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

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Keywords

- Riemann problem → Problems with discontinuous initial conditions
- Neural networks → Physics-Informed Neural Networks
- Euler equations
- Relativistic hydrodynamics

  (both) → Problems in Astrophysics: New application

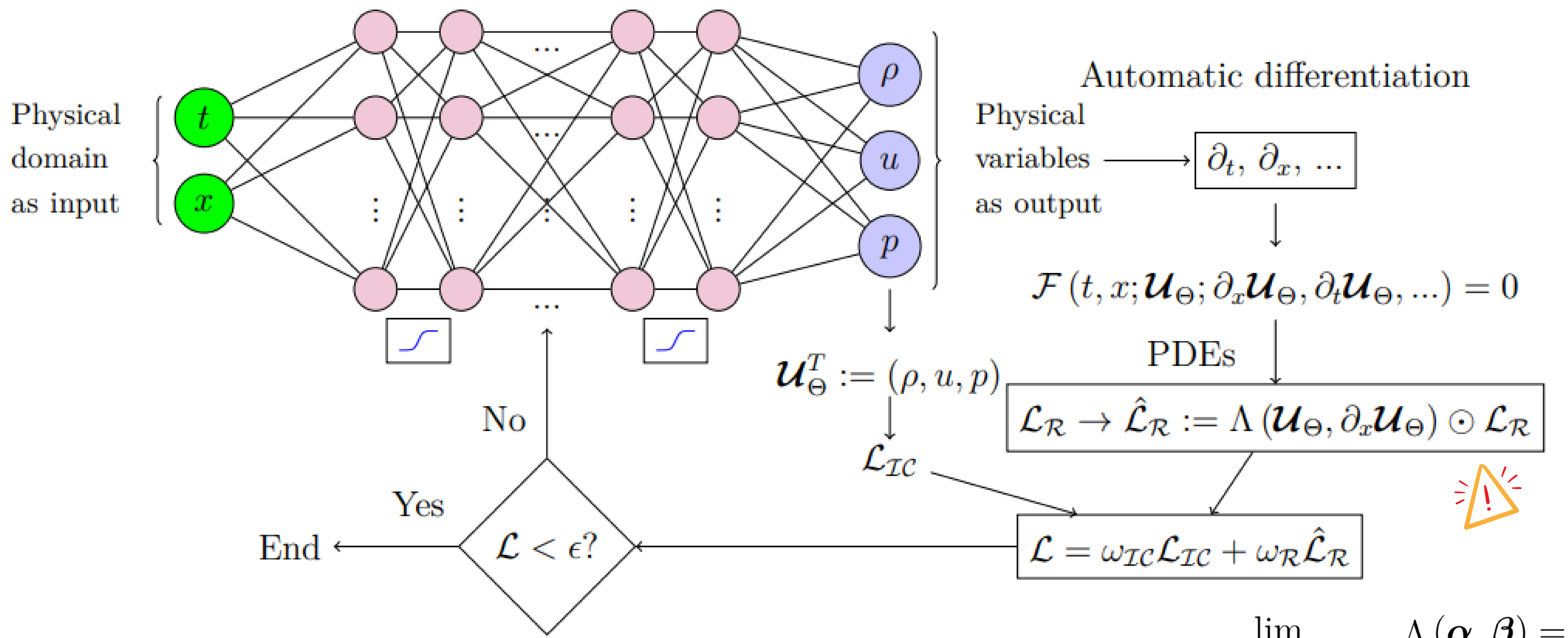
$$\frac{\partial \mathcal{U}}{\partial t} + \nabla \cdot f(\mathcal{U}) = \mathcal{S}(\mathcal{U}) \longrightarrow \frac{\partial}{\partial t}\begin{pmatrix} D \\ S \\ \tau \end{pmatrix} + \frac{\partial}{\partial x}\begin{pmatrix} Du \\ Su + p \\ S - Du \end{pmatrix} = 0 \quad \Big\} \; \rho, u, p$$

D, S, τ: Relativistic densities of mass, momentum and energy, respectively.

ρ, u, p: Density, velocity and pressure of the fluid: primitive variables.

METHOLOGY PROPOSED

Diagram and algorithm



$$\lim_{|\partial_x \rho|, |\partial_x u|, |\partial_x p| \to \infty} \Lambda(\boldsymbol{\alpha}, \boldsymbol{\beta}) = 0$$

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SOME RESULTS

Riemann problems in Relativistic Hydrodynamics

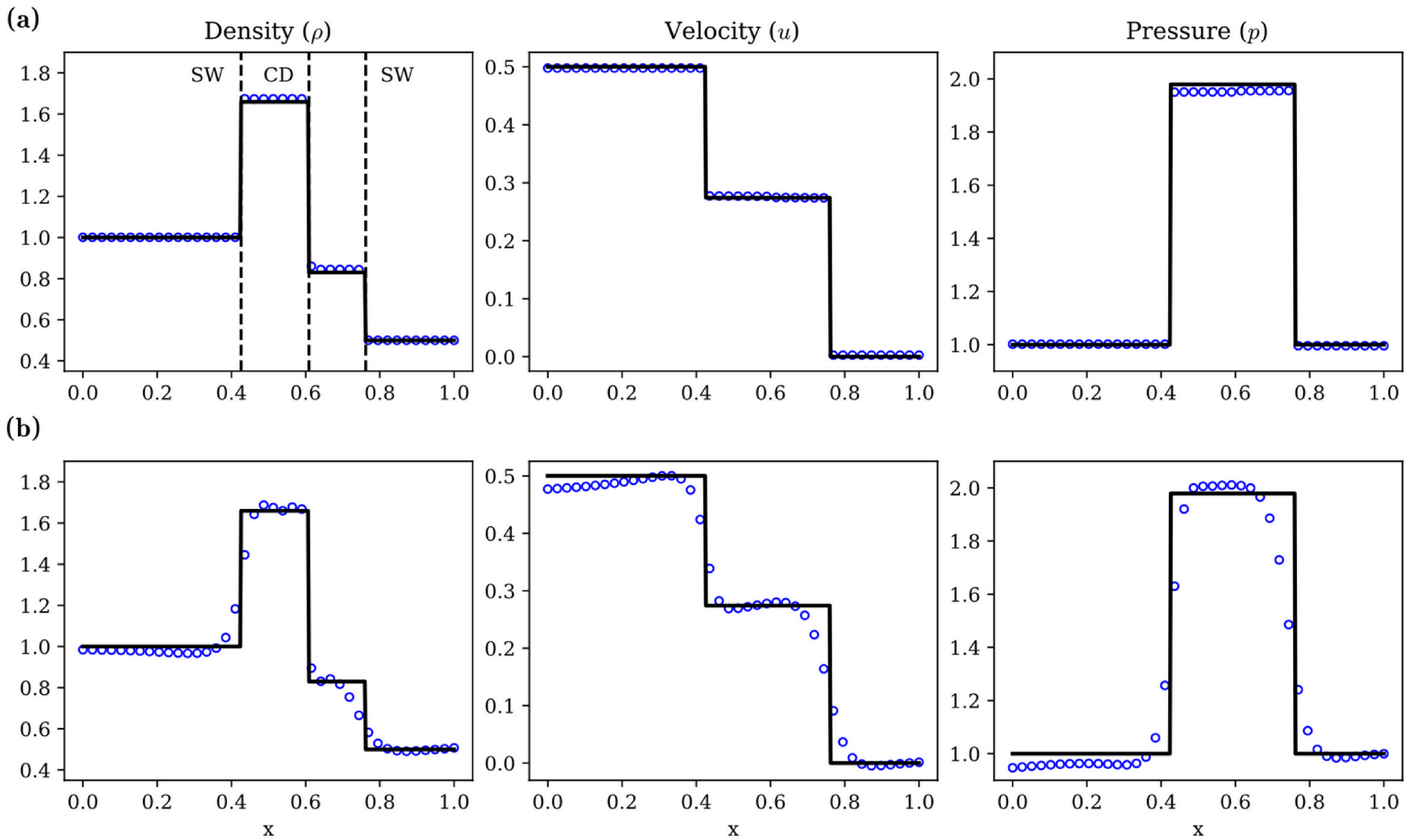

Figure 2: Final profiles for the primitive variables (density, velocity and pressure) with respect to the analytical solution (black solid line) obtained by the GA-PINN in **(a)** and by a vanilla PINN model in **(b)**.