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Deep learning of free boundary and Stefan problems

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Free boundary problems appear naturally in numerous areas of mathematics, science and engineering. These problems present a great computational challenge because they necessitate numerical methods that can yield an accurate approximation of free boundaries and complex dynamic interfaces. In this work, we propose a multi-network model based on physics-informed neural networks to tackle a general class of forward and inverse free boundary problems called Stefan problems. Specifically, we approximate the unknown solution as well as any moving boundaries by two deep neural networks. Besides, we formulate a new type of inverse Stefan problems that aim to reconstruct the solution and free boundaries directly from sparse and noisy measurements. We demonstrate the effectiveness of our approach in a series of benchmarks spanning different types of Stefan problems, and illustrate how the proposed framework can accurately recover solutions of partial differential equations with moving boundaries and dynamic interfaces.