Skin Model Shapes for Additive Manufacturing (in collaboration with FAU Erlangen, Germany)

Additive Manufacturing (AM) is becoming a promising technology capable of building complex customized parts with internal geometries and graded material by stacking up thin individual layers that allow optimizing the component's, weight, shape and strength. Due to an increased development of digital technologies, AM has reached a level of maturity. However, a comprehensive geometric model for Additive Manufacturing is not mature yet.

The Skin Model Shapes paradigm which stemmed from the theoretical foundations of Geometrical Product Specification and Verification has been developed to consider geometric deviations that are expected, predicted or already observed in real manufacturing processes. Statistical analysis of shape variations or Statistical Shape Analysis (SSA) is commonly used for variability considerations in scientific domains. Statistical Shape Analysis is used here to i) give an efficient parameterization of the variability of different skin model shapes, ii) provide a compact representation of shapes where each Skin Model Shape is expressed as a combination of the mean skin model and the variation of the Skin Model Shape around the mean along main modes, and iii) enable to predict new Skin Model Shapes.

The work will address the fundamentals of geometric modeling in the context of additive manufacturing. First, the assessment of existing computational geometric models for AM, current techniques of Generalized Topology Optimization and lattice structure generation and actual standards (such as Additive Manufacturing File Format AMF) will be established. The second part of this work will be devoted to the development of statistical shape analysis techniques in the context of additive manufacturing. New requirements will be addressed for shape parameterization.

A new statistical model of Shapes will be proposed based on the extension of the skin model paradigm considering shape, structure, texture and material functionalities and integrating more semantics. Case studies and practical examples will be presented to illustrate the proposed approaches.

A comparative study of Lp Norm for fitting (in collaboration with LNE)

The evaluation of geometric deviations in coordinate metrology involves a minimization step which fits a substitute surface to the measured points. The nature of the objective function and distance (norm) used in fitting the substitute surface affects the estimation of the accuracy of geometric deviations. In coordinate metrology, the error objective function is defined by the Lp fitting norm. The L1 norm is lesser known than its peers, the L2 (i.e., least-squares) and the L∞ (i.e., minimum-zone or Chebyshev). Nevertheless there are interesting properties about the L1 norm that makes it the new proposal for ISO TC 213 committee to replace Chebyshev fit.

The work will first address the investigation of the L1 norm for canonical surfaces and its comparison with L2 and L∞. The second part of this work will evaluate the sensitiveness of the exponent p and to determine the best value of the exponent p used in the fitting function considering the measured geometry and sampling. Case studies using simulated and measured datasets will be presented to illustrate the research findings.

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