Towards a general framework for measurement uncertainty estimation with *any* complex surface topography

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Abstract

It is commonplace in many manufacturing industries to hear users expressing concern about the comparability of optical instruments with contact methods of measuring surface topography, and these concerns are often borne out in formal comparisons. In many cases, the difference between the results from optical and contact instruments can be explained after critical assessment of the measurement conditions and sample geometries, but the damage has already been done: the take up of optical instruments in many industries has been slowed or, when they are employed, companies have to go through time-consuming gauge R&R processes to demonstrate the instrument can be used for a specific product. One of the primary reasons for the concerns with complex surfaces is the lack of a calibration framework for optical instruments, where calibration is the process of comparing a measurement result to a reference result in order to establish traceability. Whilst it is relatively simple to understand and model the physical interaction of a contact probe tip with a surface, it not so simple to model the equivalent optical interaction – it is a more complex physics problem. It is this complex physics problem that we are addressing to offer forward methods that allow measurement of any complex surface geometry with a high degree of confidence.

To partly address this issue in the surface texture measurement community, a framework is being developed that introduces a number of common or instrument-independent metrological characteristics (ISO 25178 part 600) – these can be determined with suitable artefacts and procedures, and the resulting characteristic values can then be propagated through a measurement model to give an estimate of measurement uncertainty. However, this framework can only be applied to surfaces with relatively simple geometries, where optical effects such as multiple scattering can be ignored. We will present research aimed at extending the framework to *any* surface geometry with *any* optical surface measuring instrument and allow direct comparison of the performances of different optical instruments. This will represent a major breakthrough both from academic and industrial impact points

of view. We will present early research to develop a suite of “virtual” optical instruments by systematically combining surface scattering models with three-dimensional optical imaging theory and surface reconstruction models. The virtual systems will be integrated into the physical instruments to predict optical responses to any surface geometry and evaluate the task-specific measurement uncertainty.

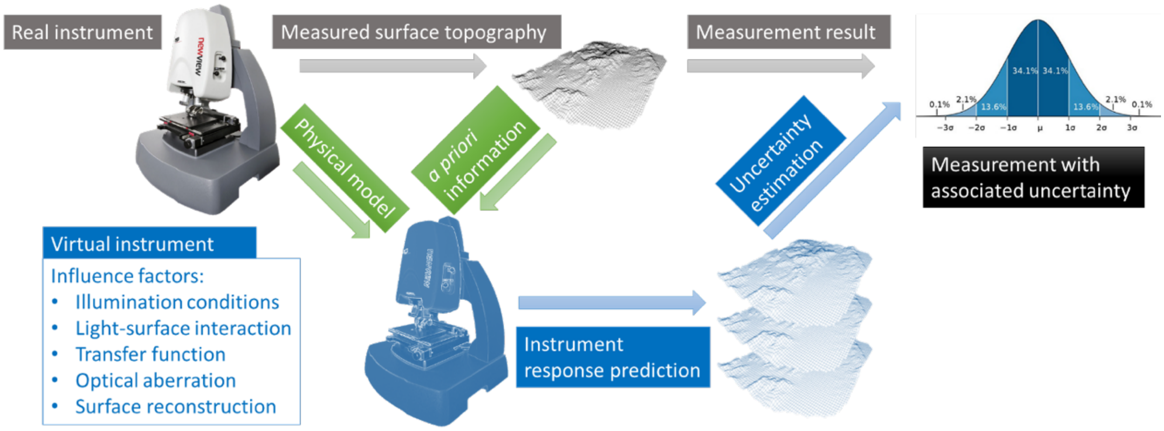

Figure 1: Illustration of the concept of virtual surface measurement