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Improvements in automated Photometric Stereo 3D SEM

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In a previous paper [1] an Automatic Alignment Procedure for a 4-Source Photometric Stereo (PS) technique has been proposed to reconstruct the third dimension in the Scanning Electron Microscope (SEM). This method, as opposed to the well known stereoscopy, returns true numerical 3-D models instead of some depth illusion from ordinary pictures. In brief the PS-based 3D recovery method consists of the acquisition of 4 Back- Scattered (BS) images, taken from the same viewpoint but under different lighting directions, from which the gradient of the surface and its "intrinsic brilliance" are first separately extracted using gray PS [2], and then the depth map is recovered by integration of the gradient vector field using the conjugate gradient method [3]. In standard equipped SEM it is necessary to rotate the specimen under the fixed detector and to sequentially acquire four images of the same specimen area upon imposing three 90° rotation steps on the specimen, and then rotating back the images. To align the images, the availability of isotropic shaded image is essential, so a twin set of images is acquired: one for alignment purposes and the other for 3D reconstruction. In this paper we use results of [1] to improve the performances of the automatic procedure so far limited to the acquisition and alignment of the image.

The next natural step is to develop a completely automated tool that enables a standard instrument and an unskilful SEM user to access the 3D domain. The missing piece of the jigsaw is to automate the initial set up of the two detectors: 1) off-axis (BS) electron detector and 2) the available one that can produce isotropic shading, which may either be the Specimen Current detector or the complete circular axial BS detector. In Fig 1a and 1b the two types of images used for the 3D evaluation and the alignment procedure have been respectively shown: the first one shows the reflectance image, whereas the second one has accentuated brightness and contrast and is useful to alignment process.

To preserve the depth information for 3D reconstruction, the off-axis BSE detector image needs to not have any level saturation but it must cover the highest histogram values range, so brightness and contrast must be properly set. The modern digital SEM have an oscilloscope (sometimes called videoscope) to visualize the signal excursion in the frame: it's straightforward that, in order to have a perfect image, the signal must be included between the minimum (black) and the maximum (white) without saturation.

On the contrary, the isotropic shadow image should has contrast variations in order to have well defined image patterns for the automated alignment procedure. Some examples are illustrated in Fig. 1 where the 3D reconstruction of a detail of a 1euro coin and of a microfossil have been shown.

The automatic brightness and contrast set up of the two detectors leaves to the SEM operator the only duty of choosing the interested area and of setting focus and magnification, daily routine operations for any microscope user.

References:

[1] Pintus R.et all.in press on IEEE Transactions on Instrumentation and Measurement

[2] Barsky et all, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 25, NO. 10 October 2003, pp. 1239-1252
[3] Press W.H. et all "Numerical Recipes 3rd edition: The Art of Scientific Computing", 2007, Cambridge University Press

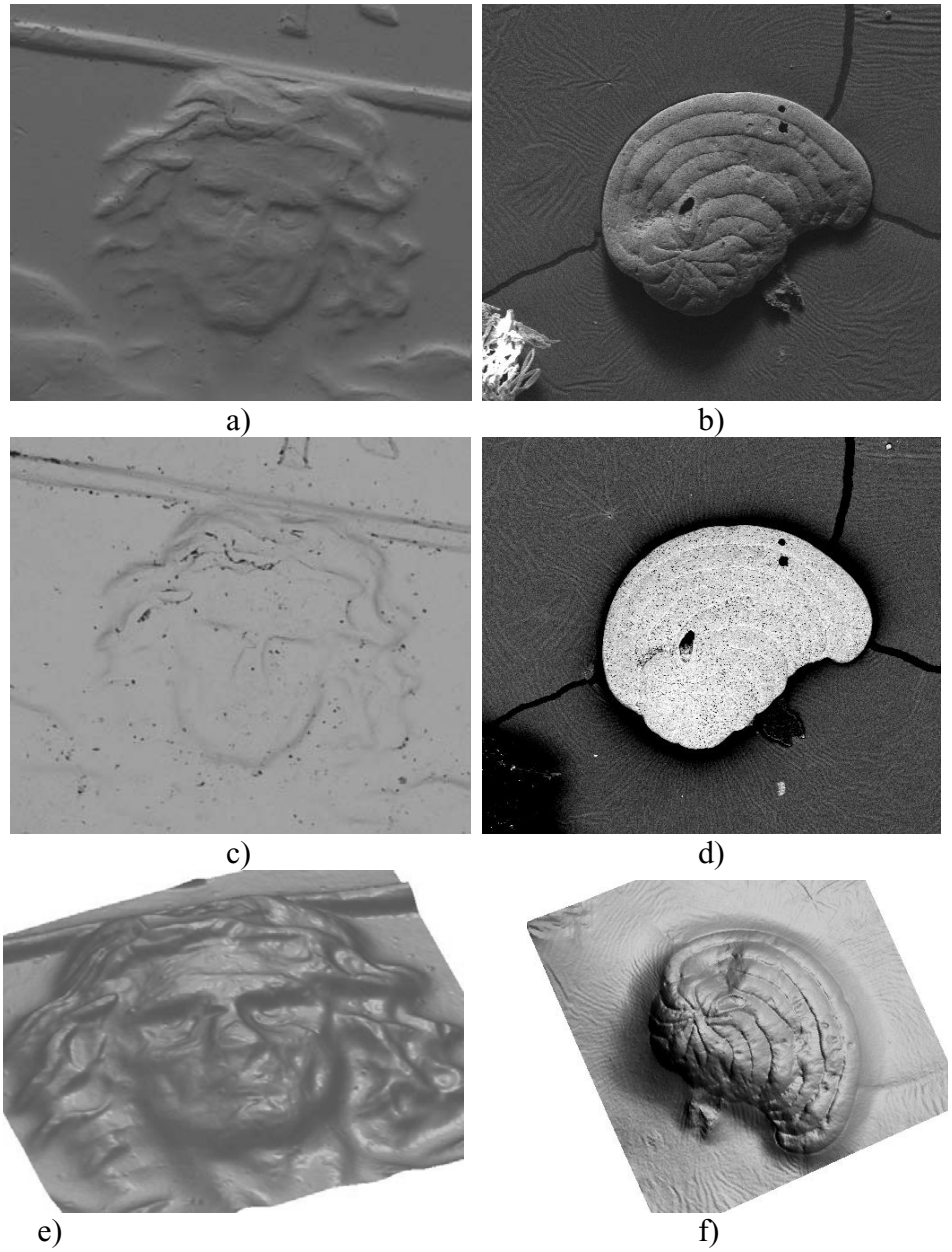

Fig.1 – Images used for the 3D reconstruction: detail of a coin and a microfossil. a) and b) are the reflectance images; c) and d) are the isotropic-shaded images used in the alignment process; e) and f) are the 3D maps.