



復旦大學

数据科学与深度学习
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GMLS and RBF-FD Methods for Solving PDEs on Manifolds



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Abstract: Solving partial differential equations (PDEs) on manifolds is a challenging problem in scientific computing and has broad applications in various fields. In this talk, we introduce two meshfree approaches, generalized moving least-squares (GMLS) and radial basis function-generated finite difference (RBF-FD), for solving PDEs on manifolds with or without boundaries, identified by randomly sampled point cloud data. For RBF-FD, we develop a novel two-step generalized RBF-FD (gRBF-FD) method based on a PHS+Poly interpolant defined over the tangent space in a Monge coordinate system, where PHS stands for polyharmonic spline. Our gRBF-FD method shares the same interpolant form as the standard RBF-FD but differs in how the interpolation coefficients are computed. To enhance stability and reduce the solution error, we employ a specific weight function in both GMLS and gRBF-FD. We establish an error bound for the operator approximation in terms of the so-called local stencil diameter as well as the number of data points. We further demonstrate the accuracy of the two approaches on three tasks, including manifold approximation, scalar-valued PDEs, and vector-valued PDEs, across various manifolds.

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