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Comparison of Different Additive Manufacturing Methods Using Optimized Computed Tomography
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Introduction
Additive manufacturing (AM) allows for fast fabrication of three-dimensional objects with the use of considerably less resource, less energy consumption and shorter supply chain than would be the case in traditional manufacturing. AM has gained significance due to its cost effective method which allows the ability to produce components with a previously unachievable level of geometric complexity in prototyping and end user industrial applications, such as aerospace, automotive and medical industries. However these processes currently lack reproducibility and repeatability with some ‘prints’ having a high probability of requiring rework or even scraping due to out of specification or high porosity levels, leading to failure due to structural stresses.

This paper presents a artefact that is optimised for characterisation of form using computed tomography (CT) with representatives geometric dimensioning and tolerancing features and internal channels and structures comparable to cooling channel in high tech components. Furthermore the optimisation of the CT acquisition conditions for this artefact are presented in light of feature dimensions and form analysis. This paper investigates the accuracy and capability of CT measurements compared to CMM measurements from coordinate measuring machine (CMM), as well as focus on the evaluation of different AM methods.

Project Outline
1. Detail the development of a CT-specific artefact, produced using representative industrial AM technologies.
2. Measurements from CMM will be used as a reference and compared to features extracted from CT scanned data.
3. An outline validation of the CT scanning method using CMM data is presented, uncertainty budget is determined and compensation parameters calculated.

Additive Manufacturing Methods

The three AM methods used in this study include printing parameters and material characteristics are as follows:

1. Direct photo-chemical alteration of liquid polymer or Stereolithography (SLA) utilise scanning vectoring and projection of digital data with photopolymerisation of liquid polymer. This curing or hardening without machine design process to produce the feature involves using CAD/CAM software to design the part and layer, similar to a thin coconut slice of polymer to create a cross section of the part by layer, to perform a hot glue gun or gas metal arc welding.

Artfact Design

This benchmark artefact has potential to be implemented in testing some process limitations due to the feature sizes ranging from 2mm to 8mm. The method used for determining the artefact may be required. 44 GDT features have been designed in an arrangement beneficial to the process of CT scanning. This cylindrical artefact will provide even attenuation of x-rays in hope to maximise detail and resolution while taking a series of projection scans; this includes thermal drift, mechanical stability, magnification and object orientation to name a few, these factors which combined contribute to the overall noise of the measurement system and is difficult to compensate for. This paper explores the application of deviation analysis of an AM artefact optimised for the use in CT in error comparison to CMM reference measurements. Visual deviation, using software to superimpose scanned CT data to original CAD models allowed for visual comparison of a variety of AM methods, which provided a means to preliminary analyse the form that is created as well as its tolerances in feature position. These AM methods were analysed for 2D and dimensional accuracy, with a goal to assess the capability of scanning and software reconstruction and measurement abilities to the gold standard CMM method. The comparison evidently demonstrates correlations between different measurement techniques with few outliers, with a correlation of surface determination inaccuracy and resolution to the black box potential of the contributing uncertainty factors.

Methodology

ISO and VDI/VDE guidelines have not currently been applied widely to directly assess and characterise AM artefacts using CT, in this paper details and seeks to do this, applying these principles to AM materials constructed using different methods. All features on the AM artefact are measured and compared to CMM data to assess stability and variability, deviation is studied and CT data is re-evaluated. A comprehensive GDT strategy is created and from this a template is generated and applied to scanned data using best fit algorithms to register samples. Through this determined method the capability of geometrical features including form, dimension are investigated.

Results

The CT measurements are less accurate and the level of uncertainty is greater than that using CMM. Furthermore any influencing factor contributing to the inaccuracy of a CT measurement is in this case usually lower than the voxel size of the scan; this includes thermal drift, mechanical stability, magnification and object orientation to name a few, these factors when combined contribute to the overall noise of the measurement system and is difficult to compensate for. This paper explores the application of deviation analysis of an AM artefact optimised for the use in CT in error comparison to CMM reference measurements. Visual deviation, using software to superimpose scanned CT data to original CAD models allowed for visual comparison of a variety of AM methods, which provided a means to preliminary analyse the form that is created as well as its tolerances in feature position. These AM methods were analysed for 2D and dimensional accuracy, with a goal to assess the capability of scanning and software reconstruction and measurement abilities to the gold standard CMM method. The comparison evidently demonstrates correlations between different measurement techniques with few outliers, with a correlation of surface determination inaccuracy and resolution to the black box potential of the contributing uncertainty factors.