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Neural network learning of multi-scale and discrete temporal features in directed percolation

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Neural network methods are increasingly applied to solve phase transition problems, particularly in identifying critical points in non-equilibrium phase transitions, offering more convenience compared to traditional methods. In this paper, we analyze the (1+1)-dimensional and (2+1)-dimensional directed percolation models using an autoencoder network. We demonstrate that single-step configurations after reaching steady state can replace traditional full configurations for learning purposes. This approach significantly reduces data size and accelerates training time.Furthermore, we introduce a multi-input branch autoencoder network to extract shared features from systems of different sizes. The neural network is capable of learning results from finite-size scaling. By modifying the network input to include configurations at discrete time steps, the network can also capture temporal information, enabling dynamic analysis of non-equilibrium phase boundaries. Our proposed method allows for high-precision identification of critical points using both spatial and temporal features.

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