Prediction of Quantum Dynamics using Experimental Measurements

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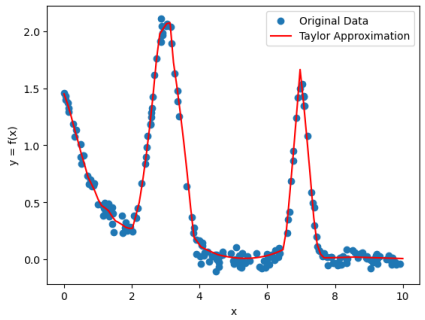
- **Idea:** Predict the evolution of probability density function $|\psi(x,t)|^2$ of a quantum systems from measurements of position.
- **Targets achieved:**
  - Choosing the representation of the wave-functions.
  - Prediction of Classical Dynamics using PINN as a proof of concept.
  - Prediction of Quantum dynamics using PINN. We found that interpolation could be achieved, but fails miserably at extrapolation.

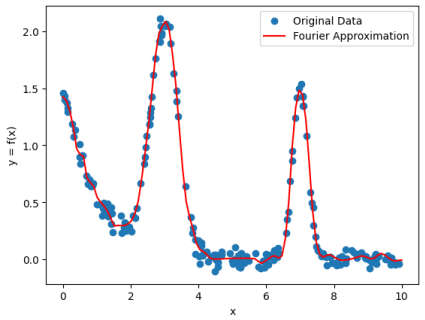
Related works

1. **Hamiltonian Neural Networks:** [2] Explains how one can extract Hamiltonian of a classical system using neural networks and use them to predict the evolution of states for longer period of time.
2. **Prediction of Arbitrary Quantum Process:**[3] Explains how even if the quantum process involved is highly complex, there exist a low-dimensional effective Hamiltonian that can capture the dynamics effectively.
3. **Fisher information for wave-function inference:**[1] Explains how to use the concept of Fisher information to predict the pure state's wave-unction from limited measurements of expectation values of an operator.

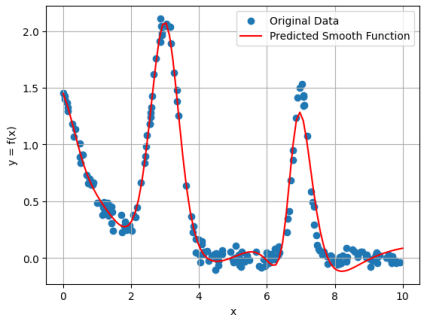
Methodology



(a) Taylor Expansion



(b) Fourier Expansion



(c) Deep NN

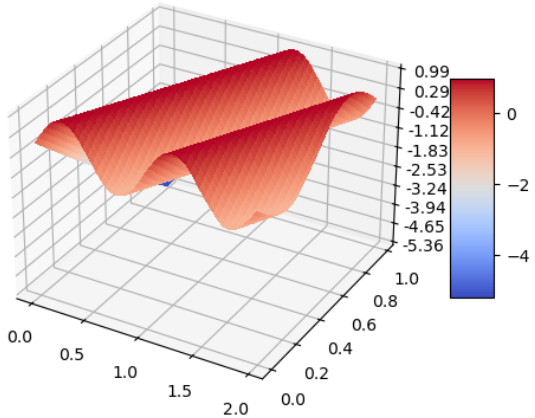


Figure: Prediction of Classical Dynamics - Advection Equation

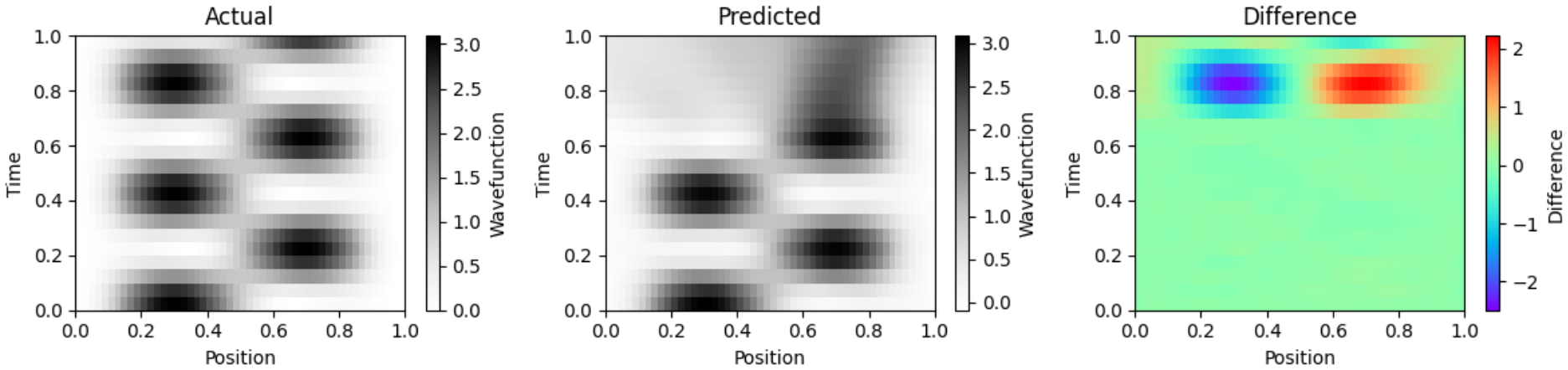


Figure: Failure of simple PINN

The actual answer we need is the oscillation of Gaussian like peak (as can be seen in the figure). When the model is trained on the data with time series information till $t = 0.6$, it just 'remembers' the data and is unable to generalise beyond $t = 0.6$. Hence we can say that the model can interpolate well but is unable to extrapolate.

Future Plans:

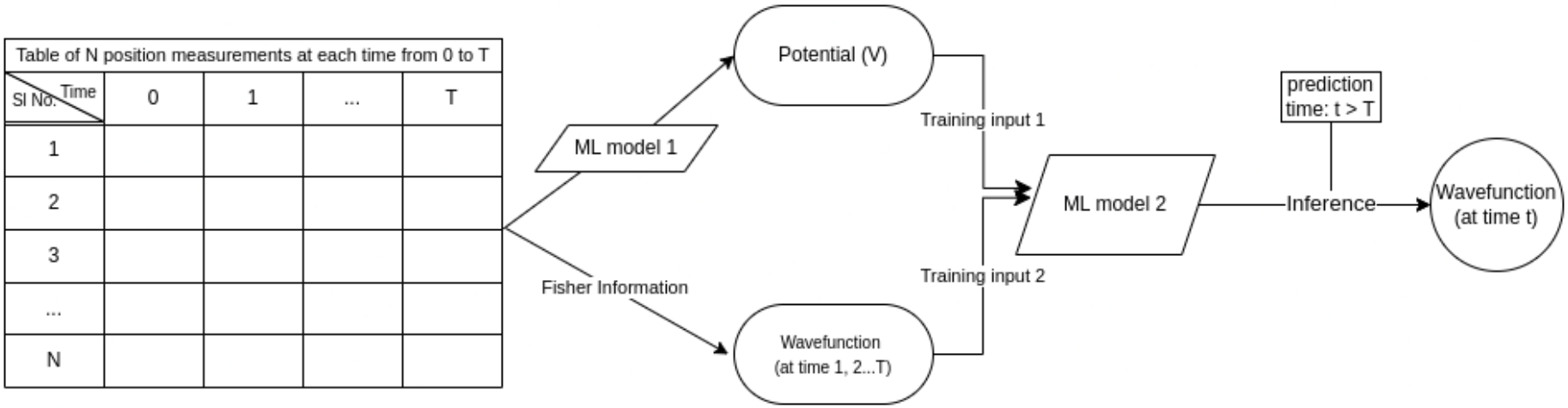


Figure: The prediction pipeline to be implemented

References:

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