Analysis of Neural ODE Performance in Long-term PDE Sequence Modeling

ICLR Machine Learning Multiscale Processes

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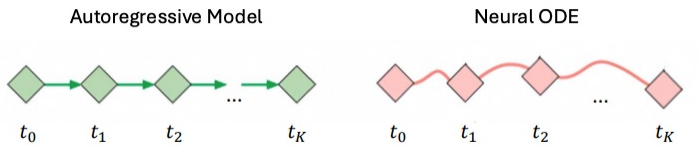
Problem Definition:

Task: To learn a predictor M that maps the first L snapshots to the next K snapshots (for a 1D PDE system discretized on N spatial cells):

$$\hat{\mathbf{u}}^{(t_{L+1}:t_{L+K})} = \mathcal{M}\left(\mathbf{u}^{(t_1:t_L)}\right).$$



Autoregressive GNN-based architectures predict each step sequentially, leading to error accumulation, whereas Neural ODEs model the dynamics continuously, mitigating compounding errors.

Experiment Results:

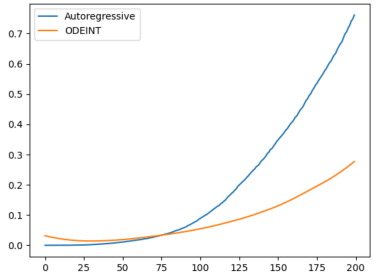
Dataset: Burger's equation (without diffusion), 25→200 prediction task

RQ1: Sequence recovery accuracy

Method	$\frac{1}{n_x}\sum_{x,t}$ MSE ↓
MP-PDE	1.2176
Ours	**0.5267**

RQ2: Long term prediction stability

Comparison of average $\sum_x$ MSE loss per timestep



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