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A NEW NUMERICAL APPROACH TO THE SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS WITH OPTIMAL ACCURACY ON IRREGULAR DOMAINS AND EMBEDDED UNIFORM MESHES

Alexander Idesman

Texas Tech University, Box 41021, Lubbock, TX, USA, E-mail: alexander.idesman@ttu.edu

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A new numerical approach based on the minimization of the local truncation error is suggested for the solution of partial differential equations. Uniform Cartesian meshes are currently used for the space discretization. Similar to the finite difference method, the form and the width of the stencil equations are assumed in advance. A discrete system of equations includes regular uniform stencils for internal points and non-uniform cut stencils for the nodes located close to the boundary. The unknown coefficients of the discrete system are calculated by the minimization of the order of the local truncation error. The main advantages of the new approach are a high accuracy and the simplicity of the formation of a discrete (semi-discrete) system of equations for irregular domains. For the regular uniform stencils, the stencil coefficients can be found analytically. For non-uniform cut stencils, the stencil coefficients are numerically calculated by the solution of a small system of linear algebraic equations (10-20 algebraic equations). In contrast to the finite elements, there is no necessity to calculate by integration the elemental mass and stiffness matrices that is time consuming for high-order elements. As a mesh, the grid points of a uniform rectangular (square) mesh as well as the points of the intersection of the boundary of a complex irregular domain with the horizontal, vertical and diagonal lines of the uniform mesh are used; i.e., in contrast to the finite element meshes, a trivial mesh is used with the new approach. Changing the width of the stencil equations, different high-order numerical techniques can be developed with the new approach. Currently the new technique is applied to the solution of the time dependent wave and heat equations and the time independent Laplace equation. The theoretical and numerical results show that for the width of the stencil equations equal to that for the linear quadrilateral finite elements, the new technique yields the fourth order of accuracy of the numerical results on irregular domains for the considered partial differential equations (it is much more accurate compared with the linear and even quadratic finite elements at the same number of degrees of freedom).