The Importance of Accurate Image Stitching and Registration between Optical and X-ray Images in Macro-XRF Analyses

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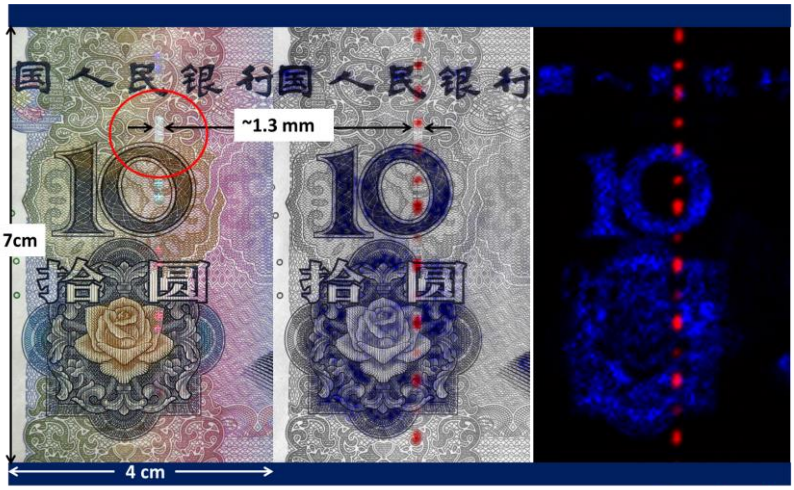
Macro-XRF analysis, also called X-ray Spectrum Imaging, is described using a commercial portable XRF instrument, capable of mapping a 10X10 cm^2 area. The instrument, called ELIO, is manufactured by XGLab, Milan Italy. ELIO provides non-contact XRF analysis and features a 1 mm spot size with laser-assisted positioning and an internal microscope video camera (10X magnification), all housed within a small, lightweight analysis head. The analysis head is mounted onto the mapping stage, which in turn is mounted onto a light weight tripod, enabling macro XRF imaging with 1 mm spatial resolution to be performed on the object, in situ [1]. The axis of the camera is close to that of the X-ray beam, always insuring good registration between the optical and X-ray images.

When working with a suitably small X-ray spot size, an accurate stitched optical image and a calibration procedure to register the optical image with the X-ray maps are fundamental requirements for accurate interpretation of elemental distributions in and around fine visual features of analyzed objects. A high resolution and essentially seamless montage is created from individual pixel images; a calibration sample and procedure allow the determination of the coordinates of the X-ray spot in the internal camera's field of view. Under ideal conditions, the result is a stitched optical image of the entire mapped area which is in registration with the associated elemental maps to within 500 microns for an X-ray spot size of 1 mm. A fine calibration procedure to bring local areas into near-perfect registration, using a ceramic PCB with a sharply defined 500 micron feature, is also described. The software is added to PyMca v.5.03 [2].

Applying these procedures to a currency paper with elaborate visual features produces the results shown in the adjacent figure. Note the unequivocal positioning of the Fe rich areas (red dots) in line with the 1.3 mm wide rectangular features highlighted by the arrows. The 4x7 cm^2 map took ~ 4.5 hours. (Rh tube; 40kV/75μA; ½ mm step size; 1 second collection time per point).



[1] L. S. Mosca, T. Frizzi, M. Pontone, R. Alberti, L. Bombelli, V. Capogrosso, A. Nevin, G. Valentini, D. Comelli: "Identification of Pigments in different layers of illuminated manuscripts by X-ray fluorescence mapping and Raman Spectroscopy", Microchemical Journal, Volume 124, January 2016, Pages 775-784, ISSN 0026-265X, https://doi.org/10.1016/j.microc.2015.10.038.

[2] V.A. Solé, E. Papillon, M. Cotte, Ph. Walter, J. Susini, A multiplatform code for the analysis of energy-dispersive X-ray fluorescence spectra, Spectrochim. Acta Part B 62 (2007) 63-68.