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Original Citation

Zeng, Wenhan, Jiang, Xiang, Lou, Shan, Abdul-Rahman, Hussein S. and Scott, Paul J. (2016) Complex Structured Surface Characterisation by using PDE based Adaptive Nonlinear Diffusion Filter. In: International Workshop on Mathematics and Statistics for Metrology, 7-9th November 2016, Berlin, Germany. (Unpublished)

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Complex Structured Surface Characterisation by using PDE based Adaptive Nonlinear Diffusion Filter

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Manufactured parts with *complex structured* surfaces have been widely used in automobile, bio-engineering, medical and consumer electronics etc. Compared with traditional ‘stochastic surface’, the complex structured surfaces have two significant characteristics: one is that they have *complex base surface* (reference surface/mean surface) which has complex shape, the other is that they have *deterministic features* with high aspect ratio on the base surface. The scale of complex structured surfaces ranges from the macro scale down to the nano scale. Specific examples include Flexible/wearable electronics, MEMS/NEMS devices, micro moulding, micro fluidic systems, defined geometry abrasives, and bio integration coatings. The ability to adequately characterise these complex structured surface geometry features is crucial in the optimisation and control of such functional device/components. From the function point of view, the accuracy of the geometrical features (line width, step height etc.) of these complex structured are generally more important than the roughness. It is therefore the basic requirements of the filtration techniques are that they should not only filter out the reference surface/mean surface and reduce the measurement noise, but do so without blurring or changing the location of the features. However, traditional single filtration techniques are lack of the ability to preserve the feature boundary with high accuracy. For example, when using the Gaussian filter for the MEMs surface, the boundary of the lines and steps are smoothed. As a consequence, it is very difficult to exactly evaluate the width of lines and heights of steps. In this paper, a Partial Differential Equation (PDE) based adaptive nonlinear diffusion filter combined with the robust filtration to process complex structured surface is proposed. In this method, robust filtration acting as pre-processing step to remove the complex reference surface and the diffusion filter is used to extract the structured features. The proposed diffusion filter is based on the PDE method and can be seen as a nonlinear heat equation, which describes the distribution of heat (or variation in temperature) in a given region over time. The diffusivity function based on the gradient of the surface can help to separate the internal region area of boundary area of the measured feature. In this way the diffusion process will take place mainly in the interior regions (line, step, etc.) of the surface, and it will not affect the region boundaries where the magnitude of gradient is large. The model proposed here has been coded with Matlab. Experimental work shows that the proposed filter can separate the geometrical feature (especially the line and step) from roughness and measurement noise and outliers with ideal edge preserving property.