# Reinforcement Learning

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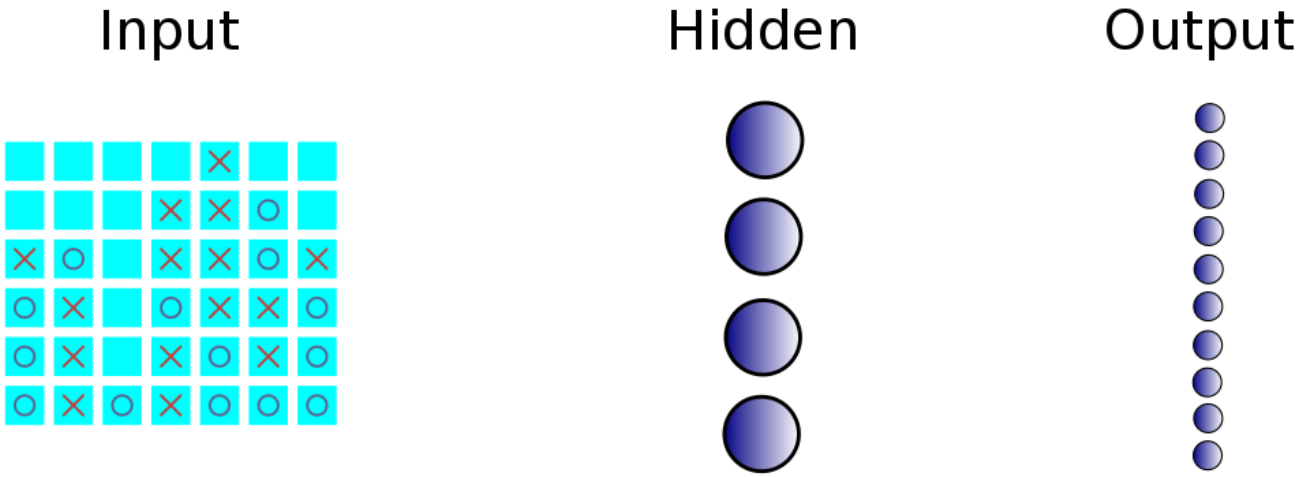
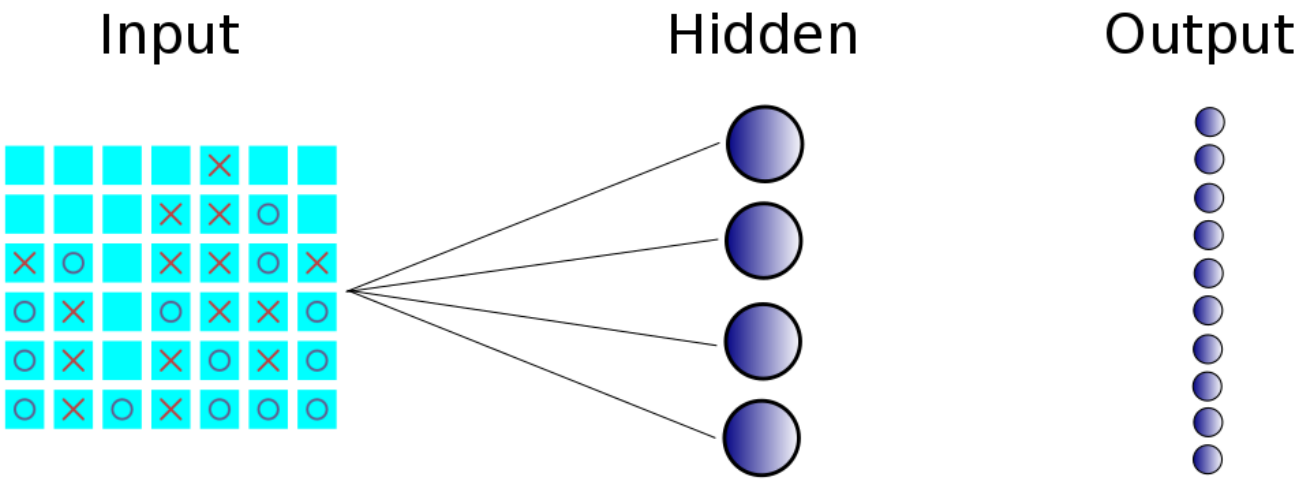
# Outline


1. Machine Learning
2. Neural Networks
   - Simple Perceptron
   - Multilayer Perceptron
   - Convolutional Neural Network
3. Temporal Difference Learning
4. results
5. The End

# Supervised Learning vs Reinforcement Learning

- Supervised Learning
  - Have access to a large set of data with known desired results
  - Adjust model parameters to minimize an objective function
- Reinforcement Learning
  - Have access to an environment that can be modeled
  - Typically a reward function is used as a signal for how to adjust model parameters
  - Board games present a natural environment that is easily modeled and can provide a reward whenever a game finishes.


Input
Hidden
Output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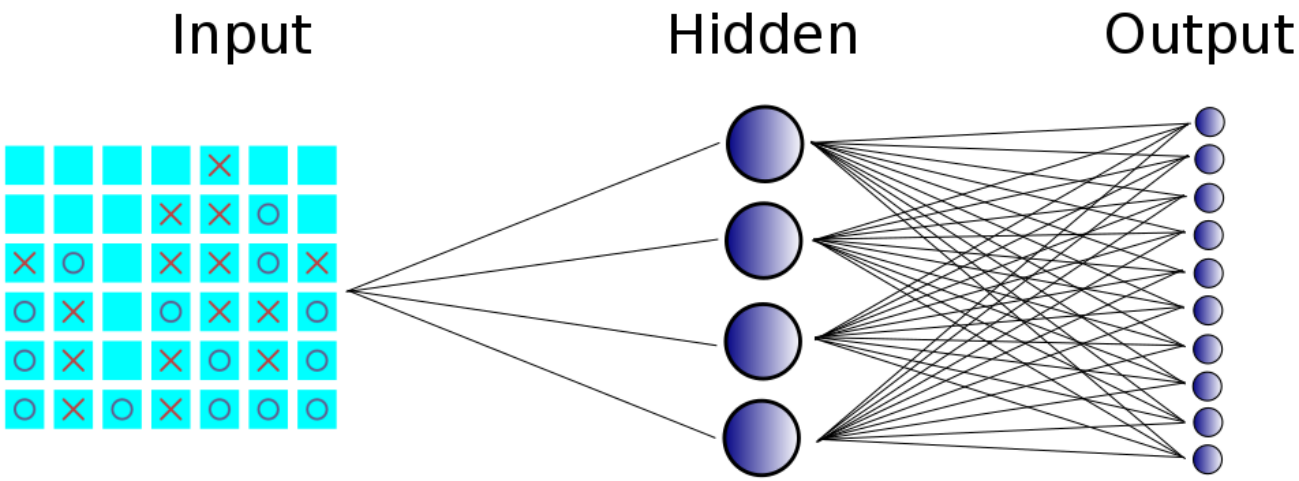
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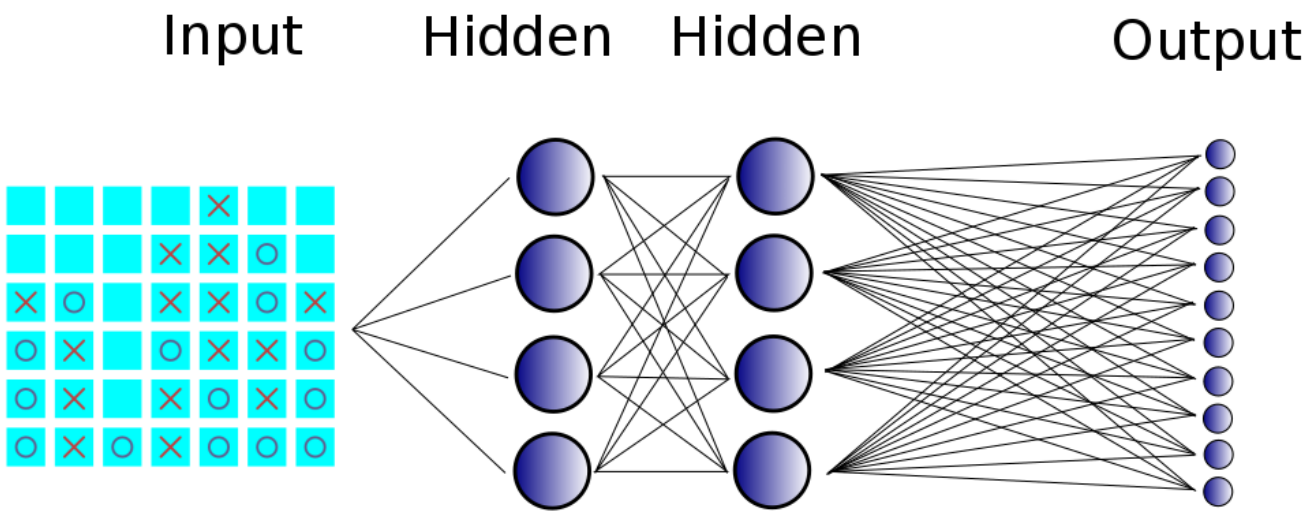
Output


Input
Hidden
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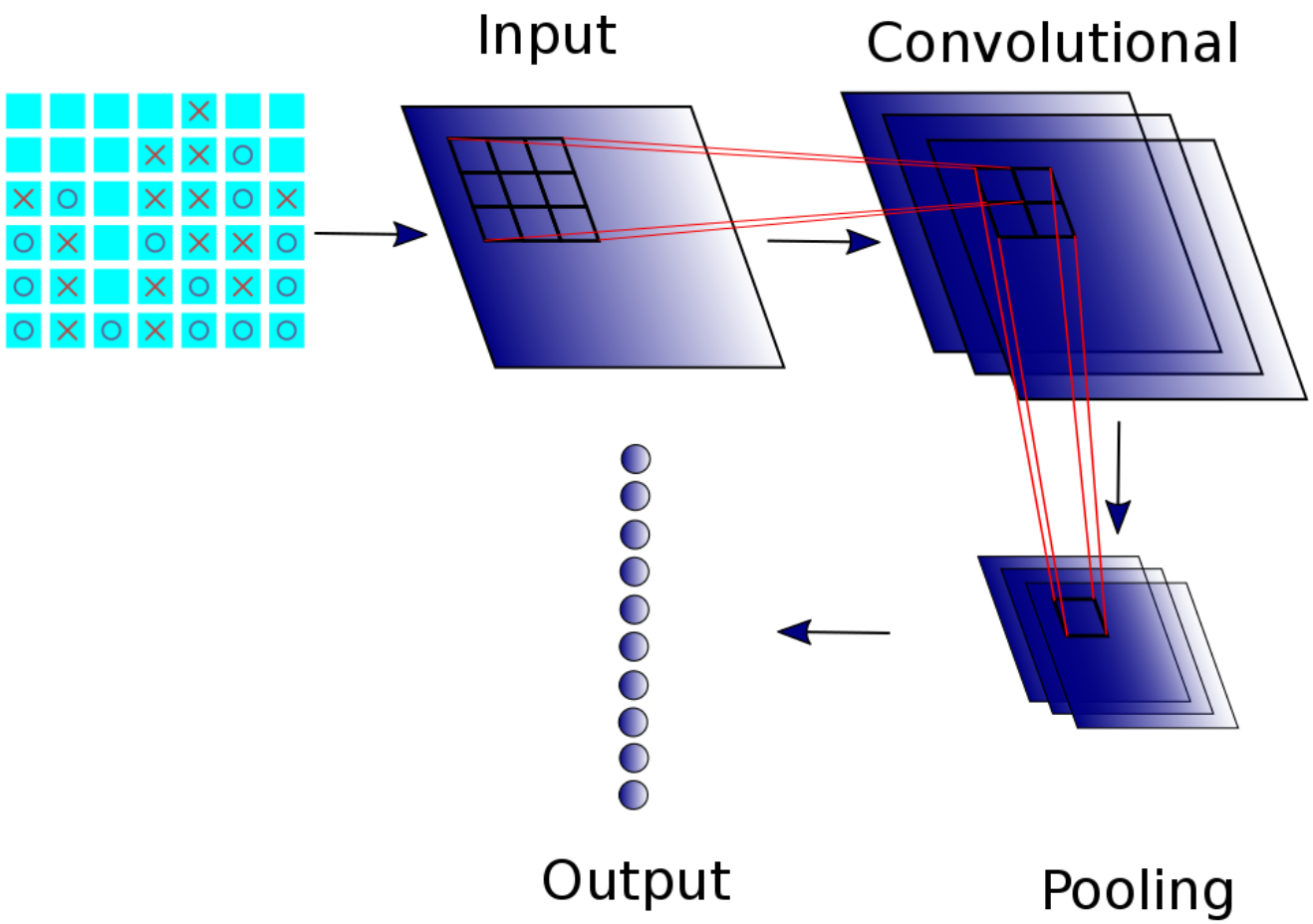
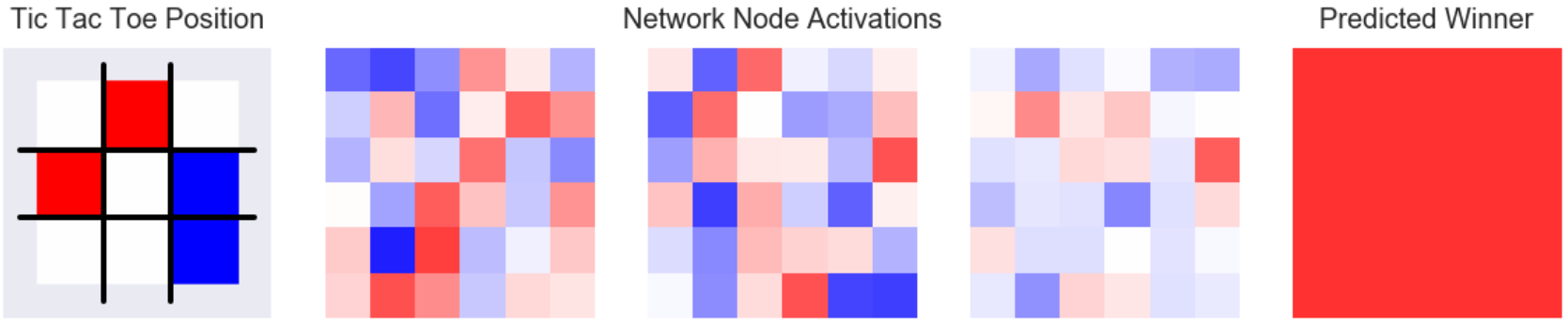
Output


Input
Convolutional
Output
Pooling

# Value Network

- A value network is a neural network that evaluates an environment and determines a value to associate to it
- In the case of board games, a value network can be used to determine the probability of winning from any given position
- Here is an example of a multi-layered neural network in action
- The network takes a Tic Tac Toe board as input, and through a succession of node activations the network outputs a prediction on who will win, in this case: the red player

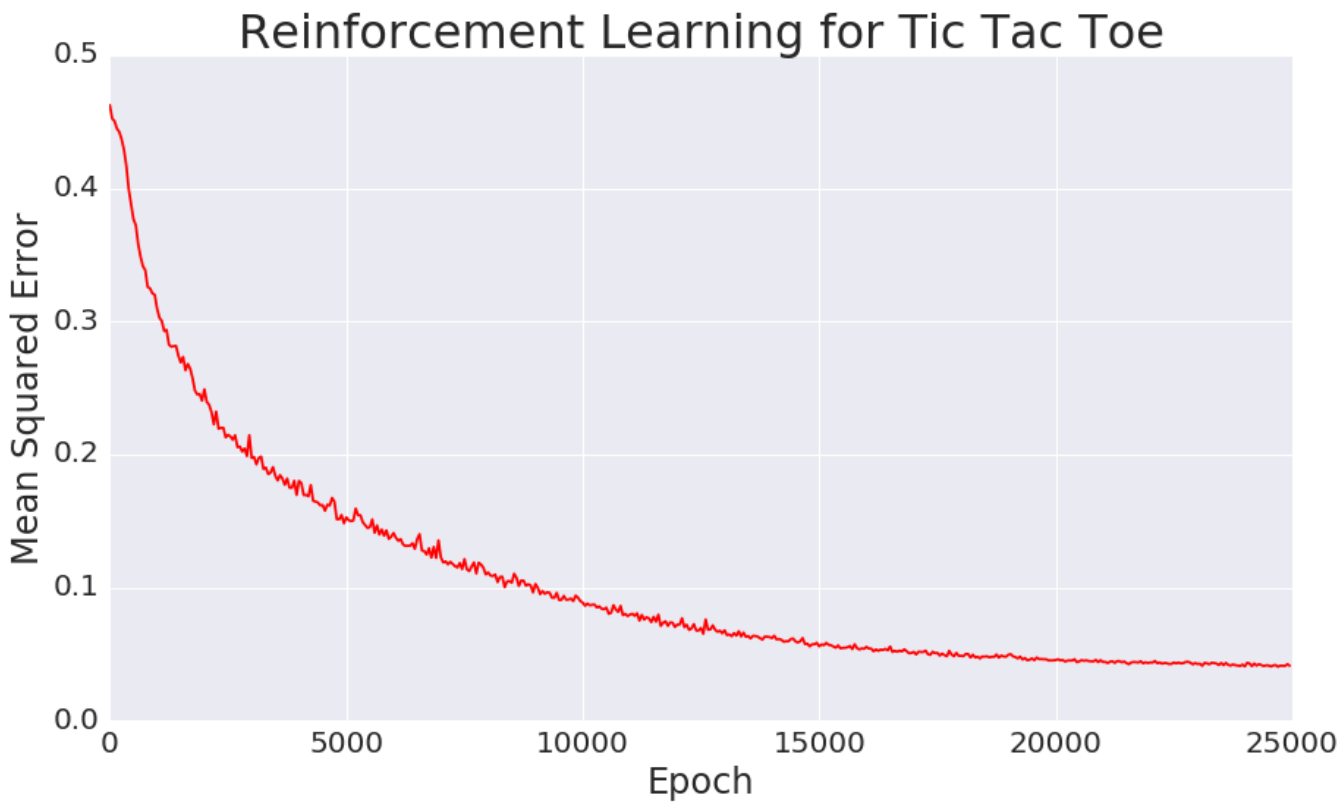


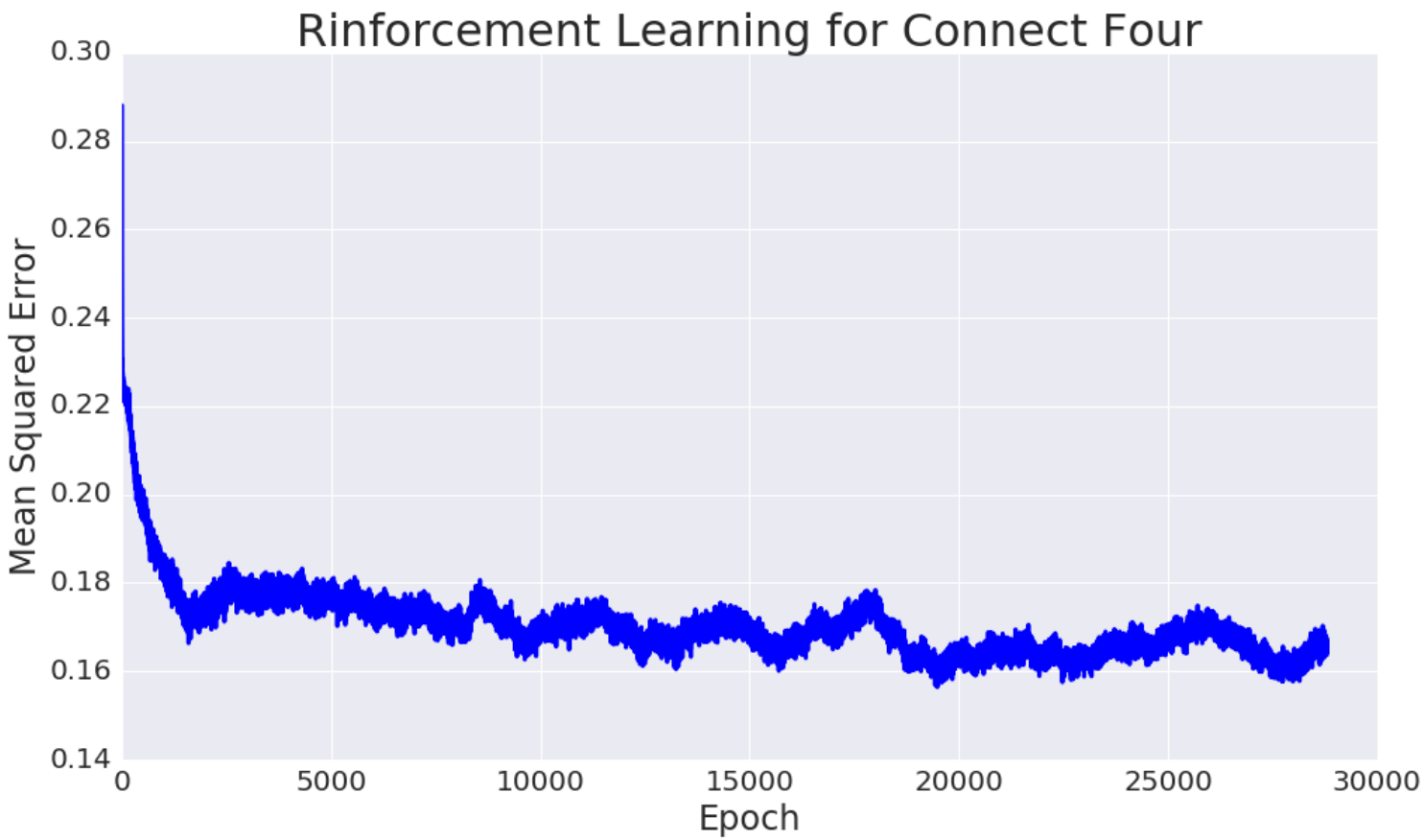
- TD($\lambda$) Equation

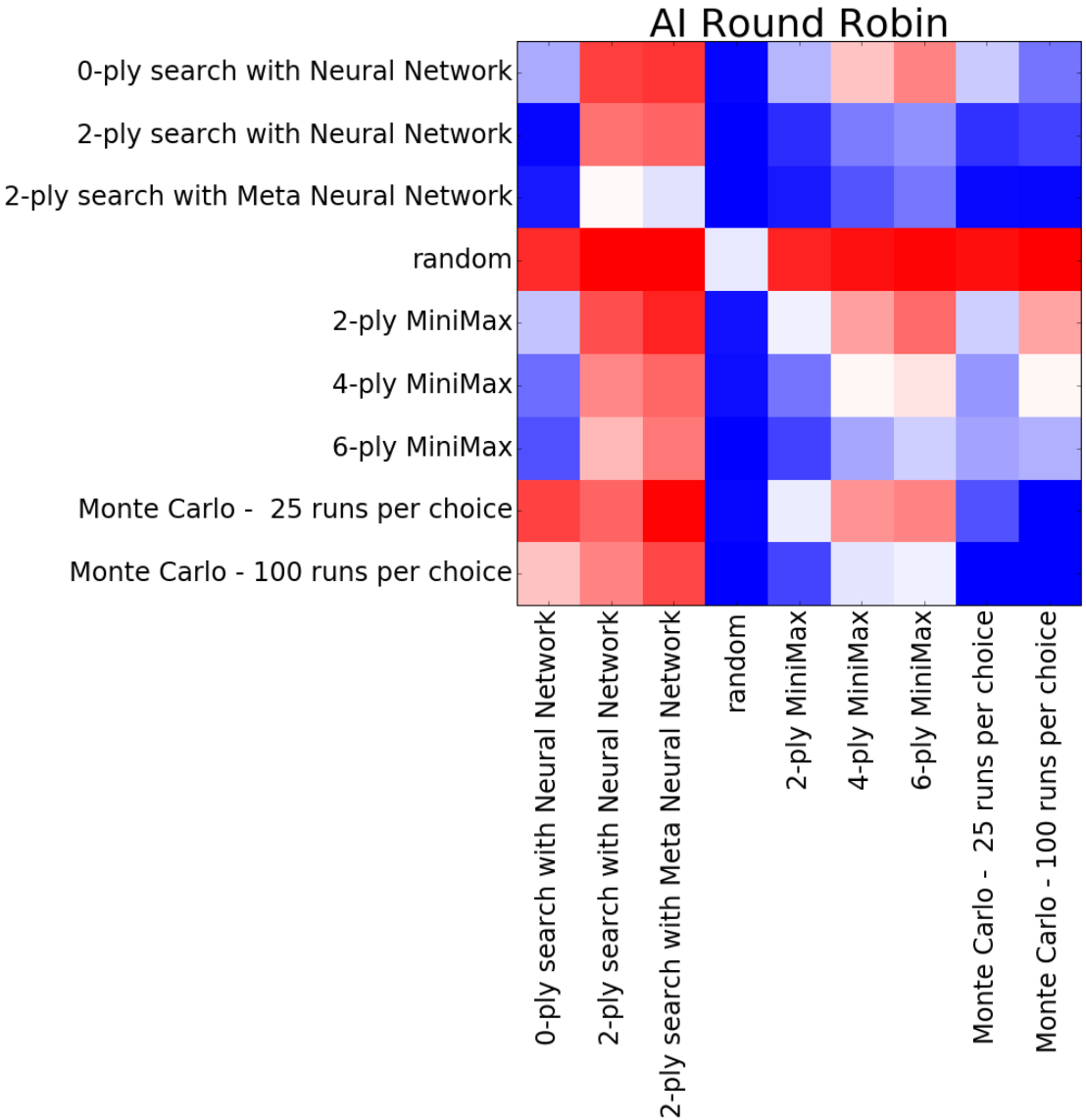
$$T_n = \quad (1-\lambda) \quad V_n + \lambda \quad r$$

- TD($\lambda$) Equation

$$T_n = \sum_{n=0}^{N_0} (1-\lambda)\lambda^n V_n + \lambda^{N_0} r$$


Reinforcement Learning for Tic Tac Toe
Mean Squared Error
0.0
0.1
0.2
0.3
0.4
0.5
0
5000
10000
15000
20000
25000
Epoch


Rinforcement Learning for Connect Four
Mean Squared Error
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0
5000
10000
15000
20000
25000
30000
Epoch


AI Round Robin
0-ply search with Neural Network
2-ply search with Neural Network
2-ply search with Meta Neural Network
random
2-ply MiniMax
4-ply MiniMax
6-ply MiniMax
Monte Carlo - 25 runs per choice
Monte Carlo - 100 runs per choice
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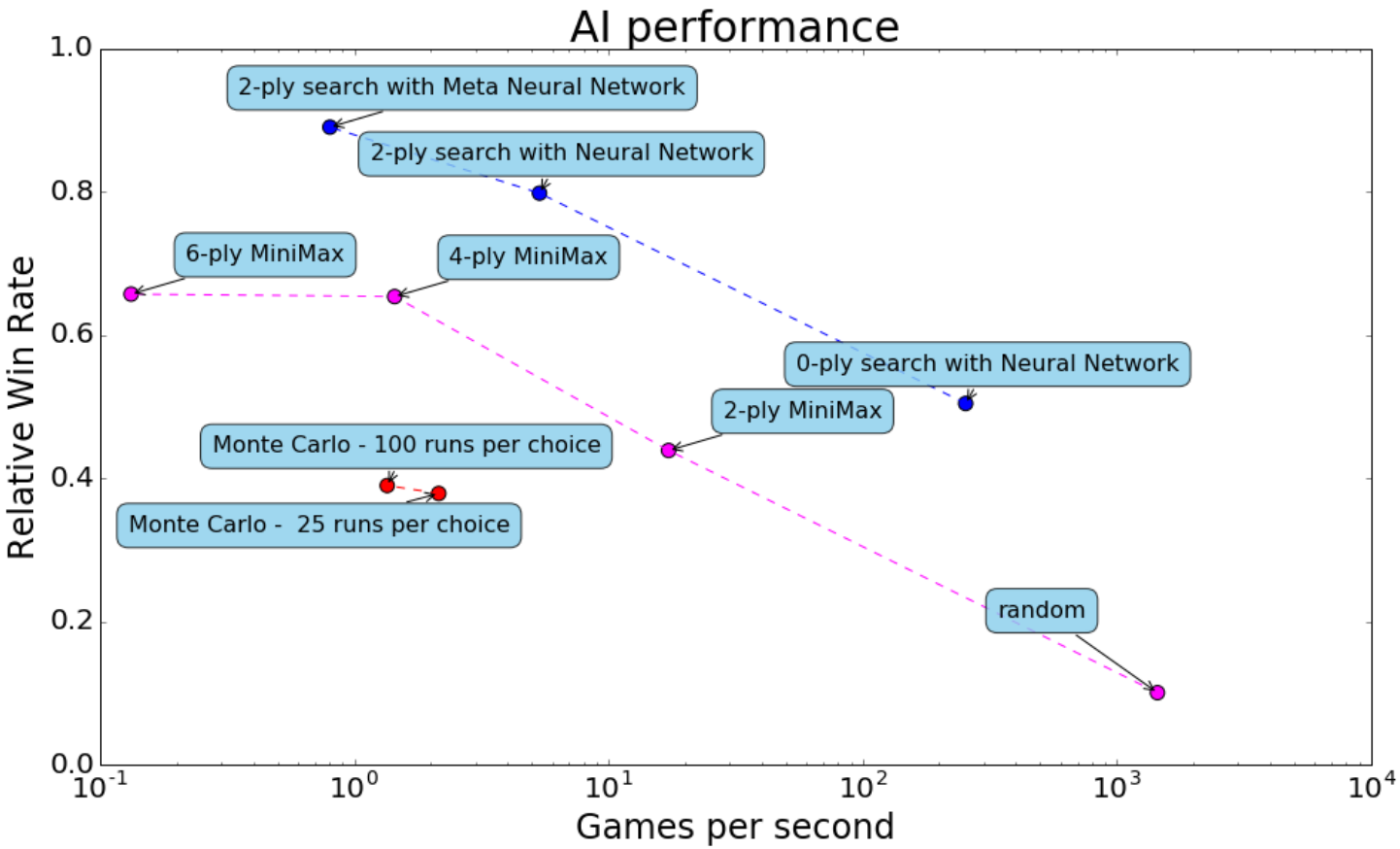
AI performance
2-ply search with Meta Neural Network
2-ply search with Neural Network
6-ply MiniMax
4-ply MiniMax
0-ply search with Neural Network
2-ply MiniMax
Monte Carlo - 100 runs per choice
Monte Carlo - 25 runs per choice
random
Relative Win Rate
Games per second
1.0
0.8
0.6
0.4
0.2
0.0
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
$10^{3}$
$10^{4}$

# The End

The End