Deep Learning

Project Proposal

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Proposed Problem

The goal of this project is to train a reinforcement learning agent to play Tetris using the Tetris Gymnasium environment. Tetris is a NP-Hard problem which means that while we can verify a solution efficiently, there is no known algorithm to find a solution efficiently in polynomial time. Solving Tetris is interesting because it pushes RL agents to reason over delayed rewards and manage increasingly complex game states. Success in this environment would demonstrate an agent's ability to balance immediate and long-term strategies in complex environments.

Importance of the Problem

Since Tetris is in NP-Hard problem, training a reinforcement learning agent to play it means attempting to create an algorithm to solve an NP-Hard problem. Many NP-Hard and NP-Complete problems share underlying structural similarities, like scheduling, routing, packing, and optimization challenges. Advancements made by successfully training an agent on Tetris could inspire new methods or heuristics that generalize to solving real-world NP-Hard problems, such as optimizing supply chains, allocating limited resources, or even aspects of automated theorem proving.

Challenges

1. Tetris requires the agent to plan many steps ahead, making short-sighted strategies ineffective.
2. The state and action spaces grow significantly as the game progresses.
3. Sparse and delayed rewards make it difficult to train and for the model to create complex strategies.

Environment

Instead of using a dataset, the agent will use the Tetris Gymnasium from https://github.com/Max-We/Tetris-Gymnasium, which has been designed for reinforcement learning agents to interface with.

Method and Improvements

I propose to use a Deep Q-Network (DQN) as the baseline RL method. Tetris Gymnasium was built to support DQN agents. Based off performance, I may look into RL algorithms such as Double DQN, Dueling DQN, or PPO to improve performance beyond simple Q-learning. The Tetris Gymnasium has a couple examples, but I plan to improve these by placing an emphasis on penalizing quick, simple strategies and rewarding complex, long game strategies. I may also begin with easy, small board setups, then advance to larger, complex boards to push the agent.

Evaluation

Since Tetris already has a points system built in, evaluation of the agent is straightforward. However, I plan on making this more complex by evaluating based on the number of rows cleared and length of games to reward more complex strategies.