Artificial Intelligence Research in Video Games

By Jacob Schrum

schrum2@southwestern.edu
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

- **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

- **Start-up code:**
  [http://www.marioai.org/home](http://www.marioai.org/home)

- **Video:**
  [https://youtu.be/DlkMs4ZHHr8](https://youtu.be/DlkMs4ZHHr8)
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

• 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

 Software: http://pogamut.cuni.cz/
 BotPrize: http://botprize.org/
 Video: https://youtu.be/1BdcNaexk3M
 UT^2: http://nn.cs.utexas.edu/?ut2
Artificial Neural Networks

• Brain = network of neurons
• ANN = abstraction of brain
  – Neurons organized into layers
Neuroevolution Example

Start With Parent Population
Neuroevolution Example

Start With Parent Population

Evaluate and Assign Fitness

100 90 75 61 56 50 31
Neuroevolution Example

Start With Parent Population

Evaluate and Assign Fitness

Clone, Crossover and Mutate

To Get Child Population
Neuroevolution Example

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

• 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

• Software: http://nerogame.org/
• Open Source Reimplementation: https://opennero.github.io
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:**
  - What if there are many agents?
  - What if there are many actions?

- **Software (MM-NEAT):** [http://nn.cs.utexas.edu/?mm-neat](http://nn.cs.utexas.edu/?mm-neat)
- **Screen capture competition:** [http://dces.essex.ac.uk/staff/sml/pacman/PacManContest.html](http://dces.essex.ac.uk/staff/sml/pacman/PacManContest.html)
- **Videos:** [http://nn.cs.utexas.edu/?ml-pm](http://nn.cs.utexas.edu/?ml-pm)
StarCraft AI Competition

• 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: http://galacticarmsrace.blogspot.com/
• Video: https://youtu.be/7IBmiyGkQyg
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: https://youtu.be/V1eYniJ0Rnk
• Code: https://sites.google.com/a/deepmind.com/dqn/
General Video Game Playing

- **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

- **Competition:**
  [http://www.gvgai.net/](http://www.gvgai.net/)

- **Explanation Video:**
  [https://youtu.be/iAaleW3ofyk](https://youtu.be/iAaleW3ofyk)

- If these topics interest you…
SCOPE

• ...you should apply to SCOPE!
  – Summer research program at Southwestern
  – First time CS has participated
  – Two/Three students will do research with me
  – Get paid for your time
  – Application deadline: November 13th, 5pm
  – Application Link: 
    http://www.southwestern.edu/departments/hhmi/scope-application/
Questions?
Contact me
schrum2@southwestern.edu