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# On the trustworthiness of simulation based uncertainty evaluations for industrial measurement instruments like CMMs

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In metrology, the science of measurement, as well in industrial applications in which measurement accuracy is of importance, it is required to evaluate the uncertainty of each measurement. For complex instruments like an industrial work horse as the coordinate measurement machine (CMM), evaluating the uncertainty can be a similarly complex task. To this purpose a simulation model, often called a virtual experiment, virtual instrument or digital metrological twin, is created, with the help of which a task specific measurement uncertainty can be determined [1]. The main metrological guidance documents that can be used in these circumstances are the Guide to the Evaluation of Uncertainty (GUM) [2] and its first supplement [3]. Various implementation can be thought of as being in line with the ideas of this document. In earlier papers some aspects related to sensitivity to input values [4] and GUM-conformity [5] were considered.

In this contribution we will analyse how different ways of performing the computer instrument lead to different values for the measurement uncertainty. This will be mainly done by means of an experimental numerical study involving a virtual CMM. In this simplified two-dimensional numerical model, the scale errors of the axes of the CMM as well as their deviation from orthogonality are modelled, together with fully random instrument noise. The object of interest is an imperfect circle of which the radius and non-circularity is to be determined.

By varying the input to the virtual experiment we will study the robustness of the outcome. The trustworthiness will be assessed in terms of frequentist long-run success rates of the calculated coverage intervals against the ground truth given by the virtual experiment. Although the GUM is not based on frequentist statistics, and long-run success rates are not mentioned as the way of validating an estimator with an uncertainty, we will argue that this is nevertheless a very useful way of validating uncertainty statements, as it is also not so clear how Bayesian statistical methods could be applied in a straightforward manner.

*References*

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## Type of presentation

Contributed Talk

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