MorphCol supplement #15 - Evaluation of AVM version 1.1

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Introduction

The PC-based LabView program AVM (Automatische Vermessung von Mikrofossilien, see Dietiker, 2009) was created for batch processing grey-level images, that were generated with AMOR. AVM reads one or several grey-level images with a microfossil and produces outline data at different formats and other geometric measurements. The following outline formats are generated with AVM: TRACED files (all outline points extracted from the image as cartesian coordinates, in micrometers), POL files (all outline points in polar coordinates, rays in micrometers, angles in radians), INT files (interpolated cartesian outlines from the traced files), and NORD and NORM outlines (normalized interpolated cartesian outlines, NORD for averaged normalization, NORM for maximum value normalization, no dimensions).

The present report compares these AVM generated output files with the results when the previous Macintosh-based programs described in MorphCol (Knappertsbusch, 2004) are applied to the same input image.

Test experiments

The grey-level image 18280AxxxbK0101.tif (640x480 pixels, 8 bit), which was generated with AMOR 3.5, was used for the test (Figure 1). The image was directly fed into AVM version 1.1 and TRACED-, POL-, INT-, NORD-, and NORM-files were generated. The grey-level threshold for this image was 93.

A List_of_files_corr was generated, also the result file DATA.txt and the image processing log file bv.log.

The same outlines (TRACED-, POL-, INT-, NORD-, and NORM-files) were generated from this image using the old Macintosh-based programs described in MorphCol, i.e. MagCorr1.out to correct for the magnification from AMOR, Trace_AMOR1_batch.out to extract outline coordinates using mag-corrected values, Sprep53.out to generate INT and POL files, and NORM51.out to generate NORM files on the interpolated data. Prior to outline extraction on theMacintosh-based programs the input image was processed to a black- and white image using the automation macro in Nih-Image, then saved as a raw file with Adobe-Photoshop.

Note, that AVM 1.1 returns all image coordinates for the POL data, while in Sprep53.out POL files are generated on interpolated outlines.
Also note, that the usage of NORM and NORD in AVM is reverse to the usage of NORM and NORD in the Norm51.out program (In AVM NORM files are normalized so that the maximum value becomes 1 or -1; in AVM NORD files are normalized, so that the mean radius becomes 1. In Norm51.out this file usage is exactly reversed).

After processing the outline coordinates are plotted and compared to each other.

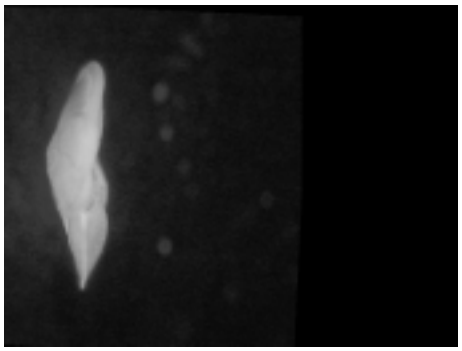

Figure 1: Input image (File 18280AxxxbK0101.tif, 640x480 pixels) for the test series herein. This image was generated with AMOR 3.5.

Results

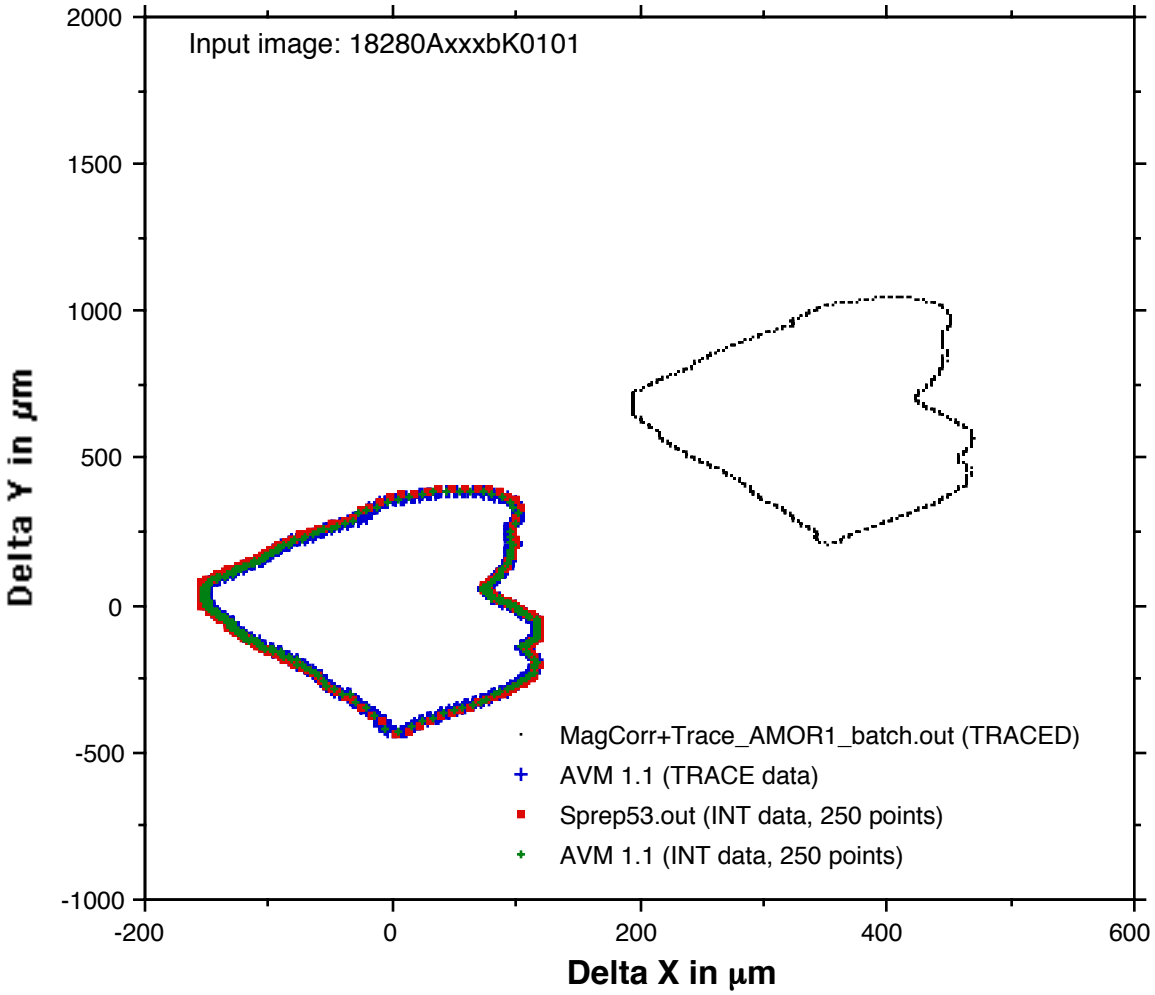

Figure 2. Comparison of AVM outlines (blue showing the traced data, green showing the INT data) versus MagCorr1.out and Trace_AMOR1_batch.out programs (Traced, black) and

Sprep53.out program (INT, red) on Macintosh. Outline coordinates show good overlap between both systems. The black outline generated with Trace_AMOR1_batch.out is off-side because coordinates are not centroid-transformed to the origin of the coordinate system.

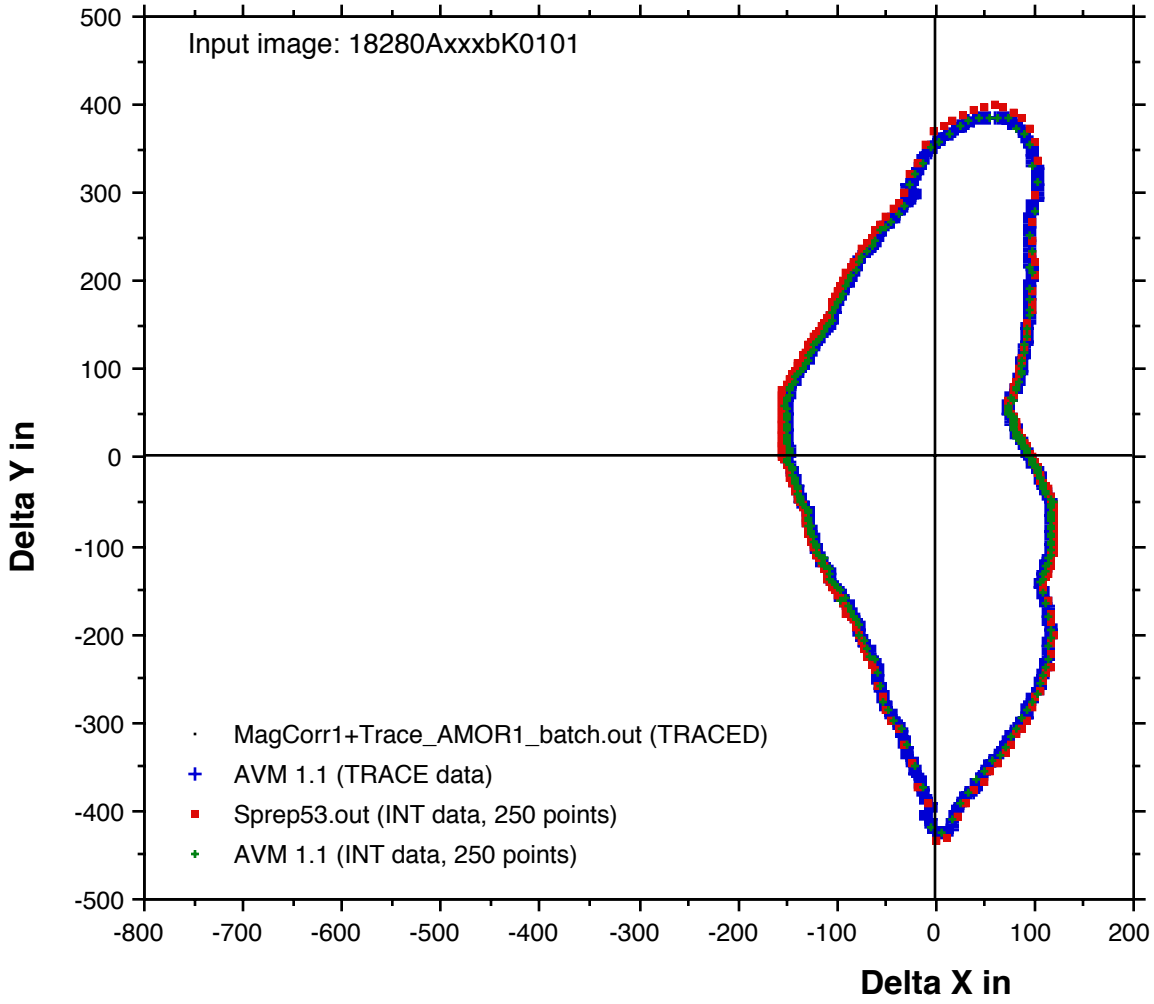

Figure 3. Same outlines as shown in Figure 2 (without black outline), but properly scaled.

Figures 2 and 3 illustrate the plotted cartesian outline coordinates from the same image using AVM and Mac-based image-processing. The sense of the cartesian outline coordinates in the two methods is the same and correct (in version 1.0 of AVM the extracted outlines were rotated by 180° with respect to the input image). It appears (from Figure 3) that the Macintosh-program derived outline is slightly larger (red points) than the AVM-derived outline (blue and green). The excess size is mostly in the keel region. Also the comparison of the area shows, that with the programs on the Macintosh the area is slightly larger than with AVM 1.1 (difference of 0.0056 mm2, which is 3.9% of the larger of the two areas). I think that the reason for these differences is in the thresholding of the image, which is not the same in the Macintosh way than in AVM 1.1. During the Macintosh method the automation macro is applied for the segmentation of the image. In AVM image segmentation is different. Experimentation has shown, that AMOR derived images are often a bit unsharp and have low contrast. Improvement signal to noise ratio and contrast

enhancement of AMOR images can eventually lead to a better image segmentation during LUT filtering in Mac-based programs and/or during thresholding in AVM 1.1.

Method	Image	Width, μm	Height, μm	Area, μm2
AVM 1.1	0101	291.3	812.3	0.1376
Sprep53.out	0101	276.6	836.8	0.1432

Table 1: Comparison of results between Macintosh-based programs and AVM 1.1 on the PC.

Fourier spectra:

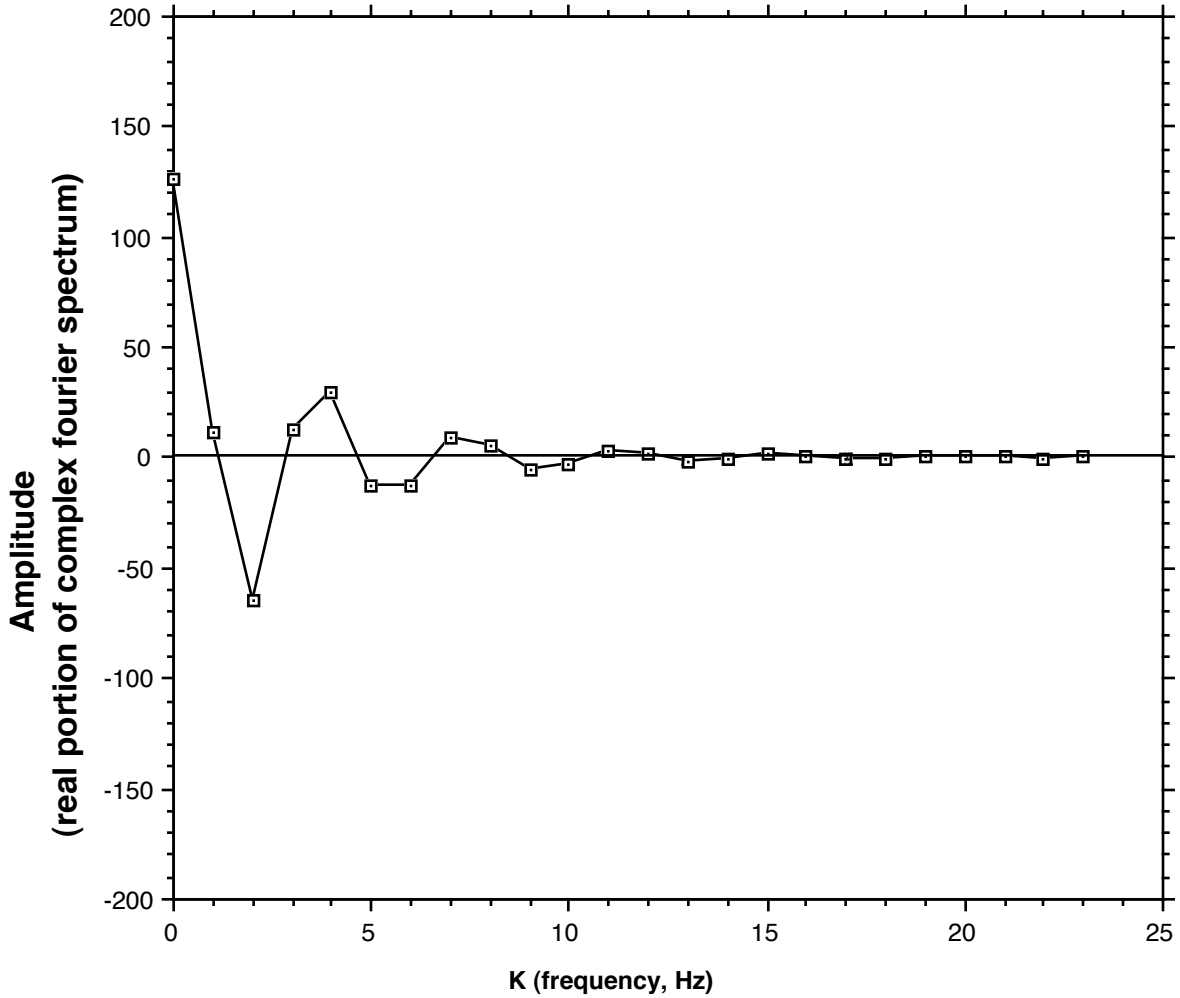

Figure 4. Fourier spectrum for outline from specimen 18280AxxxbK0101 obtained from AVM 1.1.

In AVM the fourier spectrum of the image is derived by FFT from the binary image (.bmp file, see Figure 4), which is a different approach than applied in the Macintosh-based programs, where the outline vectors are expanded by a fourier series. For determination of elliptic fourier components with AVM the outlines must also be explicitely expanded too, and not determined with LabView FFT filters.

Known difficulties of AVM 1.1

- The determination of Phi1 and Phi2 is not ideal, because control-points, that are used to trigonometrically calculate angles may sit at the beginning of a horozontal or vertical segment, which returns false control-points.

- The usage of the fractal dimension is not useful because outlines are not fractal (the highest number of points in the outline is governed by the camera resolution or the resolution of the image).

- Output of harmonic coefficients: With 250 outline points the number of harmonic functions should be 125 (Nyquist frequency). This has not been considered in AVM 1.1.

Conclusions

The main difficulty of using AVM 1.1 in combination with the previous Macintosh-based outline processing programs is the grey-level threshold. The results are acceptable within an error of about 4%, but the quality can be increased. One way is the improvement of the signal-to-noise ratio and a gretaer contrast enhancement of images generated with AMOR 3.5. Signal-to-noise improvement could be done in AMOR by averaging life image frames (for example averaging 16 frames) and by application of a median filter. Contrast enhancement can be done by the sequence of 3x(smooth,sharpen) and multiplication of the image by 1.25 (as was earlier done in Nih-Image during manual imaging). Eventually, signal-to-noise improvement can also be done by altering the settings of the Sony camera, that is used with AMOR.

Suggestions for further improvements

- Implementation of a vi generating the Zahn & Roskies function for eigenshape analysis.
- Implementation of a vi for polar and elliptical fourier analysis (true expansion of outline coordinates to series, not fourier transformation of binary image with outline !).
- Improvement of signal/noise ratio and contrast enhancement in AMOR images (eventually modify the settings of the Sony DXP camera of AMOR).

References

Dietiker, S. (2009). Automatisierte Vermessung von Mikrofossilien. Bachelor Thesis. Institut für Automation, Fachhochschule Nordwestschweiz, 55 p. Chair: Prof. Dr. Jean Eisenecker.

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