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Physics-Informed ELM for Singularly Perturbed Problems

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This study presents a physics-informed Extreme Learning Machine (ELM) approach for solving singularly perturbed integro-differential boundary value problems. The main novelty lies in the development of a specialized ELM ansatz that exactly satisfies the boundary conditions and analytically incorporates boundary layer behavior. In this framework, the basis functions are modified to enforce the boundary conditions algebraically, while the multiscale structure of the solution, particularly the thin boundary layers, is captured using appropriate exponential weighting functions. As a result, the model is trained solely through the governing equation, without requiring any training data.

References

[1] Arzani, A., Cassel, K.W., D'Souza, R.M.: Theory-guided physics-informed neural networks for boundary layer problems with singular perturbation. Journal of Computational, Physics, 2023, 111768.

[2] Lu, L., Jin, P., Pang, G., Zhang, Z., Karniadakis, G.E.: Learning nonlinear operators via DeepONet based on the universal approximation theorem of operators. Nature machine intelligence, 2021, 218-229.

[3] Wang, L., Lei Z., Guowei, H.: Chien-physics-informed neural networks for solving singularly perturbed boundary-layer problems. Applied Mathematics and Mechanics, 2024, 1467-1480.