A COMPARATIVE ANALYSIS OF PINN AND FINITE DIFFERENCE METHOD FOR PRESERVING THE ASYMPTOTIC BEHAVIOR OF A TIME-DELAYED MARINE RISER EQUATION

Abstract. We investigate a marine riser equation subject to linear damping with a constant time-delay. The well-posedness of the problem was established by semi-group theory, and the exponential decay of the solutions was demonstrated through the energy method. The core focus of this study is a comparative analysis between two distinct numerical approaches: a finite difference method adapted for time-delay equations and a modified approach based on Physics-Informed Neural Networks (PINN). Given the lack of prior research evaluating the performance of PINNs in this direction, our central objective is to answer the following research question: Which of the two numerical methods better represents the exponential decay of the solutions for the time-delayed marine riser equation? The final numerical simulations illustrate the theoretical results and provide a comparative evaluation of both methods.

The model considered here is a marine riser with viscous damping and time-delay term given by

$$\begin{cases} mu_{tt} + EIu_{xxxx} - N_{eff}u_{xx} + \beta u_{tx} + \gamma_1 u_t + \gamma_2 u_t(x, t-\tau) = 0, \quad x \in (0, L),\ t \in (0, \infty), \\ u(0,t) = u_{xx}(0,t) = u(L,t) = u_{xx}(L,t) = 0, \\ u(x,0) = u_0(x), \quad u_t(x,0) = u_1(x), \quad u_t(x, t-\tau) = f_0(x, t-\tau), \quad (x,t) \in (0,L) \times (0,\tau), \end{cases} \tag{1}$$

where L is the length of the pipe, the riser flexural rigidity EI, mass line density m, effective tension N_{eff}, coefficient of the Coriolis force β, a constant $\tau > 0$, and the damping coefficients $|\gamma_2| \le \gamma_1$.

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References.

(1) I. E. Lagaris, A. Likas, and D. I. Fotiadis. *Artificial neural networks for solving ordinary and partial differential equations.* IEEE Transactions on Neural Networks, 9(5), 1998, 987–1000.
(2) M.Raissi, P. Perdikaris, and G. E. Karniadakis. *Physics informed deep learning (part i): Data driven solutions of nonlinear partial differential equations.* arXiv preprint, arXiv:1711.10561, 2017.
(3) Subrata K. *Chakrabarti and Ralph E. Frampton. Review of riser analysis techniques.* Applied Ocean Research, 4(2), 1982,73–90.