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Dimensional metrology with X-ray CT: a comparison with CMM measurements on internal features and compliant structures

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Highlights

- The objectives of this study are to compare dimensional measurements on artifacts containing mechanically compliant features using current state of the art CT and CMM techniques and also to discuss some of the issues with recently developed standards for CT measurement uncertainty estimation.
- This paper presents practical solutions for measuring parts made of flexible structures or containing compliant features, and special strategies are shown to reduce measurement uncertainties due to mechanical deformation or distortion of the part.
- As a result, in the particular case of measuring flexible parts, it is shown that using extrapolation methods, measurements from these two systems converged to within ±2 µm and demonstrates consistency between CT scans and zero force CMM extrapolation strategies.
- Creation of strategies for dimensional measurement of diameters, form, and relative distances in the components of an artifact are suggested for both a compliant part and a metallic artifact that has features inaccessible to tactile or vision-based measurement techniques.
- Generally, for dimensions of geometric features ranging from 0.6 mm to 65 mm, a comparison between CT and CMM measurements typically resulted in differences of approximately 5 µm or less for most of the measurements, while expanded uncertainties computed for the CT measurements ranged from 1 to 20 µm.
- A generalized formalism for uncertainty budgeting in CT metrology (still based on the ISO 15530 guidelines but with some differences) is applied to the measurements presented throughout this paper.

Abstract

X-ray computed tomography (CT) is uniquely suited for dimensional measurement of components having internal geometry, difficult-to-reach part features, and easy-to-deform or flexible structures. Through the development of standards it is also becoming accepted as a metrology tool. The objectives of this study are to compare dimensional measurements on artifacts containing internal structures and mechanically compliant features using current state-of-the-art CT and coordinate measure machine (CMM) techniques. It also aims to discuss some of the issues with recently developed standards for CT measurement uncertainty estimation. To illustrate the challenges of CMM and the potential of X-ray CT for reliable dimensional inspection, two different problems are presented: 1) characterization of internal geometry in a

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