Evaluation of Spiking vs. Artificial Networks in Reinforcement Learning of Control Tasks

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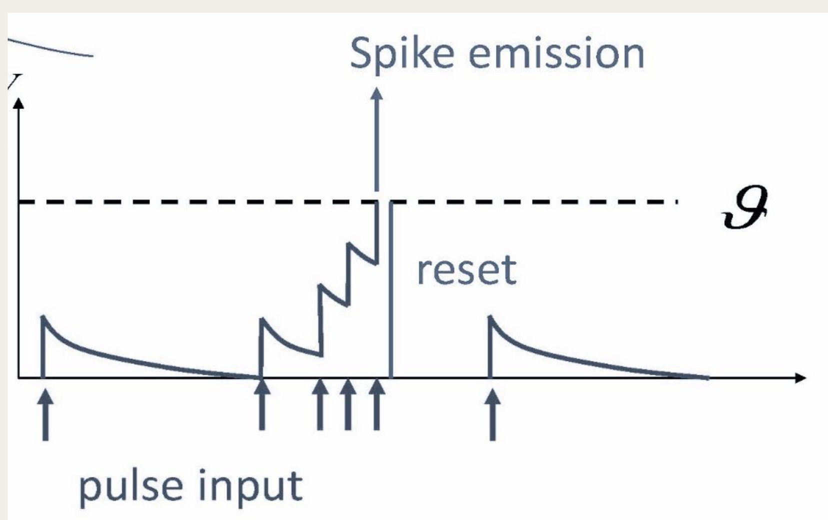
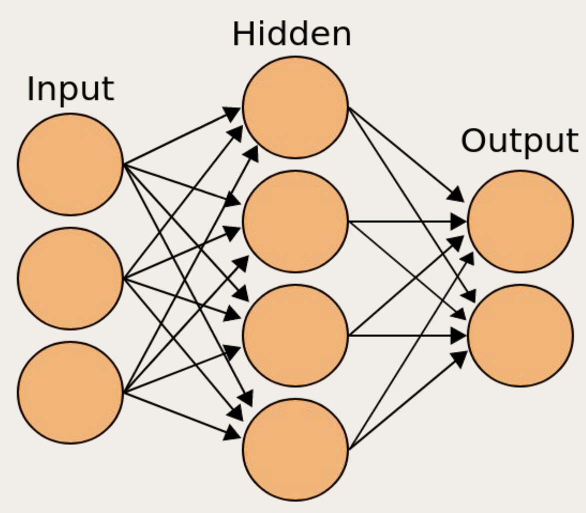
Motivation & Objectives

1. The biological brain learns *extremely* **efficiently**
2. Spiking neurons model **real biological neurons**
3. Neuron firing is **event-based** and **real-time**
   Temporal representations of information
4. **Biological plausibility** for learning control tasks
5. Evaluate the performance, efficiency, and implementation complexity of SNNs vs. ANNs





Methodology

Classic **Reinforcement Learning** problem
Trained for **250 episodes** on GPU

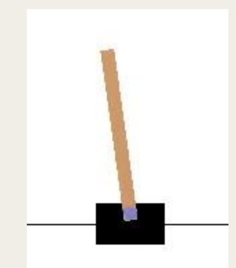
1. **Libraries:** PyTorch + Norse
2. **Network Implementations:**
   SNN: Constant-Current Encoding of inputs
   Leaky-Integrate & Fire (LIF) Neurons with recurrent spiking & linear weighting of outputs
   ANN: 2 Hidden Layers w/ ReLU activation
   Both networks used:
   Dropout to prevent overfitting
   Adam optimizer with adaptive learning rate
3. **Hyperparameter Tuning**
4. **Analysis and Evaluations**

Future Work & Conclusions

1. Facilitation of state-current-action representations.
2. Analyze how performance scales with more complex network topologies and RL tasks.
3. Spiking networks have great potential to improve upon the classic network models in many ways.
4. However, they are difficult to train and complex to understand which is still a limiting factor.
5. Continued research efforts seek to unlock the full potential of SNNs to enable fast & efficient learning comparable to the human brain.

OpenAI Gym - CartPole

Goal: Balance a pendulum on a sliding cart
Observation space: position, angle, velocities
Action space: push cart left or right



Challenges in Representation:

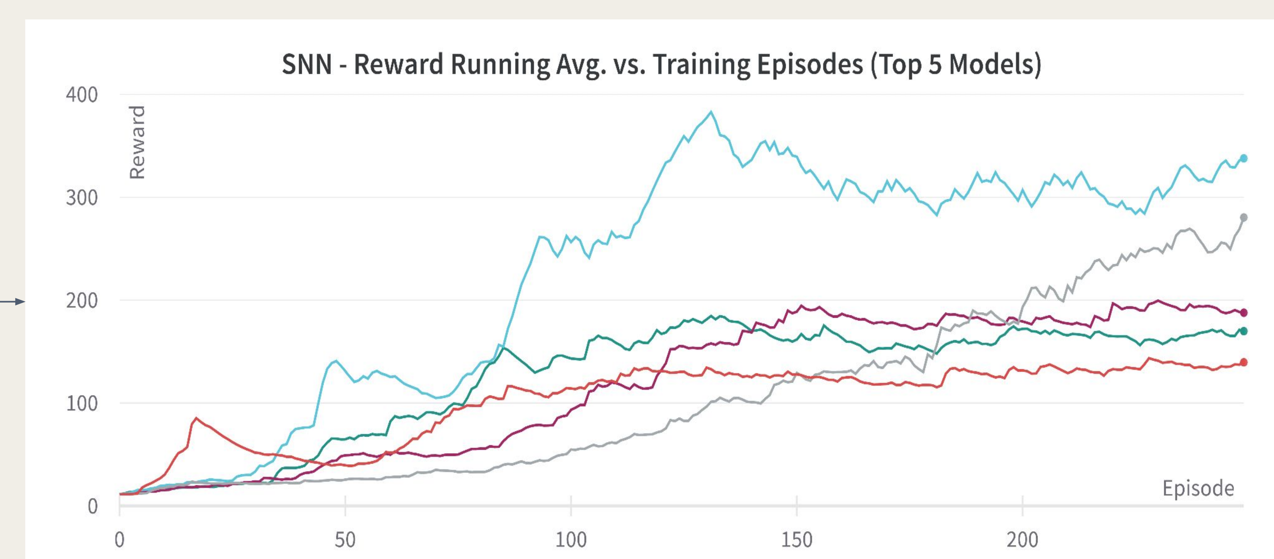
1. Encoding of states made up of both continuous and discrete variables
2. Decoding multivariate continuous actions

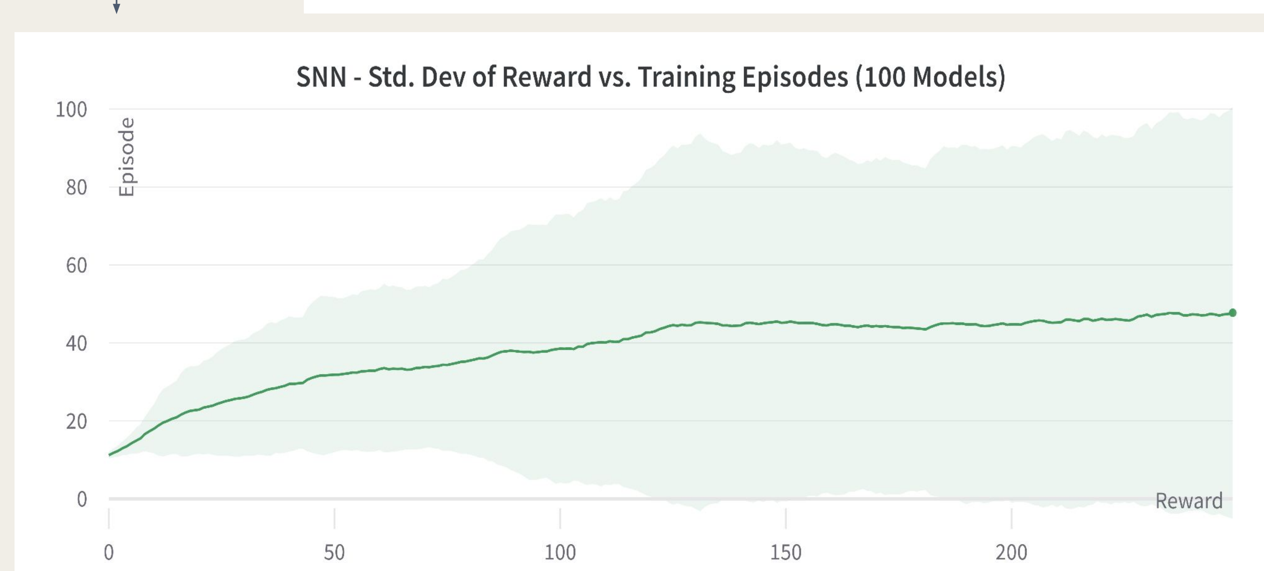
Results

SNN: Higher avg. scores in less episodes.
Efficient learning, but prone to overfitting.
Worse variance in scores, also very sensitive parameter choices and random initialization.

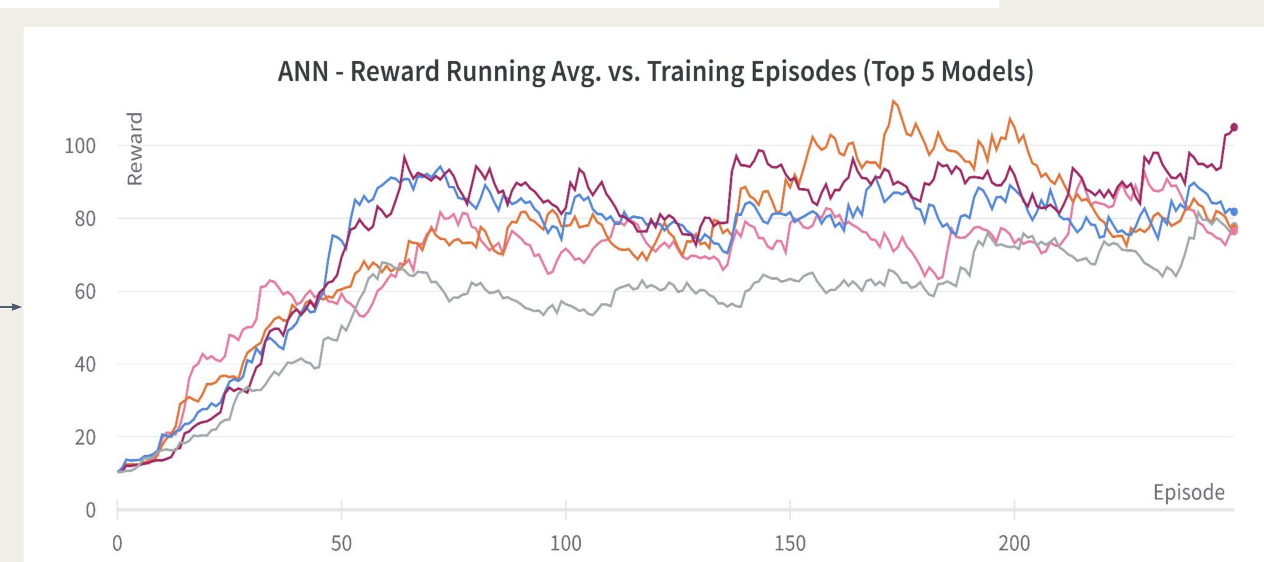
ANN: Better variance in scores among models.
Lower overall avg. scores. Likely to benefit from deeper network topologies.

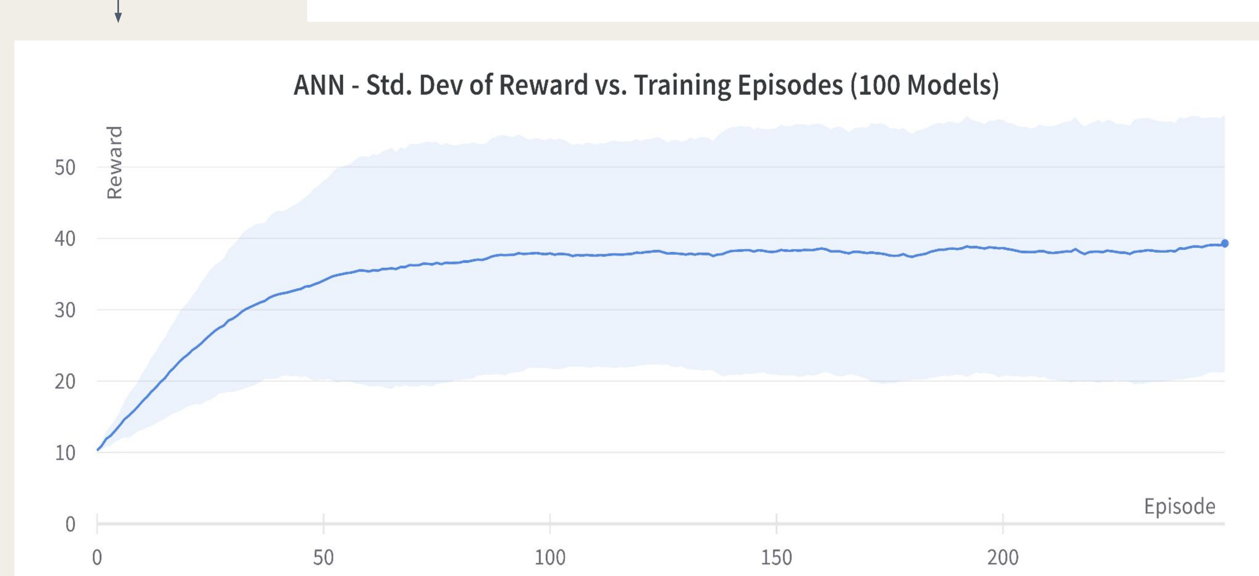
SNN





ANN





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