Botprize 2010

Jacob Schrum, Igor Karpov, and Risto Miikkulainen
{schrum2,ikarpov,risto}@cs.utexas.edu
Unreal Tournament 2004

- Commercial videogame
- First Person Shooter genre
- Play vs. humans and bots
- Programming API: Pogamut
  - Gamebots message protocol
Turing Test For Bots

• Can humans tell bots from other humans?

• Botprize 2008, 2009
  – In style of traditional Turing Test
    • Bot vs. Judge vs. Confederate
    • 3 individuals per match

• Botprize 2010
  – Judging game
    • Multiple humans vs. multiple bots
    • All humans are judges and players
Judging Game

• Special judging gun
  – Replaces the Link Gun

• Primary and alternate fire look identical
  – Primary fire against bots
  – Alternate fire against humans

• Correctly judge opponent:
  – Kills opponent, +10 frags

• Incorrectly judge opponent:
  – Shooter dies, -10 frags

• Bots can use this gun!
Competition

- 3 sessions, 1 hour each
- 4 matches per session, 15 minutes each
- 5 competing bots, 6-7 judges, and 1-2 native UT bots per session
- 3 large custom levels used:
  - Goatswood
  - IceHenge
  - Colosseum
Our Bot (Demo)

You got the Flak Cannon.

Coleman

Loren
Agent Architecture

- Agent Architecture Diagram with various nodes and connections.
Agent Architecture

Use human traces to get unstuck
Human Trace Data
Replaying Human Experience

• Record
  o Player pose
    ▪ position, orientation, velocity and acceleration
  o Events
    ▪ fall, damage, weapons, items, jumps, etc.

• Index for lookup by
  o Region of origin
  o Future events

• Replay (when stuck)
  o Short relative path from origin
What is in the Database?

t, x, y, z, rx, ry, rz, vx, vy, vz, ax, ay, az

\[ t, e \]
Indexing the Data: Octrees

• $O(\log N)$ lookup
• Offline indexing
• ~30 sec to load index
Indexing the Data: KD-Trees

- $O(\log N)$ nearest neighbor search
- Offline indexing
- $\sim 30$ sec to load index
Indexing the Data: Navpoint Graph

- Each level has graph of navpoints (under 300)
- Store navpoints in a KD-tree (quick)
- For each point in human DB, find closest navpoint (offline)
- Retrieve all points within navpoint's Voronoi region
- From here, use random or nearest selection (online)
Generating the path

Position of agent
Start of path
DB samples
Agent path
Agent Architecture

Evolve controller that fights well

[Diagram of Agent Architecture with nodes and arrows representing different actions such as Unstuck, Pickup Dropped Weapon, Get Important Item, Judge, Use Shield Gun, Battle, Chase Enemy, Get Item, Human Trace Controller, Water Controller, Traverse Locations, Goto Location, Path Controller, Shield Gun Controller, Battle Controller, Chase Controller, Follow Path, Goto Item, Advance, Retreat, Strafe, Stand Still]
Battle Controller Inputs

- Pie slice sensors for enemies
- Ray traces for walls/level geometry
- Other misc. sensors for current weapon properties, nearby item properties, etc.
Battle Controller Outputs

• 6 movement outputs
  – Advance
  – Retreat
  – Strafe left
  – Strafe right
  – Move to nearest item
  – Stand still

• 3 additional outputs
  – Shoot?
  – Alternate fire?
  – Jump?
Mutiobjective Optimization

- Pareto dominance: \( \vec{v} \succ \vec{u} \) iff
  - \( \forall i \in \{1, ..., n\}: v_i \geq u_i \)
  - \( \exists i \in \{1, ..., n\}: v_i > u_i \)
- Assumes maximization
- Want nondominated points
- NSGA-II used in this work

- What to evolve?
  - NNs as control policies
Constructive Neuroevolution

- Genetic Algorithms + Neural Networks
- Build structure incrementally (complexification)
- Good at generating control policies
- Three basic mutations (no crossover used)
Objectives

• Damage dealt
• Accuracy
• Damage received (negative)
• Geometry collisions (negative)
• Actor collisions (negative)
• Behavior diversity
Behavioral Diversity

• Behavior vector:
  – Given input vectors, concatenate outputs

<table>
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<tr>
<th>0.1</th>
<th>2.3</th>
<th>4.3</th>
<th>5.2</th>
<th>3.2</th>
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<td>4.2</td>
<td>5.6</td>
<td>4.5</td>
<td>7.7</td>
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</tbody>
</table>

• Behavioral diversity objective:
  – AVG distance from other behavior vectors

High average distance from other points
## Botprize 2010 Results

<table>
<thead>
<tr>
<th>Bot Name</th>
<th>Humanness %</th>
<th>Judging Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conscious-Robots</td>
<td>31.82%</td>
<td>N/A</td>
</tr>
<tr>
<td>UT^2</td>
<td><strong>27.27%</strong></td>
<td><strong>45.74 %</strong></td>
</tr>
<tr>
<td>ICE-2010</td>
<td>23.33%</td>
<td>N/A</td>
</tr>
<tr>
<td>Discordia</td>
<td>17.78%</td>
<td>54.83 %</td>
</tr>
<tr>
<td>w00t</td>
<td>9.30%</td>
<td>53.84 %</td>
</tr>
</tbody>
</table>

Also, native UT bot had humanness of 35.3982%. Native bot and winner did not judge at all.

<table>
<thead>
<tr>
<th>Human Player</th>
<th>Humanness %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mads Frost</td>
<td>80.00%</td>
</tr>
<tr>
<td>Simon and Will Lucas</td>
<td>59.09%</td>
</tr>
<tr>
<td>Ben Weber</td>
<td>48.28%</td>
</tr>
<tr>
<td>Nicola Beume</td>
<td>47.06%</td>
</tr>
<tr>
<td>Minh Tran</td>
<td>42.31%</td>
</tr>
<tr>
<td>Gordon Calleja</td>
<td>38.10%</td>
</tr>
<tr>
<td>Mike Preuss</td>
<td>35.48%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Human Player</th>
<th>Judging Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gordon Calleja</td>
<td>78.57%</td>
</tr>
<tr>
<td>Nicola Beume</td>
<td>67.21%</td>
</tr>
<tr>
<td>Minh Tran</td>
<td>64.29%</td>
</tr>
<tr>
<td>Ben Weber</td>
<td>64.08%</td>
</tr>
<tr>
<td>Mike Preuss</td>
<td>59.70%</td>
</tr>
<tr>
<td>Mads Frost</td>
<td>57.69%</td>
</tr>
<tr>
<td>Simon and Will Lucas</td>
<td>54.79%</td>
</tr>
</tbody>
</table>

The numbers are in percent.
Insights

• Judging for the bot is not important
  – Better to not judge then do it wrong
• Different judges, different expectations
  – Combat, dodging, jumping, etc.
  – Perhaps mimicry of opponents would help
• Human judges expect reaction/response
  – Shoot and miss, run away and wait
• Human judges like to observe
  – From roof tops, through sniper scope
Why Did We Lose?

• Specific weapon issues (sniping)
• Some tricks in our judging behavior
• Problems with following
• Perhaps perceived as too skilled
• Still got stuck a few times
• Some weird firing glitches

• Mostly minutiae!
Believable Bots

• Will be writing a book chapter on our bot
• Experiments evaluating bot performance
  – Human Trace Controller gets bot unstuck
  – Evolved Battle Controller good at combat
Human Trace Experiments

- Do the human traces help the agent get unstuck?
  - Time stuck with full system, w/o filtering, w/random paths

- Does the performance improve with more data?
  - Time stuck with 1, 2, 3 players, etc.

- Does the indexing method make a difference?
  - Random vs. nearest starting point
  - Constrained by Octree region
  - Constrained by Navpoint region
Evolution Experiments

• Does evolution improve combat?
  – Bot vs. random combat action selector

• Are all the different actions useful?
  – Usage of each type of movement action
  – Ablation studies

• Importance of weapons
  – Above experiments with limited weapon access
Future Work

• Human Traces
  – Generalize to unseen levels
  – Induce better navigation graphs
  – Make intelligent decisions about when to jump
  – Use to improve following
  – Supervised learning

• Evolution
  – Different features/input representation
  – Apply to other control modules
  – Apply to selection between modules
  – Reduce reliance on scripted behavior
Future Work

• Theory of Mind
  – Planned behavior transitions
    • e.g. a chasing bot expects to enter combat mode
  – Mimicry: expectation of similarity
    • Match opponent’s level of dodging, aggressiveness, ammo wasting, etc.
    • Establish communication
  – Deliberation
    • Sniping humans don’t move as much
    • Better human judges don’t make snap decisions
Questions?

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# Botprize 2010 Results

## Most human bots

<table>
<thead>
<tr>
<th>bot name</th>
<th>team</th>
<th>affiliation</th>
<th>humanness %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conscious-Robots</td>
<td>Raul Araújo Jorge Muñoz</td>
<td>Carlos III University, Madrid</td>
<td>31.6162 %</td>
</tr>
<tr>
<td>UT*2</td>
<td>Igor Karpov Jacob Schrum Risto Mikkulainen</td>
<td>University of Texas, Austin</td>
<td>27.2277 %</td>
</tr>
<tr>
<td>ICE-2010</td>
<td>Akihiro Kojima Daichi Hirano Takumi Sabo Seiji Murakami Ruck Thawonmas</td>
<td>Intelligent Computer Entertainment Lab. Ritsumeikan University, Japan</td>
<td>23.3333 %</td>
</tr>
<tr>
<td>Discordia</td>
<td>Casey Rosenthal Clare Bates Congdon</td>
<td>University of Southern Maine</td>
<td>17.7778 %</td>
</tr>
<tr>
<td>w00l</td>
<td>Daniel Buscher Matthias Gorzelik Jannis Seyfried Björn Witt</td>
<td>Institut für Informatik Albert-Ludwigs-Universität Freiburg, Deutschland</td>
<td>9.3023 %</td>
</tr>
</tbody>
</table>

## Most human humans

<table>
<thead>
<tr>
<th>player</th>
<th>affiliation</th>
<th>humanness %</th>
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<tbody>
<tr>
<td>Mads Frost</td>
<td>IT University Copenhagen</td>
<td>60.0000 %</td>
</tr>
<tr>
<td>Simon and Will Lucas</td>
<td>University of Essex</td>
<td>59.0909 %</td>
</tr>
<tr>
<td>Ben Weber</td>
<td>UC Santa Cruz</td>
<td>48.2759 %</td>
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<tr>
<td>Nicola Beume</td>
<td>TU Dortmund University</td>
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<td>Minh Tran</td>
<td>Edith Cowan University</td>
<td>42.3077 %</td>
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<tr>
<td>Gordon Calleja</td>
<td>IT University Copenhagen</td>
<td>38.8952 %</td>
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<td>Mike Preuss</td>
<td>TU Dortmund University</td>
<td>35.4693 %</td>
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## Best human judges

<table>
<thead>
<tr>
<th>player</th>
<th>accuracy %</th>
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<td>Gordon Calleja</td>
<td>79.5714 %</td>
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<td>Nicola Beume</td>
<td>67.2131 %</td>
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<td>Minh Tran</td>
<td>64.2857 %</td>
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<td>Ben Weber</td>
<td>64.0845 %</td>
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<td>59.7018 %</td>
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<td>Mads Frost</td>
<td>57.6923 %</td>
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<td>Simon and Will Lucas</td>
<td>54.7946 %</td>
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## Judgment Counts

<table>
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<tr>
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<th>total</th>
<th>correct</th>
<th>incorrect</th>
<th>ratio</th>
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<tr>
<td><strong>UT^2</strong></td>
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</tr>
<tr>
<td>by humans</td>
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<td>24</td>
<td>9</td>
<td>0.27</td>
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<tr>
<td>by bots</td>
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<td>0</td>
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<tr>
<td>total</td>
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<td>9</td>
<td>0.24</td>
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<td><strong>Conscious-R</strong></td>
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<td>by humans</td>
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<td>total</td>
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<tr>
<td><strong>Frost</strong></td>
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<tr>
<td>by humans</td>
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<td>0.8</td>
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<td>total</td>
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<tr>
<td><strong>Swill</strong></td>
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<tr>
<td>by humans</td>
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<tr>
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