The MOBARTECH project, funded by Regione Lombardia, is meant to develop "a technological, interactive and participatory mobile platform for the study, conservation and valorisation of historical and artistic heritage" that integrates cultural, social and creative skills; the affected fields include information technology, diagnostics, conservation and restoration of cultural heritage, intelligent logistics systems, public interaction and infotainment technologies. Among the goals of the project, there is also the development of a smart spectrophotometer able to automatically classify pigments on the bases of acquired Vis-NIR reflectance spectra.

2. Why an automated classifier?

The acquisition of reflectance spectra for the identification of pigments in artworks is a common procedure in conservation studies. The main advantages rely on its ease of use, cost-effectiveness, portability, non-invasiveness and amount of information acquired. Nevertheless, the identification of the pigment is currently mainly subjective and require the work of a trained expert. The automation of this process is thus of great interest for both unskilled operators (e.g. art historians) and educational purposes.

3. Towards the automated prototype

Several steps must be taken in order to reach the goal: from deciding how to assemble the instrument, to the acquisition of a large and reliable database. The spectra to be classified, in fact, have to be compared with reference spectra; several methods and algorithms for classification are currently under testing in the MOBARTECH project environment. In the last years, several research works have been conducted on this specific thread, mainly applied to hyperspectral imaging. For all these algorithms, a pre-processing is necessary. In the present work, we compare several pre-processing methods and extraction features, which are strictly related to the way the database is built. Up to now, the tested methods for spectral matching and classification tasks are focused on supervised and unsupervised learning algorithms [1] and spectral distance metrics [2,3].

3. How to automatically classify spectra?

In the beginning of the present research, the importance of a correct and reasoned compilation of the reference reflectance spectra database for the automatic recognition has become obvious. We first performed tests on a set of widely used pigments - azurite, malachite, cadmium red, yellow and red ochre - showing common features (single or multiple bands and s-shape), to verify whether the identification improves following automatic pre-processing. Then we tested the same procedure on mixtures, layered pigments, and different substrates/binders.
Various methods of data acquisition, pre-processing and feature selection (feature extraction, feature construction and feature enhancement) solutions have been compared for the development of a machine learning approach and for the definition of new strategies for the automatic classification of pigments reflectance spectra. Summing up, giving a number of training examples associated with desired outcome (labels), the process consists in finding the relationship between the data and labels, using solely the training examples. The goal is to predict the outcome for new test samples. To perform this task, is necessary to build a model or predictor which is typically a function with adjustable parameters. Before further elaborations, it is also necessary to refine data to be able to extract actually significant components from spectra intrinsically subject to noise. We tested the most common smoothing algorithm and considered the possibility to work on spectra derivatives. Indeed, the numerical differentiation of experimental signal is often used to ease the detection and location of components of spectra. Differentiation degrades the signal to noise ratio and thus some form of smoothing is required in conjunction to differentiation.

References

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