Construction of polynomial spline spaces over quadtree and octree T-meshes for its application in isogeometric analysis

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ABSTRACT

We present a new strategy for construction spline spaces over hierarchical T-meshes with quad- and octree subdivision scheme [1]. The proposed method is based on some simple rules for inferring, from a given T-mesh, local knot vectors to define tensor product spline blending functions. A set of cubic spline functions defined by means of this technique span a space with nice properties: it can reproduce cubic polynomials, the functions are C^2-continuous, linearly independent, and spaces spanned by nested T-meshes are also nested. In order to define spline spaces with desirable properties applying the proposed rules, the T-mesh should fulfill a mild restriction of being a strongly balanced quadtree or octree. A T-mesh with a quadtree (octree) structure is said to be strongly balanced if any cell has contact (through vertex, edge or face) only with cells that differ at most twice in depth. Balanced tree condition is commonly used in FEM to guarantee a good quality of the approximation space constructed over the mesh. To obtain a strongly balanced quadtree, a standard balancing procedure is applied. The straightforward implementation of the proposed strategy (both in 2D and 3D) and the simplicity of tree structures can make it attractive for its use in geometric design and isogeometric analysis. We give a detailed description of our technique and illustrate some examples of its application in isogeometric analysis performing adaptive refinement for 2D and 3D problems. Optimal rates of convergence are obtained during adaptive refinement for all test problems. Parameterization of computational domains is obtained using the algorithm described in our previous works [2, 3]. This technique, based on a T-mesh untangling and optimization procedure, allows us to obtain a good quality parameterization from the boundary representation of the geometry. The procedure is an extension of the ideas presented in our works [4, 5].

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