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Gradient-Annihilated PINNs for Solving Riemann Problems: Application to Relativistic Hydrodynamics

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Physics-Informed Neural Networks (PINNs) have gained significant attention in the field of deep learning for their ability to tackle physical scenarios. These networks optimize neural architectures by incorporating inductive biases derived from knowledge of physics. To embed the underlying physics, a suitable loss function is defined, encompassing the necessary physical constraints. PINNs have proven versatile in comprehending and resolving diverse physical systems. However, to accurately represent and solve systems characterized by the presence of discontinuities (e.g. shock waves), modifications to the fundamental algorithms of PINNs are necessary. In this talk we discuss a novel approach called Gradient-Annihilated Physics-Informed Neural Networks (GA-PINNs) for solving partial differential equations with discontinuous solutions. GA-PINNs use a modified loss function and weighting function to ignore high gradients in physical variables. The method demonstrates excellent performance in solving Riemann problems in special relativistic hydrodynamics. The results obtained by GA-PINNs accurately describe the propagation speeds of discontinuities and outperform a baseline PINN algorithm. Moreover, GA-PINNs avoid the costly recovery of primitive variables, a drawback in grid-based solutions of the relativistic hydrodynamics equations.