Boundary-based Mesh Partitioning for Geometrical Product Specifications and Verification

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Abstract

Partitioning, or segmentation, is a fundamental operation of geometry processing that decomposes an object into independent surface portions for further geometrical and functional analysis. In the domain of mechanical engineering, mesh models have been widely employed with the development of finite element analysis and simulation technologies as well as 3D data acquisition techniques. Therefore, mesh partitioning methods have been widely researched in recent years.

In this presentation, we put forward a state-of-the-art of research on mesh partitioning. A boundary-based mesh partitioning method is then proposed to enable a feature-based decomposition considering natural boundaries on the mesh. The proposed two-step method includes an initial partitioning based on sharp edge detection and a following partitioning process based on non-sharp edge rectification. Two surface descriptors derived from principal curvatures, Curvedness and Shape Index, are used as the partitioning criteria. A robust discrete curvature estimation method is a key enabler for the proposed method. Therefore, we assessed and compared existing methods.

In the non-sharp edge rectification step, slippable motions of a set of points are considered to merge small patches of the mesh. To refine the boundary points on non-sharp edges, we exploit conformal geometry to map the 3D surface onto a 2D unit disc and re-cluster the boundary points by 2D logistic regression. Smooth-connected regions at their natural boundaries are well partitioned after the boundary rectification process. The partitioned geometric features are then identified according to their kinematic invariance. Therefore, a statistical modeling estimation is conducted to address invariance class evaluation for the partitioned surface portions.

The work presented here contributes to the science-based standardization efforts within the ISO/TC 213 committee on Geometrical Product Specifications and Verification (ISO GPS, for short). It is also the basis of the development of ISO 18183 series, which focuses on the partitioning methods for both specification and verification.

Experiments and results on different mesh models are presented to demonstrate the effectiveness of the partitioning method.

Keywords: Partitioning, Mesh, Discrete Curvature, Conformal Geometry