Predicting Positon Solutions And Their Interaction Dynamics With Solitons Through Physics Informed Neural Networks (PINN)

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Abstract

We present two distinct studies on physics-informed neural networks. Firstly, we consider a hierarchy of nonlinear Schrödinger equations (NLSEs) and forecast the evolution of positon solutions using a deep learning approach called Physics Informed Neural Networks (PINN). Unlike conventional PINN approaches that rely on Dirichlet boundary conditions, we exclusively utilize data points at a single reference point, $x = 0$, which minimizes the loss function more rapidly for positon solutions. We have also compared the performance of our modified PINN algorithm with the traditional PINN approach for predicting positon solutions of NLSEs. Our findings reveal that, for basic NLSE, both approaches achieve similar MSE values, suggesting comparable performance for lower-order equations. For higher-order NLSEs, the considered modified PINN algorithm significantly outperforms the traditional method, requiring less iterations to achieve high accuracy. Secondly, we examine interaction dynamics between positons and solitons solutions of real and complex modified Korteweg-de Vries equations through PINN. Higher order positon solutions of real and complex mKdV equations are not studied through deep learning algorithms. We predict second order, third order positons, and hybrid solutions for both equations using the physics-informed neural network (PINN) method and examine the outcomes predicted by the PINN approach. By calculating mean squared error values, we establish a correlation between predicted outcomes and the exact analytical positon solutions, for these two nonlinear partial differential equations from which we analyze the effectiveness of the PINN in approximating positon and hybrid solutions. Our results indicate that the deep learning methodology employed through the PINN demonstrates a strong capability for accurately predicting higher-order positons and hybrid solutions.

References

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