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<tr><th>abstract</th><td>In the field of fluid numerical analysis, there has been a long-standing problem: lacking of a rigorous mathematical tool to map from a continuous flow field to discrete vortex particles, hurdling the Lagrangian particles from inheriting the high resolution of a large-scale Eulerian solver. To tackle this challenge, we propose a novel learning-based framework, the Neural Vortex Method (NVM), which builds a neural-network description of the Lagrangian vortex structures and their interaction dynamics to reconstruct the high-resolution Eulerian flow field in a physically-precise manner. The key components of our infrastructure consist of two networks: a vortex representation network to identify the Lagrangian vortices from a grid-based velocity field and a vortex interaction network to learn the underlying governing dynamics of these finite structures. By embedding these two networks with a vorticity-to-velocity Poisson solver and training its parameters using the high-fidelity data obtained from high-resolution direct numerical simulation, we can predict the accurate fluid dynamics on a precision level that was infeasible for all the previous conventional vortex methods (CVMs). To the best of our knowledge, our method is the first approach that can utilize motions of finite particles to learn infinite dimensional dynamic systems. We demonstrate the efficacy of our method in generating highly accurate prediction results, with low computational cost, of the leapfrogging vortex rings system, the turbulence system, and the systems governed by Euler equations with different external forces.</td></tr>
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