Constructing complex B-spline solid with representation of material and property

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Abstract:

There have been emerged many products complex in geometry, topology and material. The 3D printing technology makes it possible for manufacturing of these products. But the conventional design method，with the properties of separation of geometric design and performance analysis，too much manual intervention and no share of the model in different design stages has urgent need to improvement.

Heterogeneous materials widely exist in the nature. Imitating the nature, abundant heterogeneous products have been developed and used in many fields. There have been some algorithms mainly focus on the geometry and material representation methods for heterogeneous products. Finite element analysis is commonly utilized in the heterogeneous products analysis. Benefit from the efforts of the scholars in the fields of geometry and analysis, isogeometric analysis method constructing on the base of volume parametric model has been proposed and has been applied in some analysis fields. Volume parameterization method is proposed to generate proper analysis model for the isogeometric analysis. Because of many advantages of volume parametric model, constructing a heterogeneous volume parametric model becomes an interesting and worthy tasting thing.

Volume parameterization of material distribution especially the existing material is the main challenge. This point makes our method to be different with other heterogeneous product design methods and common volume parameterization methods. How to create the model is an urgent problem to solve. This paper firstly gives the expression of volume parametric model and proposes that setting control points is the core issue. After given the control points of the six boundary surfaces, based on the differential form of the harmonic functions from the computational domain to the parameter domain, a new method for creating the control points of the volume parametric model is presented. Two methods including Jacobian matrix and isoparametric network are also put forward to measure the quality of the generated volume model. Constructing volume parametric model based on point cloud model, detailed comparison is also made between our method and the other two methods including the discreet Coons interpolation method and the convex combinative interpolation method.

Using CT scan data as original data, from which point cloud data can be extracted, to achieve a construction of geometry and material space for heterogeneous products. Use volume parameterization methods to acquire geometric space of model. Use parameterization of gray-scale values to acquire materials space of model. By solving a quadratic optimization problem to embed material space into geometric space and achieve the coupling of geometry and material through. Finally, volumetric parametric heterogeneous model is constructed. After coupling of these two spaces, a volume parametric heterogeneous model is completed for design and analysis. Isogeometric analysis is implemented without model conversion. Two presented

examples show the effectiveness and efficiency, along with the future development potentials.

Take the femur model from human body as example, the algorithms of constructing the volume parameterization heterogeneous model are realized. The result shows that the method of volume parametric modeling for heterogeneous products based on reverse-material-oriented is more convenient and precise to represent the actual distribution information for heterogeneous products and can provide the models for performance analysis and rendering based on volume parameterization model.

Keyword: Material reversing; Heterogeneous product; Volume parameterization; CT scan; Material space; Geometrical space; Isogeometric analysis; domain decompostion