Quantum Reservoir Computing for Time Series Prediction

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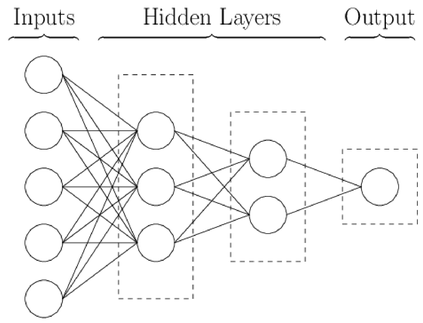
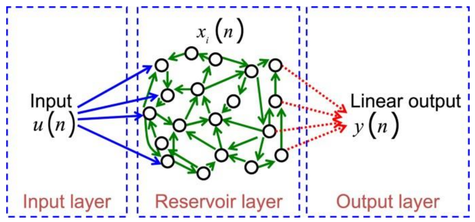
Background: Neural Networks and Time Series

- Inspired by the human brain, neural networks process data through interconnected neurons
- A time series is data measured over evenly spaced time intervals
- QRC has been shown to be able to classify entangled input states
- The Hilbert space allows for exponential growth with system size, where as the classical parameter space does not [2]



Motivation:

- Reservoir computing transforms inputs into a high-dimensional space so that the features of the inputs can be efficiently read out by a simple learning algorithms
- Quantum reservoir computing (QRC) utilizes the nonlinear nature of quantum mechanics to form the nonlinear reservoir
- **An approach to make machine learning algorithms faster**



Method

- **Hamiltonian:**
  - Our Hamiltonian is derived from the Ising model

$$H = -\sum_{\{ij\}} J_{ij} Z_i Z_j - \sum_j h_j Z_j$$

  - J_{ij} – Interaction strength
  - h_j – Magnetic field strength
- **Mapping:**
  - For example, a system with M=8 qubits will have $8 * 8 + 8 * 1 = 72$ parameters to determine in our Hamiltonian
  - Take the last 72 time steps in our input, and arbitrarily map to these parameters
  - The output of the Hamiltonian will be various expectation values for each M qubit. Some set of these will be mapped to the outputs.
- **Training:**
  - The primary source of training is in the mapping between expectation values of M qubits, and the outputs of the algorithm
- **Testing:**
  - Test on various mappings between time steps and Hamiltonian parameters
  - Test on various inputs. Different time series will have different underlying mathematical model and the algorithm should perform well on this variety
    - Stock prices, weather prediction, etc

Current Work

- Previously, QRC papers were replicated for their results in quantum over classical advantage.
  - Computational requirements were too high
  - Physical requirements of circuits were too high to justify experimentation on hardware rather than simulation on classical systems
- Developing and testing algorithm described in Methods

Future Work

- Evaluating the algorithm on multiple data sets
- Potentially testing various input to Hamiltonian parameter maps, to find underlying patterns
- Experimentation on hardware

Acknowledgements & References

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