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EUCoM: Evaluating the Uncertainty in Coordinate Metrology

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Key words: uncertainty evaluation, coordinate metrology

1 Introduction

Coordinate metrology is a fascinating discipline that bridges a very wide gap between sophisticated mathematics and practical application in industry, and particularly does the evaluation of the uncertainty. On one side, the evaluation is very complex and requires dedicated mathematical and software tools; on the other side, the impact is tremendous in industry, whether the evaluation is carried out properly, or it is not properly, or it is not at all, as unfortunately is often the case.

2 An industrial challenge

Coordinate metrology is widely used for inspection of parts. In most cases, measurements are taken for deciding upon conformance or nonconformance of parts to specifications (tolerances on drawings). This is the field of application of the JCGM 106 [6], which requires that the measurement uncertainty is known and accounted for in the decision. Due to the difficulties in the evaluation, very often this is overlooked, resulting in unreliable decisions. As the turnover of manufacturing is order of € 10^{10} in Europe alone, the impact of this poor routine is huge, ranging from economic loss to catastrophic failures (e.g. a faulty blade of an aircraft engine).

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3 A mathematical challenge

A major contribution is the CMM geometry error. Models are available [4,1] where the CMM three carriages are subject to 6 roto-translational degrees of freedom each. These 18 d.o.f.'s are functions of a coordinate, requiring 10 to 50 parameters each: several hundred parameters. These parameters are correlated and a full covariance matrix is required, amounting to order of 10^4 input uncertainties to assess.

The derivation of intermediate features does not enjoy a close form solution, and numerical iterations are the only option: the GUM [5] equation (1) is not available.

Features and operators are combined at will. The propagation of the uncertainty is reflected and uncertainty evaluations can only be *task-specific*. The effort risks having not enough return, apart from serialised measurements.

A general solution is based on Monte Carlo simulations (coordinate metrology was first in pioneering this technique [2,7]). However, this requires a significant investment in dedicated software and experimental analysis of individual CMMs. The acceptance of this method is still very limited in practice.

4 The EUCoM project

The EUCoM project [3] aims at tackling this problem in a viable and industry-friendly way. The goal of the project is to develop two methods suitable for as many ISO standards: an *a posteriori* (type A) evaluation based on the dispersion observed in reversal measurements, and an *a priori* (type B) evaluation based on prior information such as standardised CMM performance parameters. The methods will be extensively validated experimentally by all project partners with different CMMs. The project involves 12 partners and 1 permanent collaborator from 10 countries, including 9 NMIs and DIs, 3 universities and 1 research centre.

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