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Statistical models for measurement uncertainty evaluation in coordinate metrology

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Coordinate metrology is a key technology supporting the quality infrastructure associated with manufacturing. Coordinate metrology can be thought of as a two-stage process, the first stage using a coordinate measuring machine (CMM) to gather coordinate data $\mathbf{x}_{1:m} = \{\mathbf{x}_i, i = 1, \ldots, m\}$, related to a workpiece surface, the second extracting a set of parameters (features, characteristics) $\mathbf{a} = (a_1, \ldots, a_n)^\top$ from the data e.g., determining the parameters associated with the best-fit cylinder to data. The extracted parameters can then be compared with the workpiece design to assess whether or not the manufactured workpiece conforms to design within prespecified tolerance.

The evaluation of the uncertainties associated with geometric features $\mathbf{a}$ derived from coordinate data $\mathbf{x}_{1:m}$ is also a two stage process, the first in which a $3m \times 3m$ variance matrix V_X associated with the coordinate data is evaluated, the second stage in which these variances are propagated through to those for the features $\mathbf{a}$ derived from $\mathbf{x}_{1:m}$. While the true variance matrix associated with a point cloud may be difficult to evaluate, a reasonable estimate can be determined using approximate models of CMM behaviour.
In this paper we describe approximate models of CMM behaviour in terms of spatial correlation models operating at different length scales and show how the point cloud variance matrix generated using these approximate models can be propagated through to derived features. We also use the models to derive explicit formulae that characterise the uncertainties associated with commonly derived parameters such as the radius of a fitted cylinder.

Special/invited session

MATHMET/ENBIS or Measurement uncertainty SIG

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