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Convergence of boundary integral method for a free boundary system

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Abstract

Boundary integral method has been implemented successfully in practice for simulating problems with free boundaries. Though the method produces accurate and efficient numerical results, its convergence study is usually limited to numerical demonstrations by successively reducing time step and increasing resolution for a test problem. In this paper, we present a rigorous convergence and error analysis of the boundary integral method for a free boundary system. We focus our study on a nonlinear tumor growth problem. The boundary integral formulation yields a Fredholm type integral equation with moving boundaries. We show that in two dimensions, the convergence of the scheme in the L^∞ norm has first order accuracy on the time direction and $\Delta\theta^\alpha$ on the spatial direction.

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1 Introduction

Boundary integral method (BIM) is usually considered to be the most accurate method for solving partial differential equations (PDEs) if there exists a Green function for the PDEs and an integral formulation can be established [3, 27, 25, 4]. There are two advantages of applying a BIM. First, there are well-developed quadratures and stable discretization available to evaluate the integrals efficiently and accurately. Second, the dimensionality of the problem is reduced by one. Namely, a two-dimensional domain problem can be solved via the integration on a one-dimensional curve, thus computational cost is reduced dramatically.

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