





Artificial Intelligence Research in Video Games

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Motivation

Why do research in video games?

- Video games
 - Simulated, controlled, environments
 - Complex enough to be challenging
- Applications
 - Video games and non-game simulators
 - Robotics
- Beyond
 - Insight into nature of intelligence
 - Sufficient conditions for complex behavior

Super Mario AI Competition



- Start-up code: <u>http://www.marioai.org/home</u>
- Video: <u>https://youtu.be/DlkMs4ZHHr8</u>

• Goal:

- Create skilled Mario agent
- Placed in random levels
- International competition
- Victory:
 - Entry by Robin Baumgarten
 - Uses A* Search
 - Uses perfect model of game
 - Knows result of each action
 - Plans ahead using model
 - Searches for safe route to end
- Cons:
 - A* requires accurate model
 - Result is skilled, but inhuman

Turing Test

- Invented by Alan Turing
 - Father of Computer Science
 - Cracked Enigma code
 - Invented Turing machine



- Test of human-like intelligence
 - Chat session with computer and human
 - Which is which?
 - Fool humans 50% of time to pass test

Turing Test for Games



- Software: <u>http://pogamut.cuni.cz/</u>
- BotPrize: <u>http://botprize.org/</u>
- Video: <u>https://youtu.be/1BdcNaexk3M</u>
- UT^2: <u>http://nn.cs.utexas.edu/?ut2</u>

Goal:

- Bot for UT2004
- Make it human-like
- Fool humans 50% of time
- Victory:
 - UT^2 won BotPrize 2012
 - By Jacob Schrum, Igor Karpov, and Risto Miikkulainen
 - Used neuroevolution and human trace data
- Cons:
 - Made bot weaker to make it convincing
 - Does not adjust challenge level



Artificial Neural Networks

- Brain = network of neurons
- ANN = abstraction of brain
 Neurons organized into layers







Start With Parent Population

Evaluate and Assign Fitness

Start With Parent Population

Evaluate and Assign Fitness

Clone, Crossover and Mutate

> To Get Child Population



Start With Parent Population

Evaluate and Assign Fitness

Clone, Crossover and Mutate

Children Are Now the New Parents

Repeat Process: Fitness Evaluations



As the process continues, each successive population improves performance

Neuroevolution Game Neuro-Evolving Robotic Operatives (NERO)

By Kenneth Stanley, Bobby Bryant, and Risto Miikkulainen



- Software: <u>http://nerogame.org/</u>
- Open Source Reimplementation: <u>https://opennero.github.io</u>

- Goal:
 - Make game based on Machine Learning
 - Player is drill sergeant
 - Create increasingly harder tasks for evolving bots
- Success:
 - Behavior evolves in real time
 - Interactive evolution: Player manipulates environment
 - Evolved teams can face off
- Cons:
 - Evolved agents become specialists (e.g. snipers)
 - Need multimodal behavior



Ms. Pac-Man

Goal:

- Develop multimodal behavior
- Ms. Pac-Man requires behaviors for threat and edible ghosts
- Evolve modular policies

Success:

- My dissertation under Risto Miikkulainen's supervision
- Modular neural networks
- Evolution discovers when to use modules
- Unexpected task division discovered: luring behavior
- Cons:

(IN)

ΊΝ

- What if there are many agents?
- What if there are many actions?
- Software (MM-NEAT): http://nn.cs.utexas.edu/?mm-neat
- Screen capture competition: http://dces.essex.ac.uk/staff/sml/pacman/PacManContest.html
- Videos: http://nn.cs.utexas.edu/?ml-pm

StarCraft AI Competition



- Student Tournament: <u>http://sscaitournament.com/</u>
- AIIDE Competition: https://webdocs.cs.ualberta.ca/~cdavid/starcraftaicomp/
- Past Competitions: http://webdocs.cs.ualberta.ca/~cdavid/starcraftaicomp/media.shtml

- Goal:
 - Handle complexity of RTS game
 - Unit control
 - Path finding
 - Build order
 - High-level strategy
 - Be competitive with humans
- Victories:
 - Different winner each year
 - Many strategies
 - Hard-coded rules
 - Finite state machines
 - Planning
 - Supervised learning
 - Probabilistic models

What can AI do besides agent control?

Galactic Arms Race



Content Creation

- Goal:
 - Evolve interesting content
 - Insert into commercial game
- Success:
 - Space shooter
 - Weapon behavior evolves
 - Different firing patterns
 - Based on user popularity
 - Interactive evolution
- What about going beyond a single game?
- Game: <u>http://galacticarmsrace.blogspot.com/</u>
- Video: <u>https://youtu.be/7lBmiyGkQyg</u>

Atari Games ... all of them



- Goal:
 - System that can play any game
 - Only use information human has
 - Raw pixel data
- Success:
 - Google's Deep Mind team
 - Used "Deep" Neural Network
 - Can learn any Atari 2600 game
- Can we get more general?
- Video: <u>https://youtu.be/V1eYniJ0Rnk</u>
- Code: <u>https://sites.google.com/a/deepmind.com/dqn/</u>

General Video Game Playing



- Competition: <u>http://www.gvgai.net/</u>
- Explanation Video: <u>https://youtu.be/iAaleW3ofyk</u>

- Goal:
 - Play any game
 - Don't know the game in advance
 - Described in formal language
- Competition:
 - Previously unseen games
 - Many skills needed
 - Different tracks
 - Planning
 - Learning
 - Content Generation
- If these topics interest you...

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Questions?

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