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Combining Experimental and Statistical Tools for an All-round Approach to Cultural Heritage

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X-rays, thanks to the elemental selectivity coupled with the non-destructiveness, are well known for the investigation of structural and chemical properties of historical artefacts. Synchrotron radiation sources provide high-intensity X-ray beams, with the additional benefit of energy tunability, which is crucial to fully exploit the elemental sensitivity of X-rays. This talk presents several methodological case studies on samples relevant for cultural heritage. In these studies, X-rays techniques such as X-Ray Fluorescence (XRF) and X-ray Absorption Near Edge Spectroscopy (XANES) were employed not only for a chemical analysis of the artefacts but also to assess the nature of the surface contaminants.
XRF data is commonly used to evaluate the surface distribution of the elements and/or to provide quantitative analysis of the chemical content of a given specimen. Lately, a preliminary data treatment using a t-SNE algorithm has been proposed to compare the pixels in each XRF map on the basis of their spectral similarities. Upon this comparison, the pixels being the most representative of the clean specimen can be discriminated from the ones being most affected by the contamination of successive deposits due to the burial periods. This preliminary selection, operated before the quantitative analysis, ensures the minimisation of the contaminants contribution, and the identification of different phases, enhancing the accuracy of the results.
Quantitative analyses carried out after this preliminary treatment can highlight small fluctuations in the samples composition and assess the presence of trace elements. Such details can be used as proxies to grasp further information of historical relevance (e.g. fineness of coins as a function of the time of coinage, for devaluation dynamics; different composition of inks to assess the artistic knowledge in ancient times).
The areas corresponding to the pixels discarded for the quantification of the clean specimen composition, can be used to investigate the nature of the debris accumulated on the surface of the samples. In artefacts found underground, soil is likely to accumulate in the hollow areas. As the relative abundance of Fe oxides in soil depends on environmental conditions, the fraction of Fe oxides can then be used as an indicator for the provenance of the accumulated soil. From XANES spectra collected in the hollow regions, oxides can be easily identified and quantified, yielding information on the fate of the artefacts over the centuries.

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