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Ankit Srivastava</td></tr>
<tr><th>title</th><td>Exact imposition of boundary conditions with distance functions in physics-informed deep neural networks</td></tr>
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<tr><th>abstract</th><td>In this paper, we introduce a new approach based on distance fields to exactly impose boundary conditions in physics-informed deep neural networks. The challenges in satisfying Dirichlet boundary conditions in meshfree and particle methods are well-known. This issue is also pertinent in the development of physics informed neural networks (PINN) for the solution of partial differential equations. We introduce geometry-aware trial functions in artifical neural networks to improve the training in deep learning for partial differential equations. To this end, we use concepts from constructive solid geometry (R-functions) and generalized barycentric coordinates (mean value potential fields) to construct ϕ, an approximate distance function to the boundary of a domain. To exactly impose homogeneous Dirichlet boundary conditions, the trial function is taken as ϕ multiplied by the PINN approximation, and its generalization via transfinite interpolation is used to a priori satisfy inhomogeneous Dirichlet (essential), Neumann (natural), and Robin boundary conditions on complex geometries. In doing so, we eliminate modeling error associated with the satisfaction of boundary conditions in a collocation method and ensure that kinematic admissibility is met pointwise in a Ritz method. We present numerical solutions for linear and nonlinear boundary-value problems over domains with affine and curved boundaries. Benchmark problems in 1D for linear elasticity, advection-diffusion, and beam bending; and in 2D for the Poisson equation, biharmonic equation, and the nonlinear Eikonal equation are considered. The approach extends to higher dimensions, and we showcase its use by solving a Poisson problem with homogeneous Dirichlet boundary conditions over the 4D hypercube. This study provides a pathway for meshfree analysis to be conducted on the exact geometry without domain discretization.</td></tr>
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<tr><th>publication_date</th><td>2021-11-07 00:00:00</td></tr>
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