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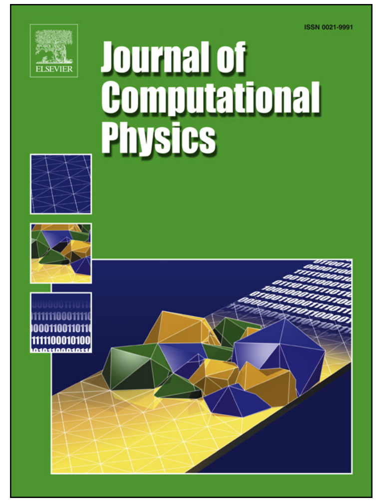

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Isogeometric Finite Element Approximation of Minimal Surfaces Based on Extended Loop Subdivision

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Abstract

In this paper, we investigate the formulation of isogeometric analysis for minimal surface models on planar bounded domains by extended Loop surface subdivision approach. The exactness of the physical domain of interest is fixed on the coarsest level of the triangular discretization with any topological structure, which is thought of as the initial control mesh of Loop subdivision. By performing extended Loop subdivision, the control mesh can be repeatedly refined, and the geometry is described as an infinite set of quartic box-spline while maintaining its original exactness. The limit function representation of extended Loop subdivision forms our finite element space, which possesses C^1 smoothness and the flexibility of mesh topology. We establish its inverse inequalities which resemble the ones of general finite element spaces. We develop the approximation estimate with the aid of H^1 convergence property of the corresponding linear models. It enables us to overcome the difficulty of proving the boundedness of the gradient of finite element solutions appearing in the coefficient of minimal surface models. Numerical examples are given with the comparison to the classical linear finite element method which is consistent with our theoretical results.

Key words: Extended Loop Subdivision; Isogeometric Analysis; Error Estimates; Minimal Surfaces.

1 Introduction

At present the system of computer-aided design (CAD) mostly uses the boundary structure (B-rep) to describe the geometries by spline basis functions and often by non-uniform rational B-splines (NURBS) with different polynomial orders. Different levels of numerical simulations are performed on desired objects. It involves using the finite element method (FEM) where the desired objects are represented by piecewise low order polynomials. The incompatible mathematical representation makes the communication between the communities of CAD and numerical simulation based on FEM very challenging. This challenge today is addressed by expensive and time-consuming human intervention.

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