COMPUTER BASED METHODS FOR ACCURATE BACKGROUND REMOVAL IN SPM METROLOGY APPLICATIONS.

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Scanning probe microscopy (SPM) images contain contrast information derived from the superposition of a true surface on a curved and tilted background. This background component comprises of the additional trajectory of the SPM scanner due to the sample tilt and the scan range. Polynomial approximation routines employing either least squares or interpolation and extrapolation methods are considered appropriate for the estimation and removal of this background. Many approximation methods require the sampling of a fixed set of data points that may include surface "peaks" and "troughs" resulting in an erroneous estimation of the scanner induced background. This error introduces an artificial "hollow" around topographic "peaks" limiting the ability of the SPM to consistently provide true information over larger scan ranges. Some algorithms address this problem by offering the user the option of removing specified portions of the image from the background data set. Such an approach can introduce other artifacts and can involve excessive user interaction.

In a previous paper we have shown that selecting points from each image linescan that best approximate the background and interpolating a polynomial through these background points provides a high quality fit to the scanner background [1]. A simple background selection procedure based on the selection of the minimum values within different regions of the line profile is the quickest way to obtain the data points that best represent the scanner curvature. This method of background selection is subject to error from negative going outliers that may be present in the data set and a more rigid background selection criterion using a median value provides a solution to this problem. Modifications to the basic interpolation algorithms for an improved quality of fit will be discussed. Least squares polynomial fitting will always provide the most accurate determination of the scanner background provided that the polynomial is estimated using only background data points. Figure 1 compares the quality of our estimation method with that of a commercial algorithm.

We will discuss appropriate methods for background selection that will provide the best possible fit for surfaces comprising of specifically bound particles, the bias in the background estimate only being limited in theory by the roughness of the substrate. In addition we will show how predictor corrector methods can be employed as a true on-line method of background extraction. These methods provide the fastest possible means of removing the scanner background and may have applications in high speed AFM, but due to the indeterminate nature of the occurrence of binding events, there is no way of guaranteeing the sampling of background data points only. The use of forgetting factors allow the effects of foreground events to be minimised.

In this paper we report on the development of these background estimation methods for the automatic removal of scanner background that can allow the unambiguous measurement of 3 nm sized particles on a surface of 1 nm roughness. We further discuss the merits of each method with respect to their application for the measurement of ferritin/anti-ferritin binding events occurring on activated biological surfaces.

References

[1] L.McDonnell, J.O'Mahony and G.Roe, Physikalische-Technische Bundensanstalt, Braunschweig, **vol.F-44**, (2002), pp.22-28.

Figures

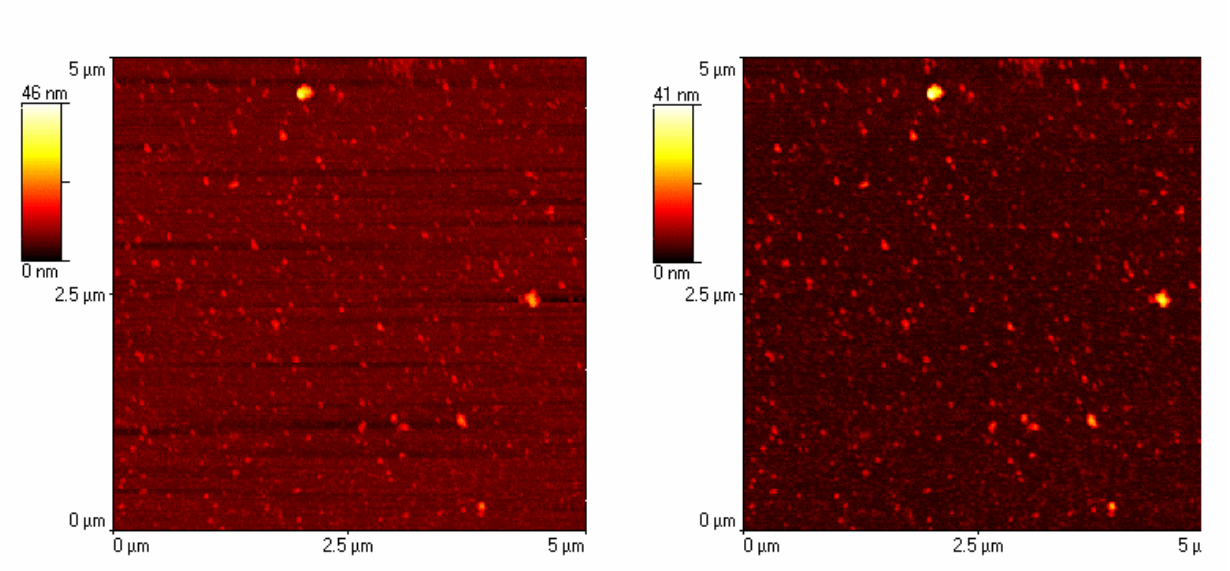

Figure 1. Comparison of the quality of fit provided by the Least Squares Algorithm with background selection (RHS) and the quality of fit provided by a commercial leveling algorithm (LHS).