

Training and Improvement of Bots in Card Games, and Why Do We Need Them?

Yiheng Zhou

NetEase

About Us:



- As a leading internet technology company based in China, NetEase, Inc. (NASDAQ: NTES; HKEX: 9999) is dedicated to providing premium online services centered around innovative and diverse content, community, communication and commerce. NetEase develops and operates some of China's most popular mobile and PC-client games. In more recent years, NetEase has expanded into international markets including Japan and North America. In addition to its self-developed game content, NetEase partners with other leading game developers, such as Blizzard Entertainment and Mojang AB (a Microsoft subsidiary), to operate globally renowned games in China. NetEase's other innovative service offerings include the intelligent learning services of its majority-controlled subsidiary, Youdao (NYSE: DAO); music streaming through its leading NetEase Cloud Music business; and its private label e-commerce platform, Yanxuan.

About Us:



- Some Game Products:



* *UNO!* is developed by Mattel 163 and it's server and operation in China is represented by NetEase

Content

- 1、 Background & Introduction**
- 2、 Technology & Solutions**
- 3、 Card Game AI Study**
- 4、 Beyond the Algorithm**

Background & Introduction

Game Bots

- Game Bots played a role since the early days of video games, and are very important in almost all types of games.
- Game Bots are an instance of artificial intelligence (AI) that can perform similar game behaviors like real players.

Game AI

- Game artificial intelligence (AI)

generate

behaviors of non-player characters (NPC)

- The purpose of Game AI is to improve the experience of game players, rather than trying to obtain a general artificial intelligence that passes the Turing test.

Game AI - Types & Examples



(Non-combat related) NPC



Teammate



Enemy



Environment

Game AI - in multiplayer online games

- The rhythm of the game can be adjusted to smooth the player's experience.
- It can balance the matching time, providing teammates or matching opponents.
- It can also be used for player training, challenge.
- Build the PVE part of a multiplayer online game.

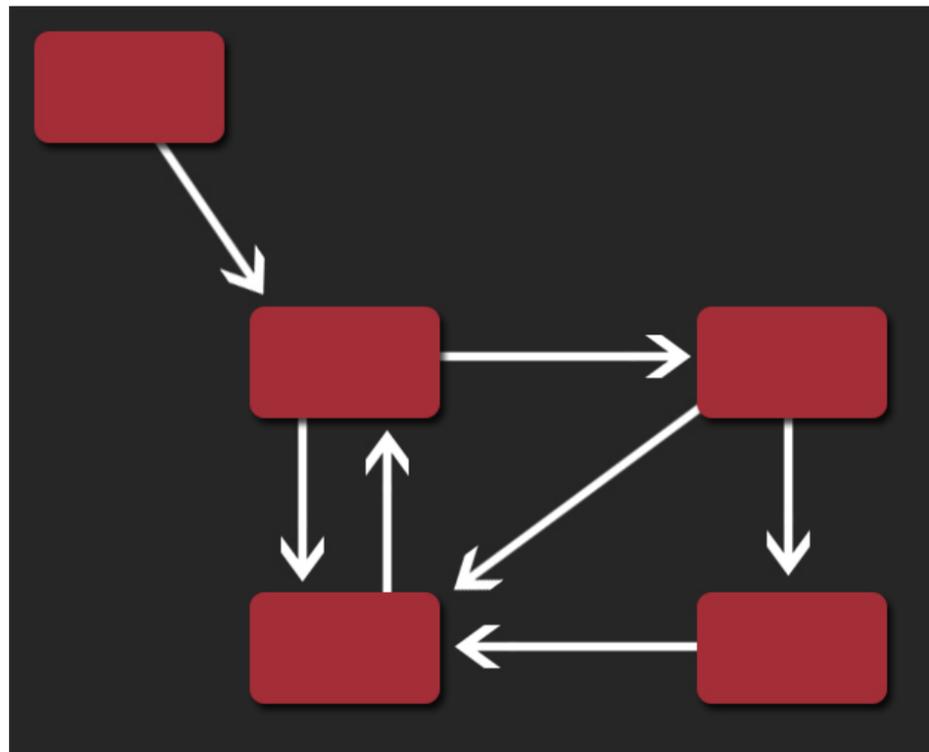
Technology & Solutions

Game Bots Solutions

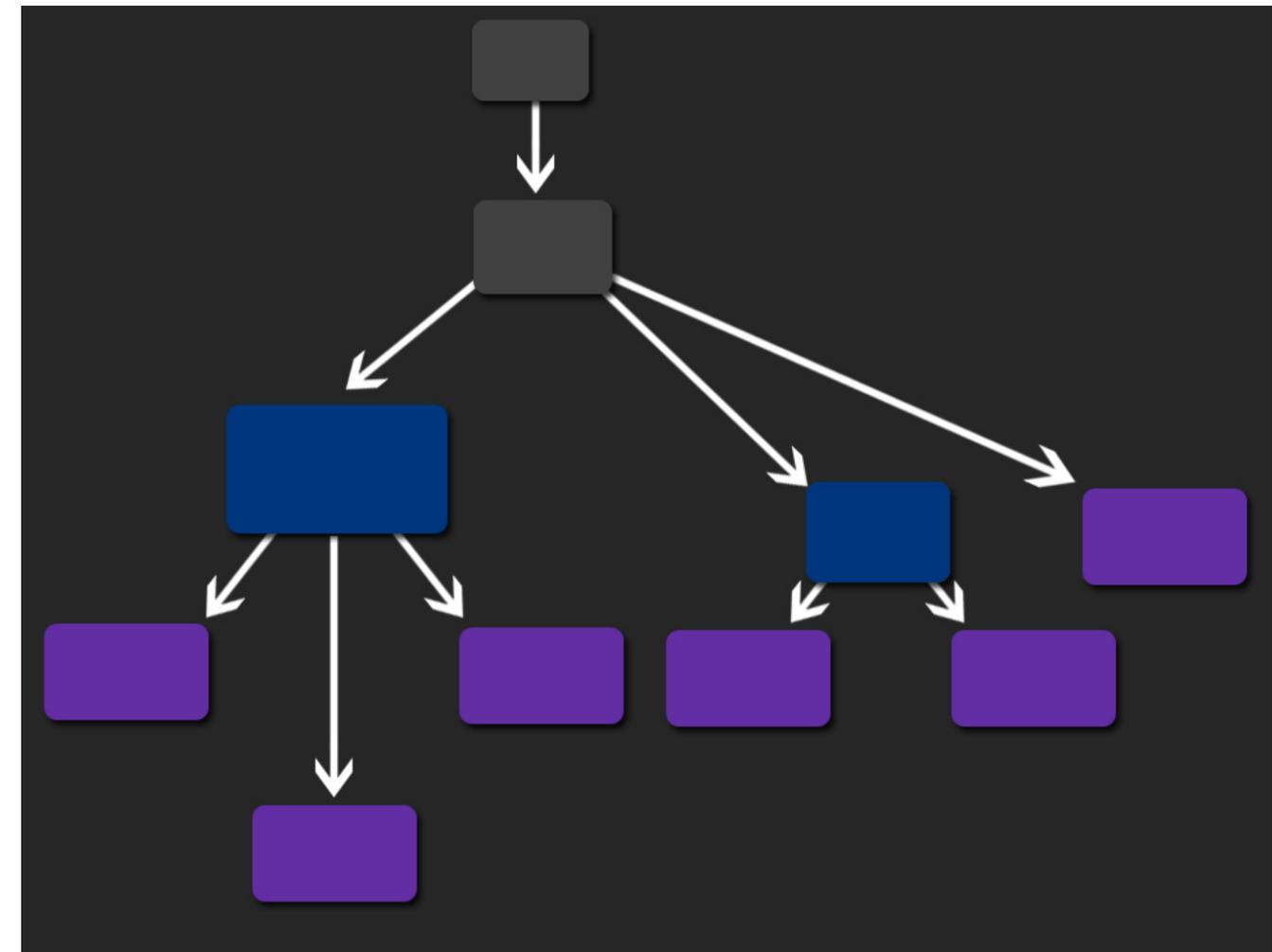
- Static bots
 - hard-coded in bots logic.
- Dynamic Game Bots
 - based on the realization of machine learning and artificial intelligence.

Static Game Bots Solutions

- Finite-State Machine



- Behavior Tree



Finite State Machine - Introduction

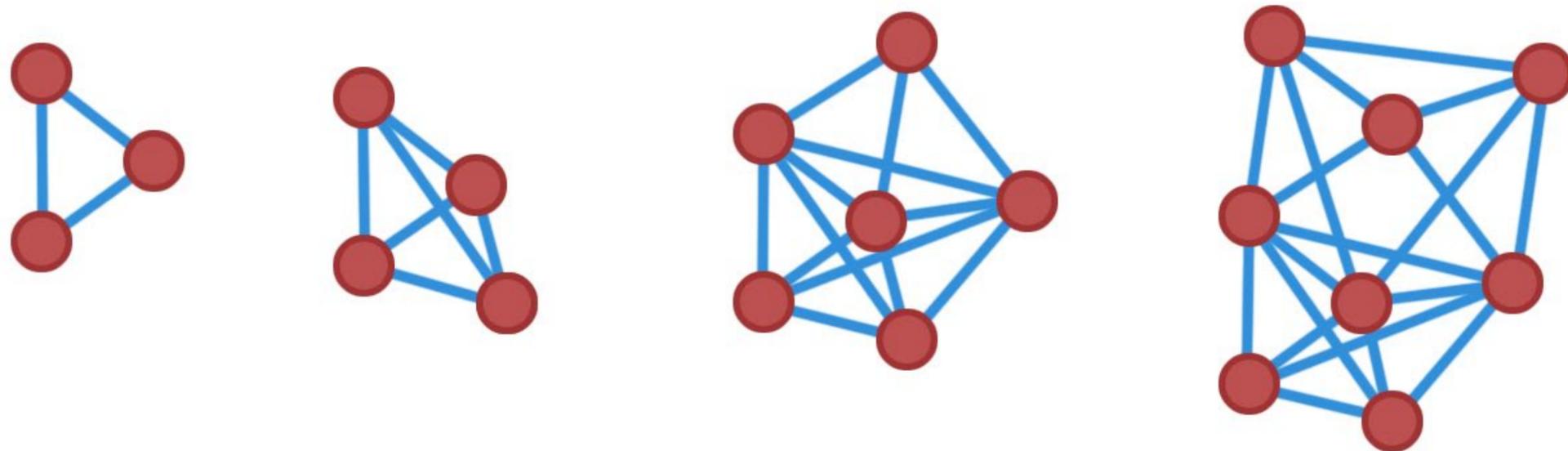
- Finite State Machine contains a finite number of states and transition conditions between states. The most straightforward view is to think of a finite state machine as a combination of several if...else... statements.
- Example: Player's partner:
 - It will run over and attack when it sees enemies;
 - It will come to help when it finds the player being attacked;
 - It will heal the player when it finds the player is injured;
 - If it is not the case above, it will just follow the player;

Finite State Machine - Definition

- Definition: **Finite State Machine (FSM)** is a mathematical model that represents a finite number of states and transitions and actions between these states.
- Concept:
 - State: a certain form of an object.
 - Transition: a state change.
 - Action: the activity to be performed at a given moment.
- The state machine is the manager used to control the state of the object.

Finite State Machine - Discussion

- Finite state machine fits our cognition very well, but it has a shortcoming -- it quickly becomes intricate with the increase of states and transition conditions.
- It is difficult for traditional finite state machine to implement and maintain the complexity Game AI.



Behavior Tree - Introduction

- Behavior Tree, is a tree structure composed of behavior nodes.
- The behavior tree uses a tree-shaped decision structure similar to a decision tree to select specific behaviors that should be performed in the current environment.

Behavior Tree - Definition

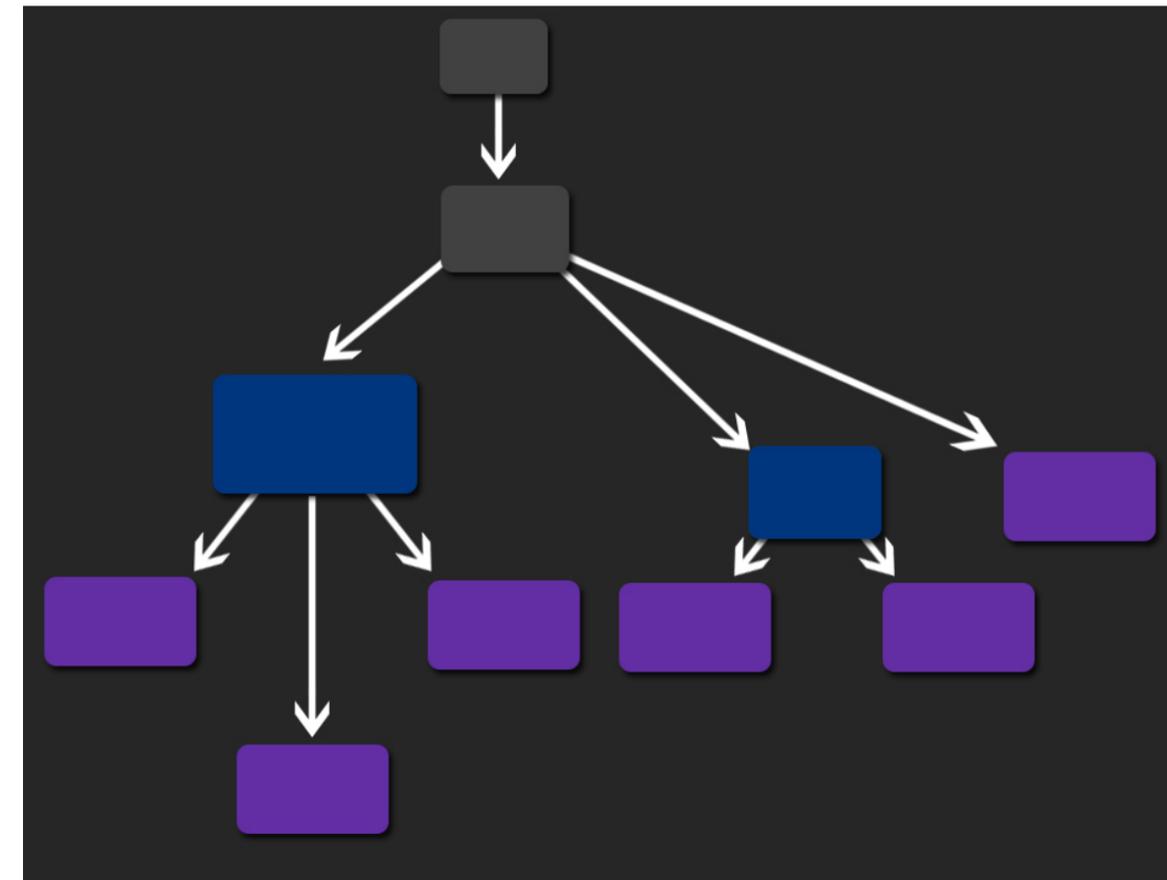
- Behavior Tree, each node represents a behavior.
- Nodes are hierarchical, and child nodes are controlled by their parent nodes.
- Nodes return one of three states as a result:

Success

Failure

Running

- Three types of nodes:
 - Composite node
 - Decorate node
 - Leaf node



Behavior Tree - Discussion

- One of the main advantages of Behavior Tree is its modularity, which makes the game logic more intuitive, and developers will not be confused by those complicated connections.
- There are many visualization tools for Behavior Tree, making the Game AI design more efficient.
- Skills are required to abstract the AI logic to build the tree.

Dynamic Game Bots Solutions

- The limitations of the rule-driven Static Game Bots Solutions:
 - * it is difficult for the rules to cover all situations
 - * a lot of manpower is needed to design and implement complex AI behavior logic.
- Artificial intelligence technology such as reinforcement learning is able to break through the above two limitations.
- More and more games claim that they use deep learning and other similar methods to improve the game's AI.

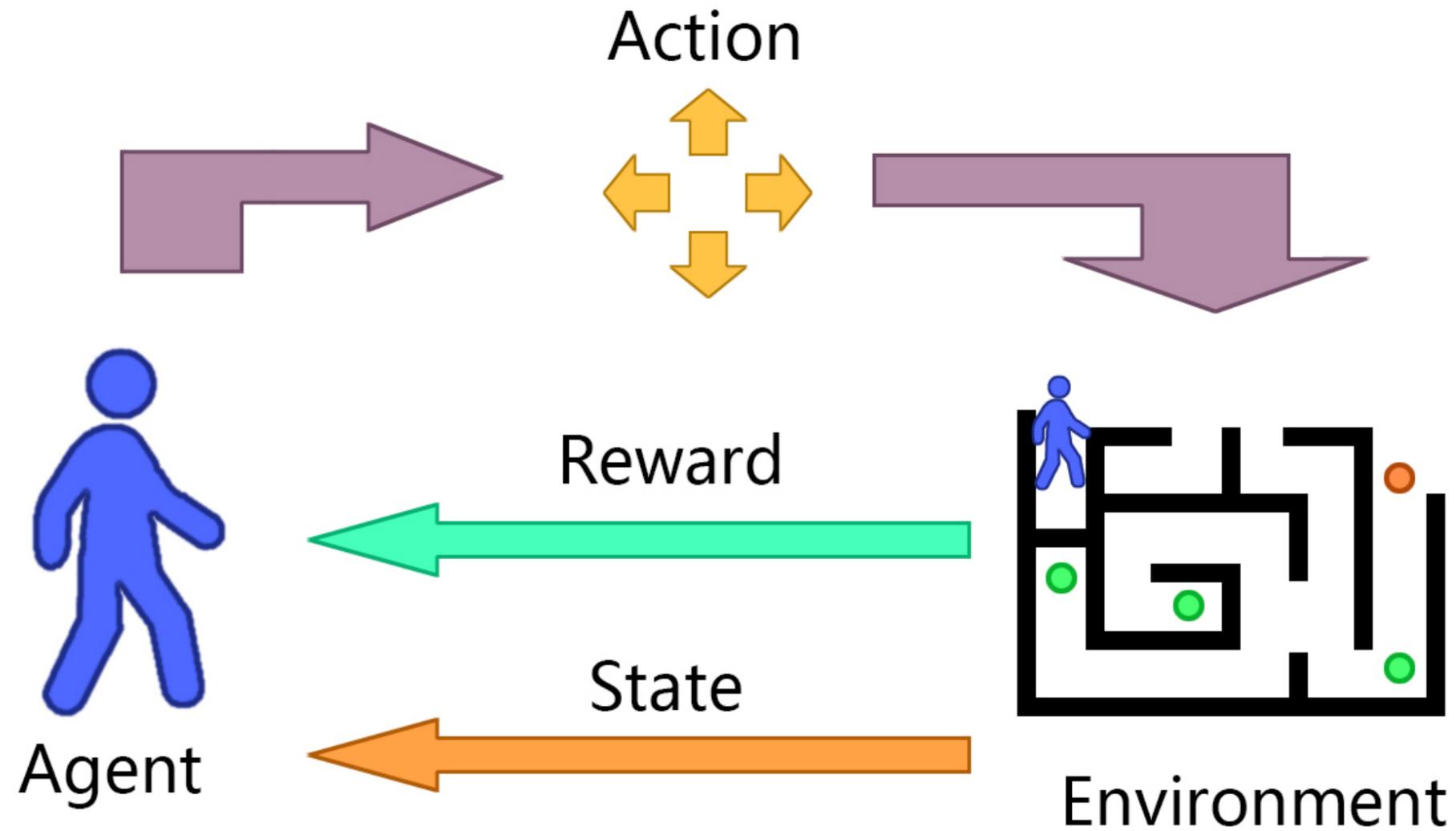
Reinforcement Learning - Introduction

- Reinforcement learning (RL) is an area of machine learning
- Supervised learning
 - labeled data \Rightarrow predicted label
- Unsupervised learning
 - unlabeled data \Rightarrow hidden structure
- Reinforcement learning
 - interaction and feedback with the environment
 - \Rightarrow strategies for the greatest long-term reward

Reinforcement Learning - Definition

- The basic model of reinforcement learning is the interaction between agent and environment.
- The goal of reinforcement learning is to hope that the individual gets the largest total reward from the environment in the long-term.
- The result of reinforcement learning is such an action decision called policy.

Reinforcement Learning - Example



Reinforcement Learning - Discussion

- Reinforcement Learning requires an environment to provide an approximately infinite number of samples (trajectory and reward).
- Many realistic environments are limited by the amount of labeled data sets.
- However, Game AI is a perfect platform for reinforcement learning.
- Reinforcement learning shows that this algorithm is very suitable for the study of game AI.

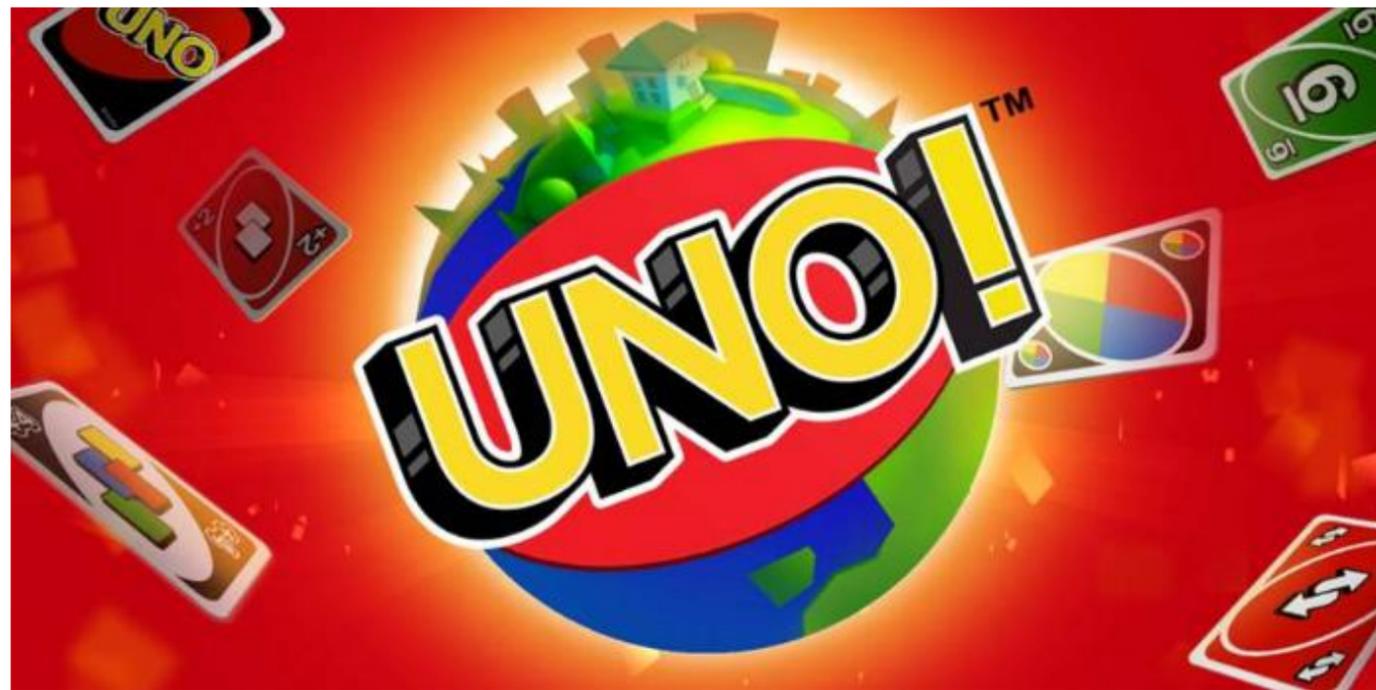
Reinforcement Learning - Discussion

- But in the real game product, to build the Game AI via Reinforcement Learning is not so simple:
 - The reward function is not well designed.
 - The winning percentage of robots does not represent the demand for robots in the game industry.
 - The difficulty of the game is not easy to adjust.
 - Model complexity brought by various game mechanics.
 - It's easy to fall into the local optima and produce trivial solutions.

Card Game AI Study

Why Card Games?

Currently, with the intensification of user time fragmentation and the improvement of mobile devices and Internet capabilities, the market share of multiplayer online card games with short single game sessions on mobile devices is also increasing.



* *UNO!*, a mobile card game with hundreds of millions of users over many countries.

Why Card Games? - Advantage

- State is discrete and easy to define and describe.
- The Gameplay is relatively fast, easy access to information, easy to explain.
- AI and people are fair, pure decision-making.
- The results are easily applied to actual game products.

Why Card Games? - Challenge

- The discrete state and turn-based game mechanism make it easier for users to perceive the behavior of Bots.
- The depth of AI model is complex because of the randomness.
- Combos leads to very large search space of algorithm.

Card Games AI Study

*"In recent years, **Hearthstone has become a testbed for AI research.** A community of passionate players and developers have started the **HearthSim** project and created several applications that allow simulating the game for the purpose of AI and machine learning experiments. A few spin-offs of that project, e.g. **HearthPWN** and **MetaStats**, provide tools for the players, which facilitate gathering data from their games. These portals obtain and aggregate users' data, such as game results, deck compositions, card usage statistics and provide this information to the community."*

—— Maciej Swiechowski, Tomasz Tajmajer and Andrzej Janusz,
"Improving Hearthstone AI by Combining MCTS and Supervised Learning Algorithms", arXiv:1808.04794v1

Card Games AI - Basic Solution

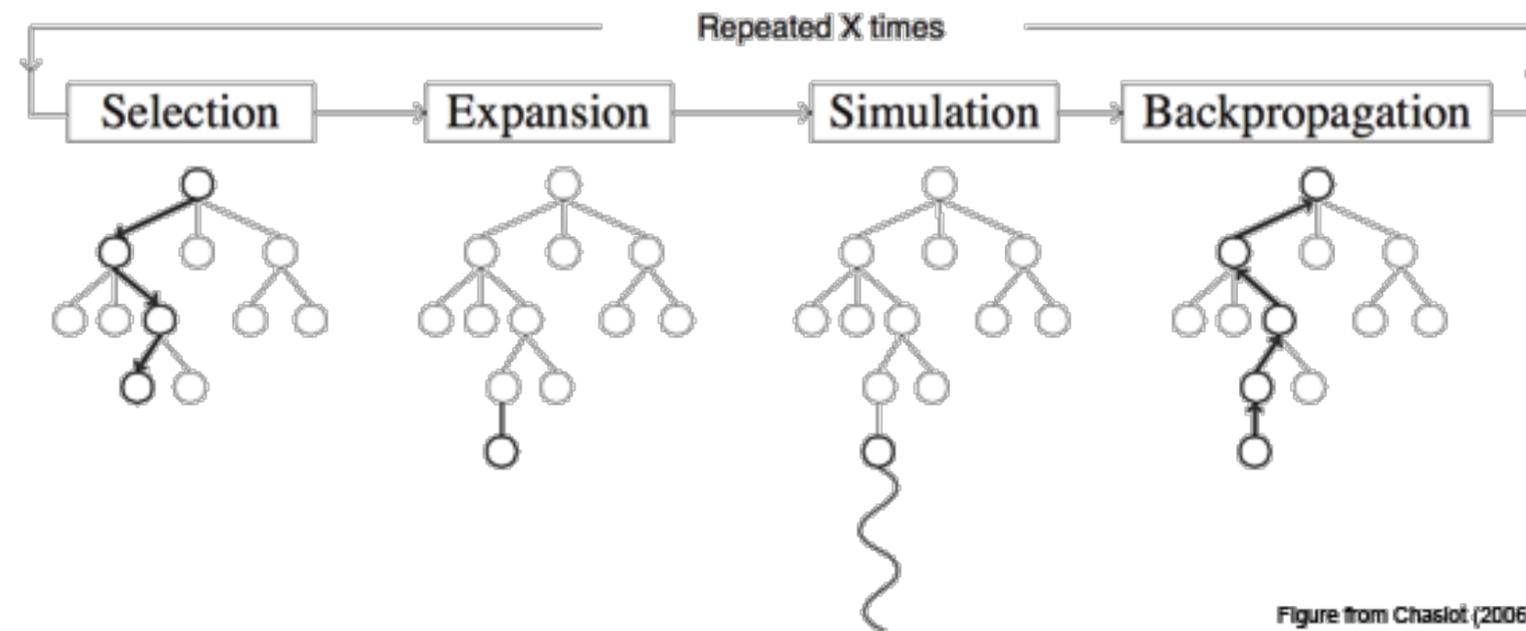
- When it is the turn of Bots to act, search all possible actions, and for each action, Score based on a certain rule.
- Then let Bots take the action with the highest score.
- This method is very effective, easy to implement in engineering, and specific effects can be achieved through manual design.
- The disadvantage is that the scoring is subjective; it can only simulate the current best; it cannot simulate complex situations; it is difficult to describe the expectations for the future.

Card Games AI - Monte Carlo Tree Search

- Monte Carlo tree search (MCTS) is a heuristic search algorithm used in certain decision-making processes, especially in games.
- There are many papers using MCTS to study card games and traditional chess games and board games.
- Monte Carlo method is based on randomness and probability. Monte Carlo Tree Search is based on the Monte Carlo method and combines the idea of tree search.

Card Games AI - Monte Carlo Tree Search

In the course of each game, before each move, the Monte Carlo tree search will simulate the game many times, just like the way humans think. And then observe whether the each action can lead to the final victory. And trying to predict the most promising action based on the simulation results.



Beyond the Algorithm

What kind Bots we need ?

- The essential question: Why do we need Game Bots?
- This issue should be considered from the perspective of player experience.
- What kind of experience do players like?
 - sense of control ↔ surprise
 - challenge ↔ gain and promote

The purpose of Bots

So, unlike academically, the final goal of game AI in actual game product is not to achieve the highest winning rate, but to improve the player's gaming experience.

In some cases, this goal is contradictory with the simulation fidelity and the Bots intensity.

Purpose - player experience

Under the above purpose, it is not easy to train Bots using current algorithms.

- Sometimes, the objective function is not the winning rate.
- The player's experience is difficult to measure.
- Differences among players at different levels.

—— Solving these problems requires a very deep understanding of player behavior and game mechanics.

Takeaway Point

Takeaway points

- Game Bots & Game AI
 - Finite State Machine
 - Behavior Tree
 - Reinforcement Learning
 - Monte Carlo Tree Search
- Purpose - player experience

Thank You