2014학년도 2학기

수학전공 Colloquium

제 목	Supra-convergence analysis and numerical treatment of Shortley-Weller scheme for Poisson equation
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초 록	The Shortley-Weller method is a basic finite difference method for solving the Poisson equation with Dirichlet boundary condition. The second order convergence of its solution has been long known but it is rather recent to pay attention to its gradient. Especially in its application to fluid flows, the gradient plays a physical role rather than the solution itself. In this talk, we first review the proof that the convergence order of its numerical solution is the second order: though consistency error is first order accurate at some locations, the convergence order is globally second order. We call this increase of the order of accuracy, supra-convergence. We then discuss a discrete divergence theorem for the Shortly-Weller method and prove that the gradient of the solution is second order accurate in general domains. Also, we show an estimation for the matrix associated with the Shortley-Weller method, where is the minimum distance between grid nodes and the boundary of the domain. Therefore the presence of even a single grid node that is too near the boundary, i.e, , severly corrupts the quality of the linear system. It not only delays the convergence but also drops many significant digits in solving the linear system with the matrix. In order to enhance the condition number, we consider preconditioning the linear system to mitigate the big ratio. Since preconditionings do not change the solution of the linear system, there is no loss of convergence. To our surprises, some of basic preconditions including Jacobi and ILU reduce the ratio size to . With this regard, the common preconditioners are enough to completely eliminate the adverse effect of . All our analyses are proved and verified through numerical tests, and furthermore the tests show that our estimates are tight. Our eigenvalue estimates and perturbation analysis in irregular domains are novel, to our best search.
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