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Application prospect of AI-driven differentiable plasma modeling

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Numerical modeling is an essential approach to understanding the behavior of plasmas in various industrial applications, such as electronic manufacturing, material synthesis, arc interruption, combustion ignition, space propulsion, waste treatment, and even biological medicine [1]. Like other multi-physics models, plasma models are typically solved by the finite element, finite volume, and finite difference methods, which are all based on the discrete meshes on the computational domain. These discrete models do not allow easy calculation of solution derivatives with respect to plasma conditions, e.g. plasma properties, boundary conditions, initial conditions, and geometries. However, this is precisely what the regulation and optimization of various industrial plasmas require. To address this problem, we propose an AI-driven differentiable plasma modeling framework which makes the discrete plasma modeling differentiable and allow easy calculation of solution derivatives by introducing neural networks in the modeling. The backbone network in this differentiable plasma simulation framework can be physics-informed neural networks (PINNs) [2], deep operator neural network (DeepONet) [3], and any other networks which support differential computation via gradient descent. Other deep learning techniques, such as transfer learning and meta learning [4] can also be used to accelerate the training and inference of differentiable plasma models. In this talk, some potential applications will be demonstrated and discussed under this framework. Although there are still a lot of works to be done, this differentiable simulation framework could provide plasma community a promising and powerful tool for plasma simulation.

References
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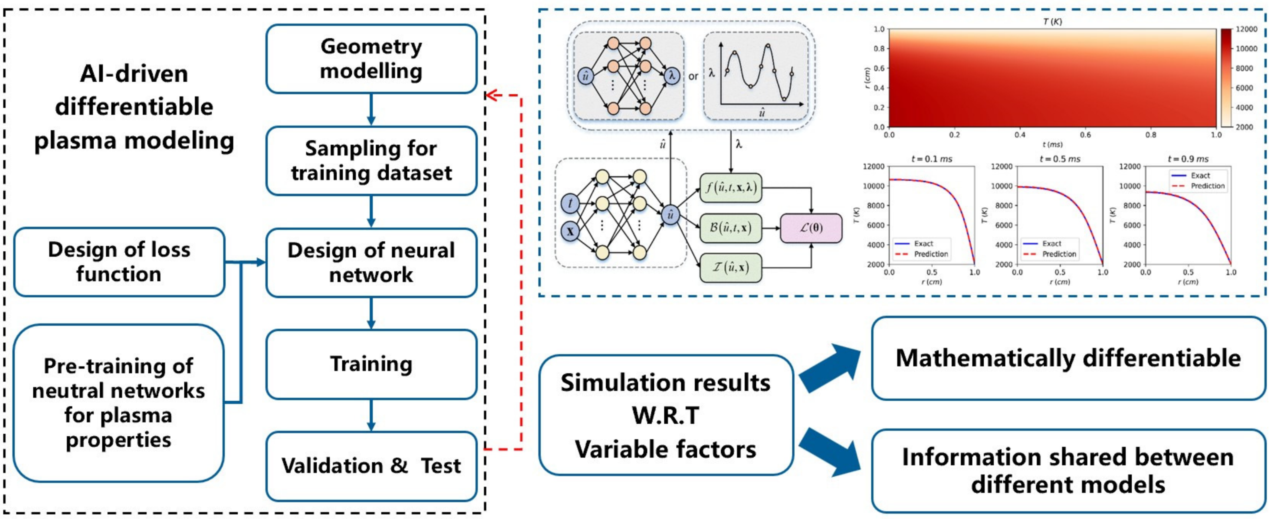

Figure 1. Framework of AI-driven differentiable plasma modeling. Part of the figure is compiled from the work by Zhong et al. [1].