UCD CASL

Complex & Adaptive Systems Laboratory

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Artificial Intelligence in Games Using Evolutionary Techniques

COMP30290 Natural Computing
COMP41190 Natural Computing and Applications

Outline

1. **Evolutionary Algorithms and Games**
2. **Move Optimisation with Toribash**
3. **Path Planning with Ms. Pac-man**
4. **Reactive Behaviour with Super Mario Bros**
5. **Observations**

Evolutionary Algorithms and Games

What are EAs?

- Population-based algorithms;
- Darwinian theory of evolution: survival of the fittest;
- Stochastic;
- Genetic operators drive evolution:
  - Selection;
  - Recombination;
  - Mutation;
  - Replacement.
- Three main decisions: **algorithm**, **representation**, **evaluation**.

Evolutionary Algorithms and Games

Why games?

- Billion-euro industry;
- Public exposure;
- Excellent research testbeds (path planning, move optimisation, dynamic responsiveness);
- Challenging (human-like behaviour, repetitiveness, opponent level).

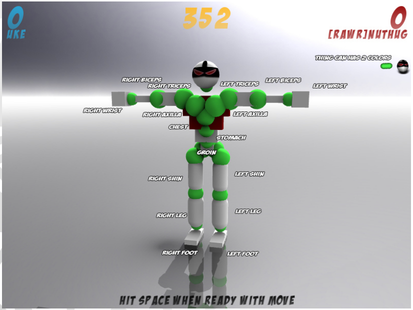
Why EAs?

- Powerful search algorithms (human competitive);
- Often find non-obvious solutions;
- Adaptability and usability.

Move Optimisation with Toribash

Game Description

- Avatar fight game, turn-based;
- At each turn, player controls joint angles of avatar;
- Objective: defeat opponent.



Move Optimisation with Toribash

Facts

- Ragdoll physics;
- Freeware;
- Active online community.

Why Toribash?

- Create adaptive behaviour;
- Reactive planning to opponent's actions;
- No predefined moves;
- Non-deterministic outcome.

Move Optimisation with Toribash

Algorithm

- Genetic Algorithm.

Representation

- Each individual encodes choice for 22 joints, for each move:
  - Contract, extend, hold or relax;
  - 4.4 trillion possible combinations per move.

Evaluation

- Evolve avatar against static opponent (1 or 3 moves);
- Fitness = Tori score - Uke score;
- Disqualification gets fitness 0.

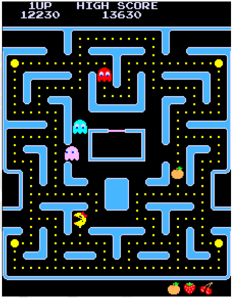
Move Optimisation with Toribash

Demo videos

Path Planning with Ms. Pac-man

Game Description

- Puzzle game, human vs. computer;
- Navigate tunnels, eat pills, avoid ghosts (power pills: eat ghosts!);
- Objective: eat all pills in each level.



Path Planning with Ms. Pac-man

Facts

- One of the most popular video games of all times;
- Originally introduced in early 1980s;
- 255 levels of increasing difficulty.

Why Ms. Pac-man?

- Path planning in a dynamic environment;
- Non-deterministic behaviour for ghosts;
- Human players still far better;
- Used as benchmark in AI competitions.

Path Planning with Ms. Pac-man

Algorithm

- Grammatical Evolution.

Representation

- Individual encodes choices of productions in a grammar:
  - Grammar provides syntactically correct solution;
  - Sequence of *if condition then action* rules with high-level functions;
  - *if (inedibleGhostDistance $>$ safeDistance) then goto(nearestPill)*.

Evaluation

- Face evolved controller against random or legacy team;
- Use available emulator;
- Fitness $=$ game score (pills $+$ bonuses).

Path Planning with Ms. Pac-man

Demo videos

Reactive Behaviour with Super Mario Bros

Game Description

- Platform game, human vs. computer;
- Navigate through obstacles and enemies;
- Objective: reach end of each level, collect extra bonuses.

Reactive Behaviour with Super Mario Bros

Facts

- Best-selling video game series of all times;
- Originally introduced in 1983;
- Hundreds of levels in mushroom world.

Why Super Mario Bros?

- Challenging mix of path planning vs. reactive behaviour;
- Popular benchmark in AI competitions;
- Compare different AI approaches.

Reactive Behaviour with Super Mario Bros

Algorithm

- Grammatical Evolution.

Representation

- Individual encodes choices of productions in a grammar:
  - Grammar encodes behaviour trees;
  - High-level conditions: *EnemyAhead*, *GapBehind*;
  - High and low level actions: *UseRightGap*, *jump*, *shoot*.

Evaluation

- Train controller on series of random maps;
- Validate on unseen maps (adaptability);
- Fitness = game score (distance + bonuses).

Reactive Behaviour with Super Mario Bros

Demo videos

Observations

EAs and Games

- Adaptability of evolutionary techniques;
- High-level behaviours easier to understand and modify.

Awards

- Mario entry finished 4th in CIG-2010 international competition.

Possible extensions

- Toribash: face against reactive opponent;
- Ms. Pacman: add more refined behaviours;
- Mario: combine path planning (hard AI) with reactive behaviours.

Next Classes

- Discussion group (Thursday);
  - Example conference paper with Mike.
- Project feedback after lectures.