

UT²: Human-like Behavior via Neuroevolution of Combat Behavior and Replay of Human Traces

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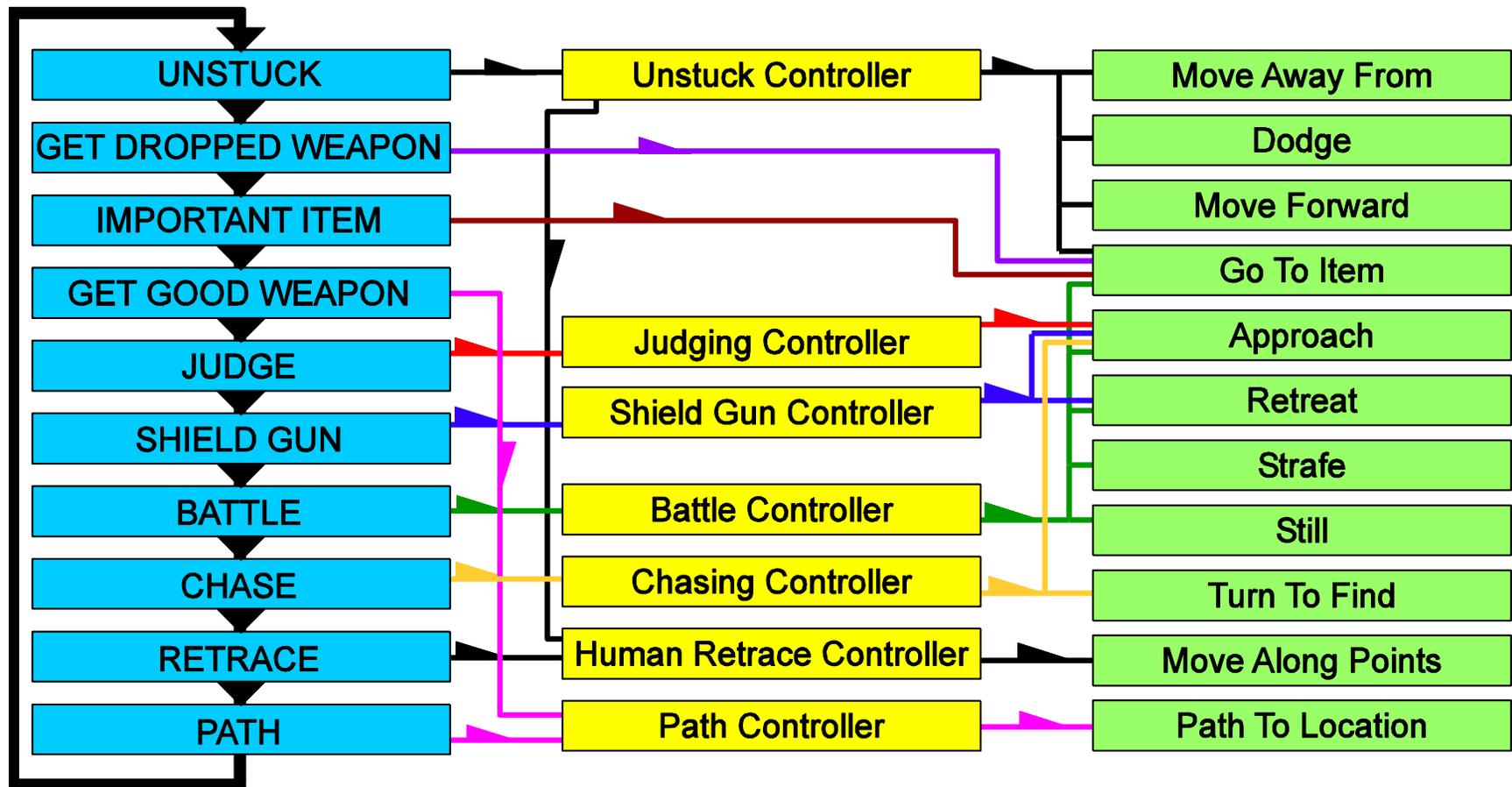


Our Approach: UT²

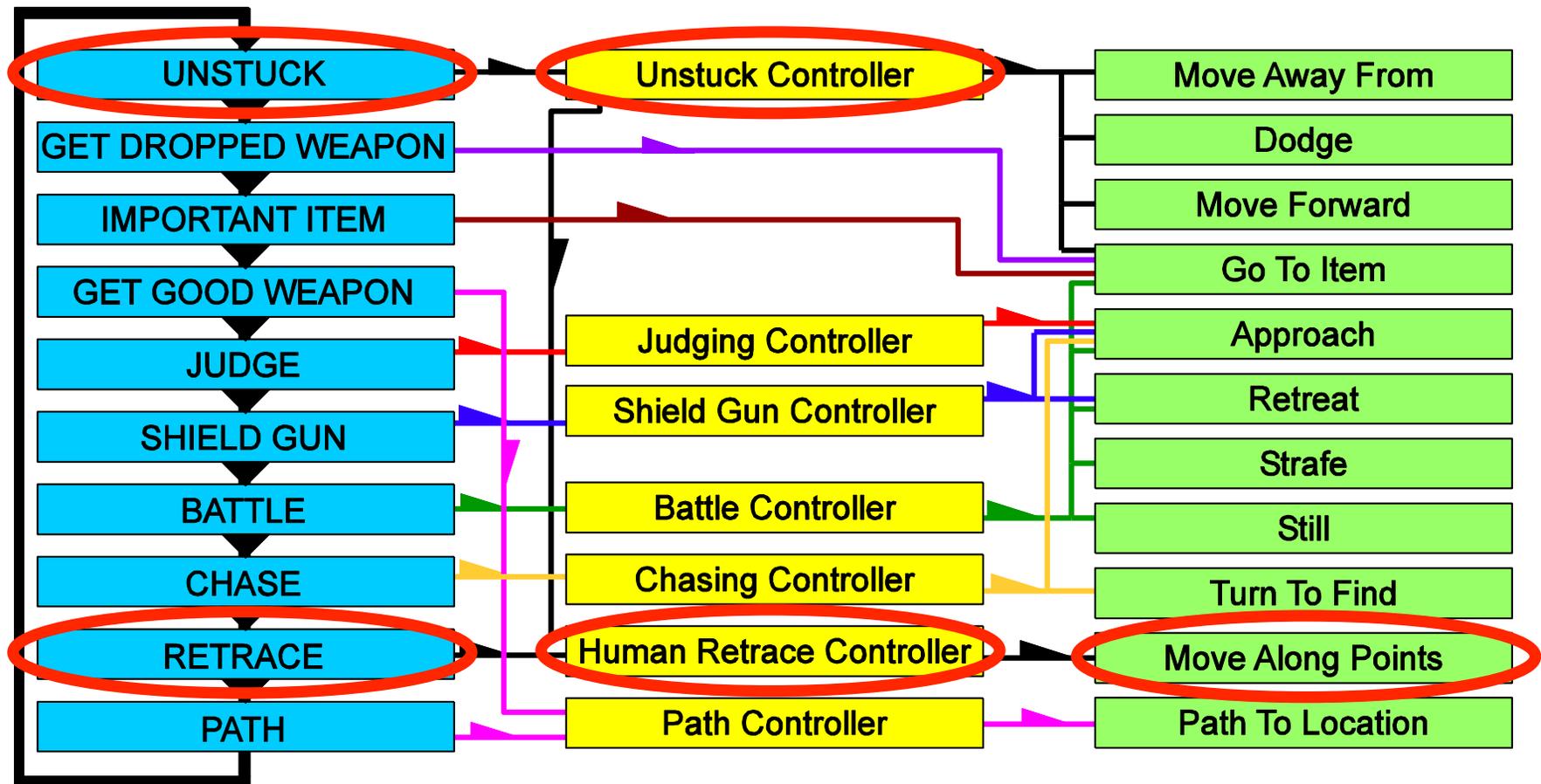
- Evolve skilled combat behavior
 - Restrictions/filters maintain humanness
- Human traces to get unstuck and navigate
 - Filter data to get general-purpose traces
 - Future goal: generalize to new levels
- Probabilistic judging based on experience
 - Also assume that humans judge well



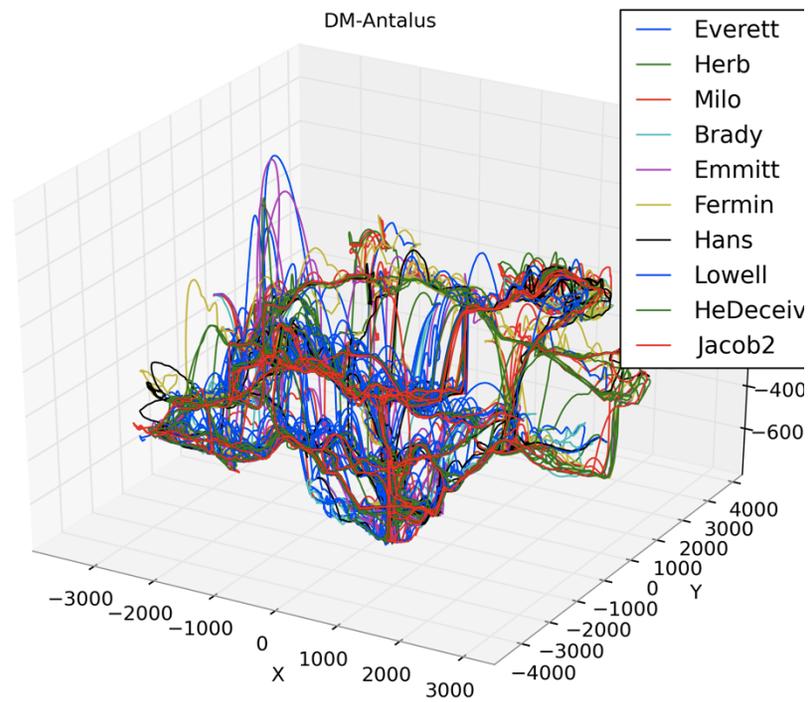
Bot Architecture



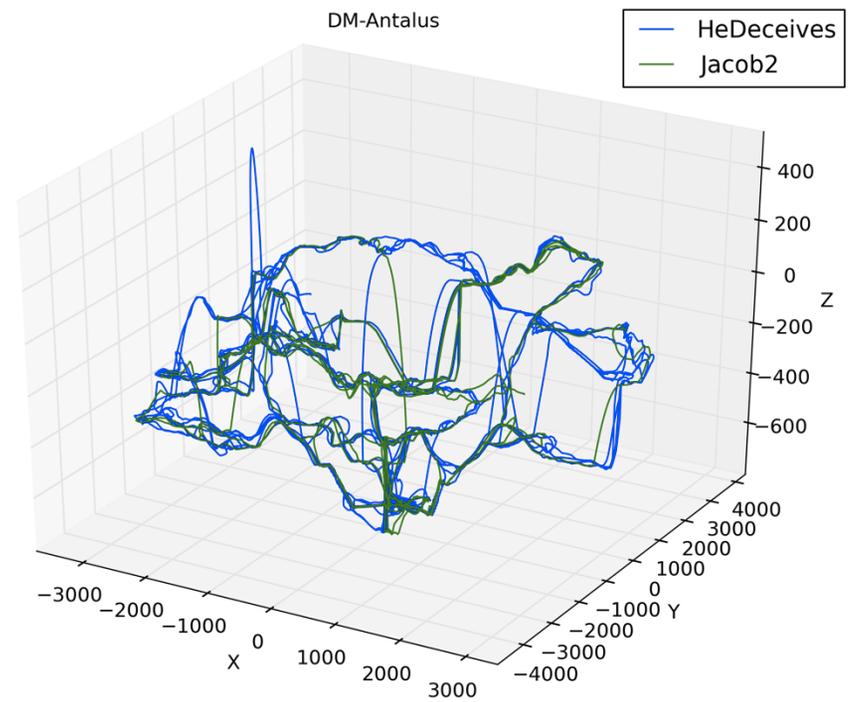
Use of Human Traces



Record Human Games

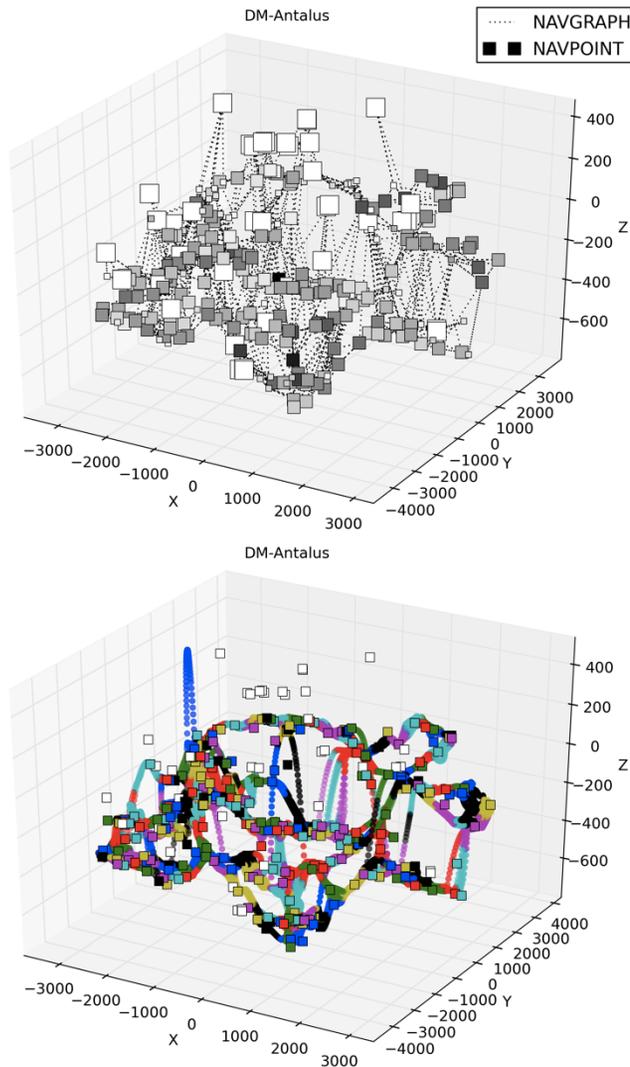


“Wild” pose data



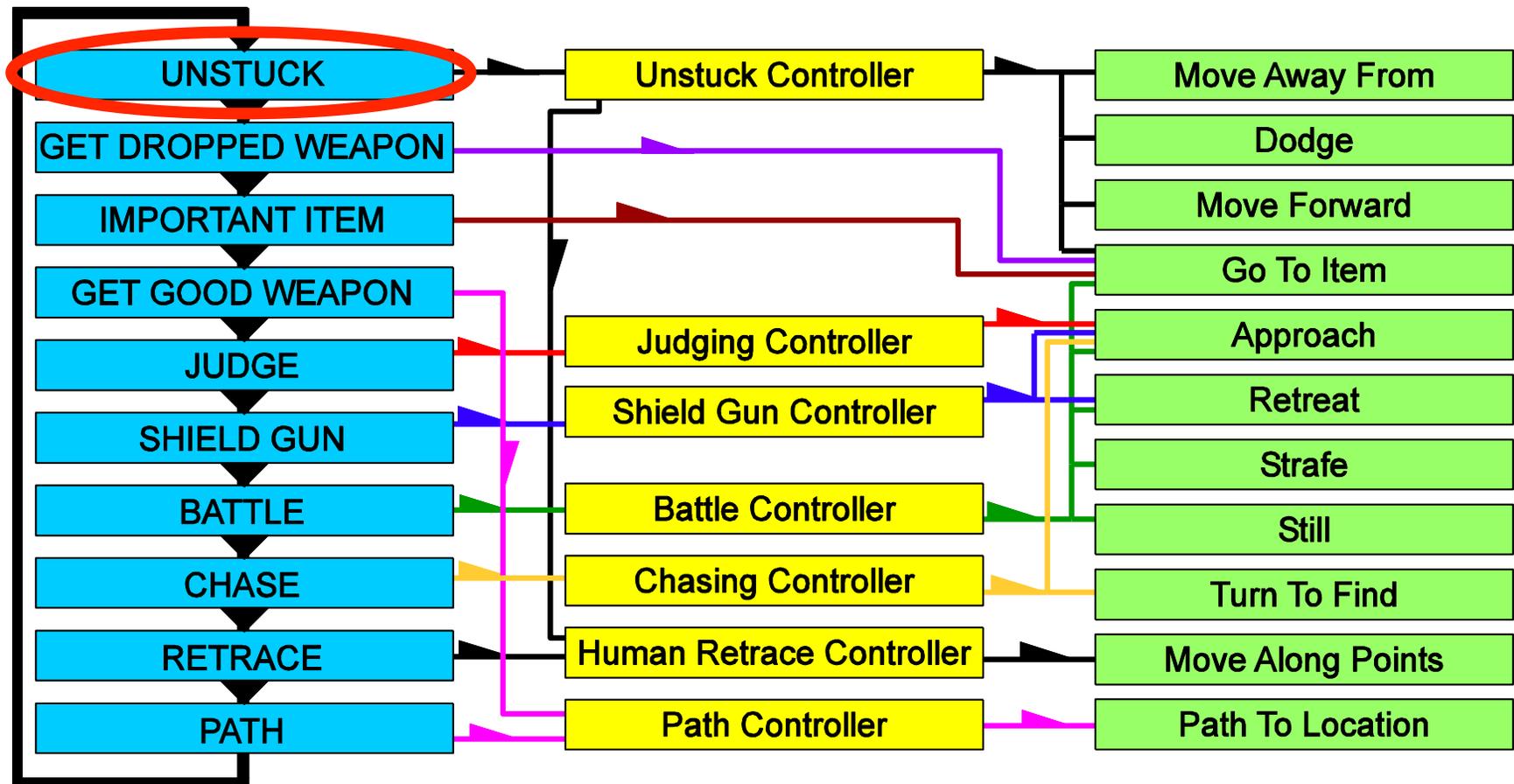
“Synthetic” pose data

Index and replay nearest traces



- Index by navpoints
 - KD-tree of navpoints
 - KD-trees of points within Voronoi cells
 - find nearest navpoint
 - find nearest path
- Playback
 - Estimate distance D
 - MoveAlong the path for about D
- Two uses
 - Get unstuck
 - Explore levels

Getting unstuck has highest priority



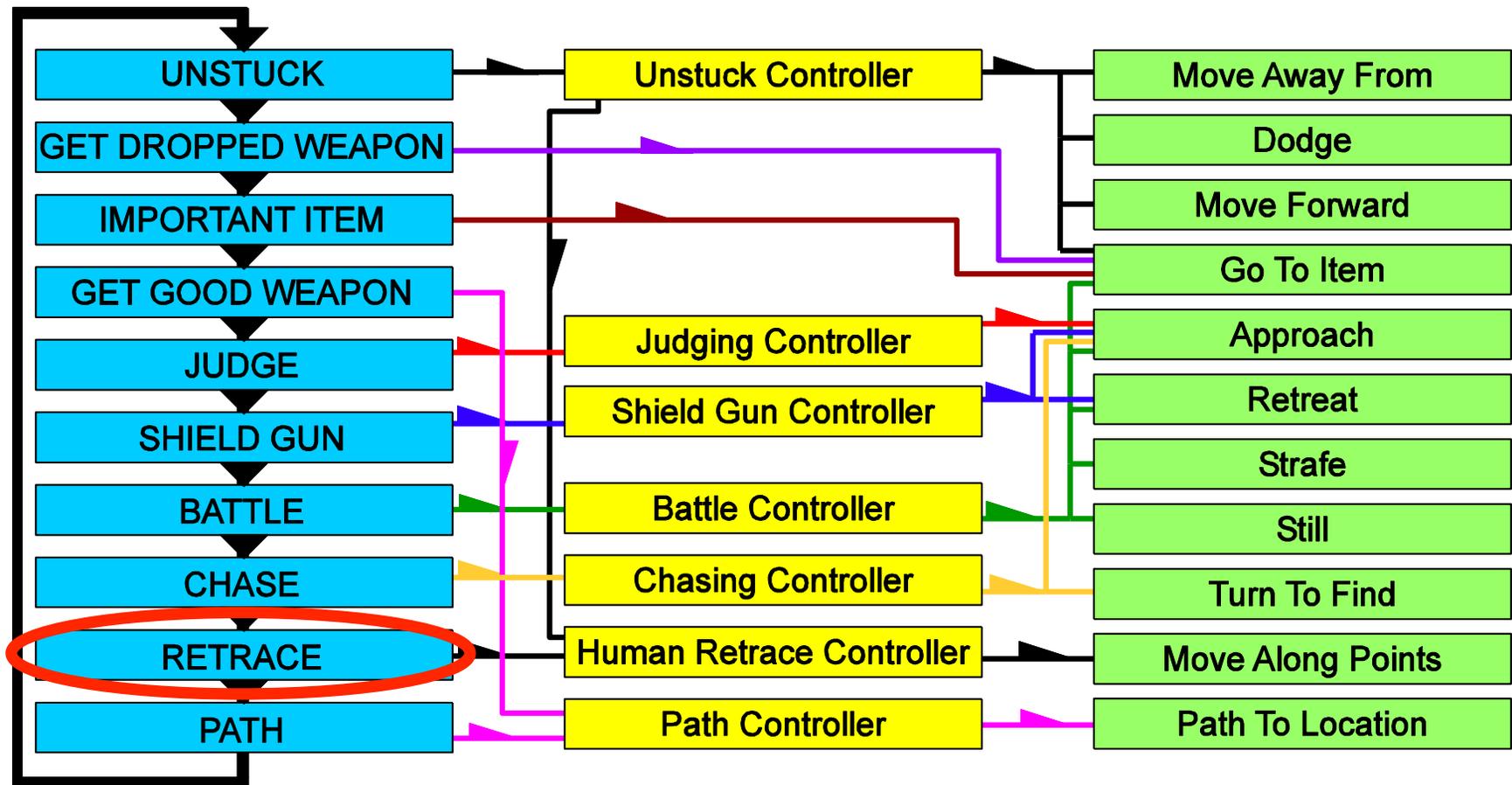
Unstuck Controller

- Mix scripted responses and human traces
 - Previous UT² used only human traces

Stuck Condition	Response
Still	Move Forward
Collide With Wall	Move Away
Frequent Collisions	Dodge Away
Bump Agent	Move Away
Same Navpoint	Human Traces
Off Navpoint Grid	Human Traces

- Human traces also used after repeated failures

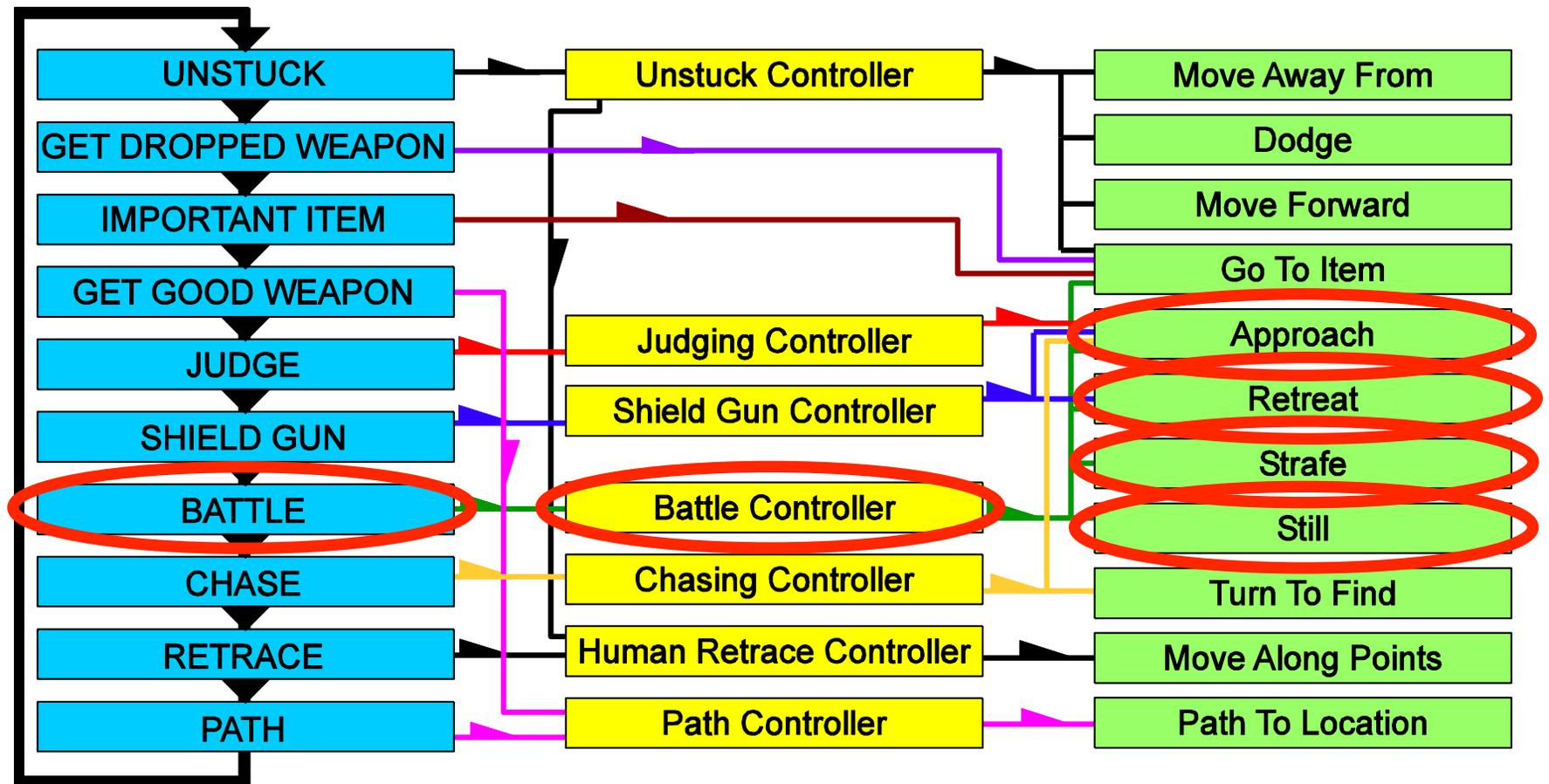
Traces used within RETRACE w/low priority



Prolonged Retracing

- Explore the level like a human
- Based on synthetic data
 - Lone human running around collecting items
- Collisions allowed when using RETRACE
 - Humans often bump walls with no problem
- If RETRACE fails
 - No trace available, or trace gets bot stuck
 - Fall through to PATH module (Nav graph)

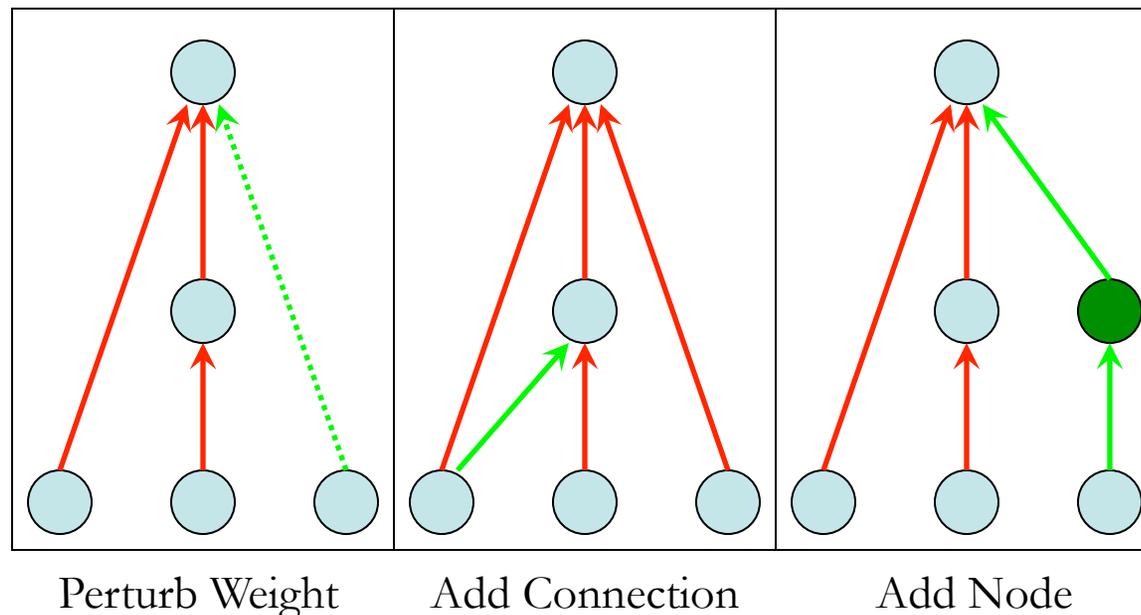
Use of Evolution



Evolved neural network in Battle Controller defines combat behavior

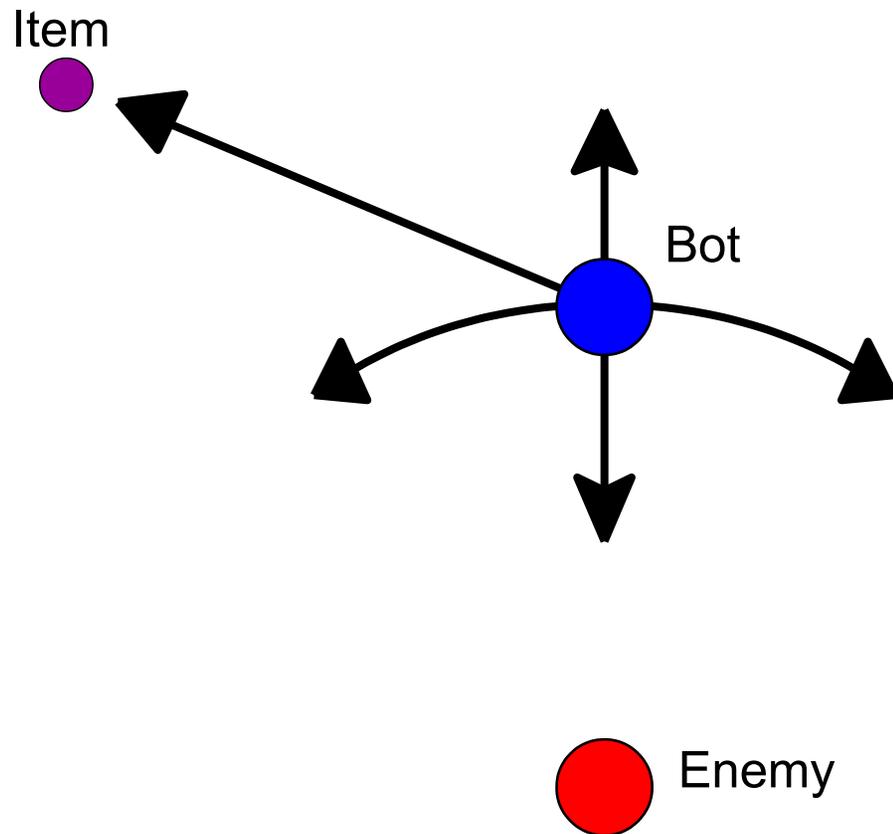
Constructive Neuroevolution

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

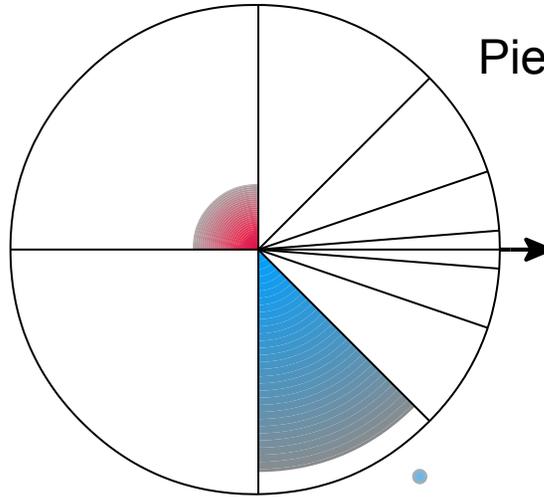


Battle Controller Outputs

- 6 movement outputs
 - Advance
 - Retreat
 - Strafe left
 - Strafe right
 - Move to nearest item
 - Stand still
- Additional output
 - Jump?



Battle Controller Inputs



Pie slice sensors for enemies

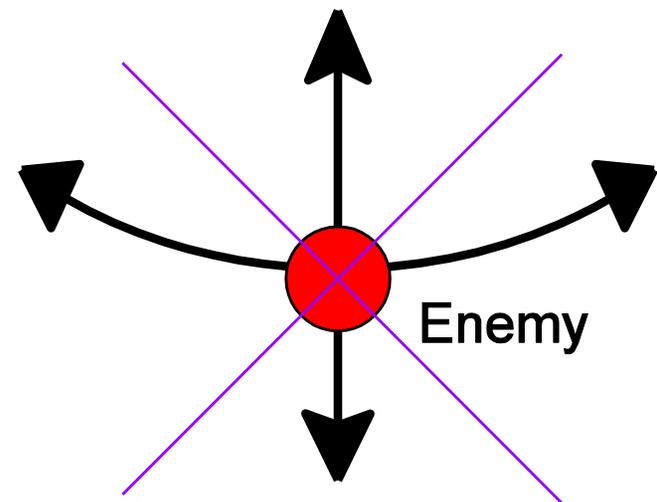
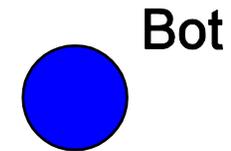
Ray traces for walls/level geometry



Other misc. sensors for current weapon properties, nearby item properties, etc.

Battle Controller Inputs

- Opponent movement sensors
 - Opponent performing movement action X?
 - Opponents modeled as moving like bot
 - Approximation used



Approximation Regions

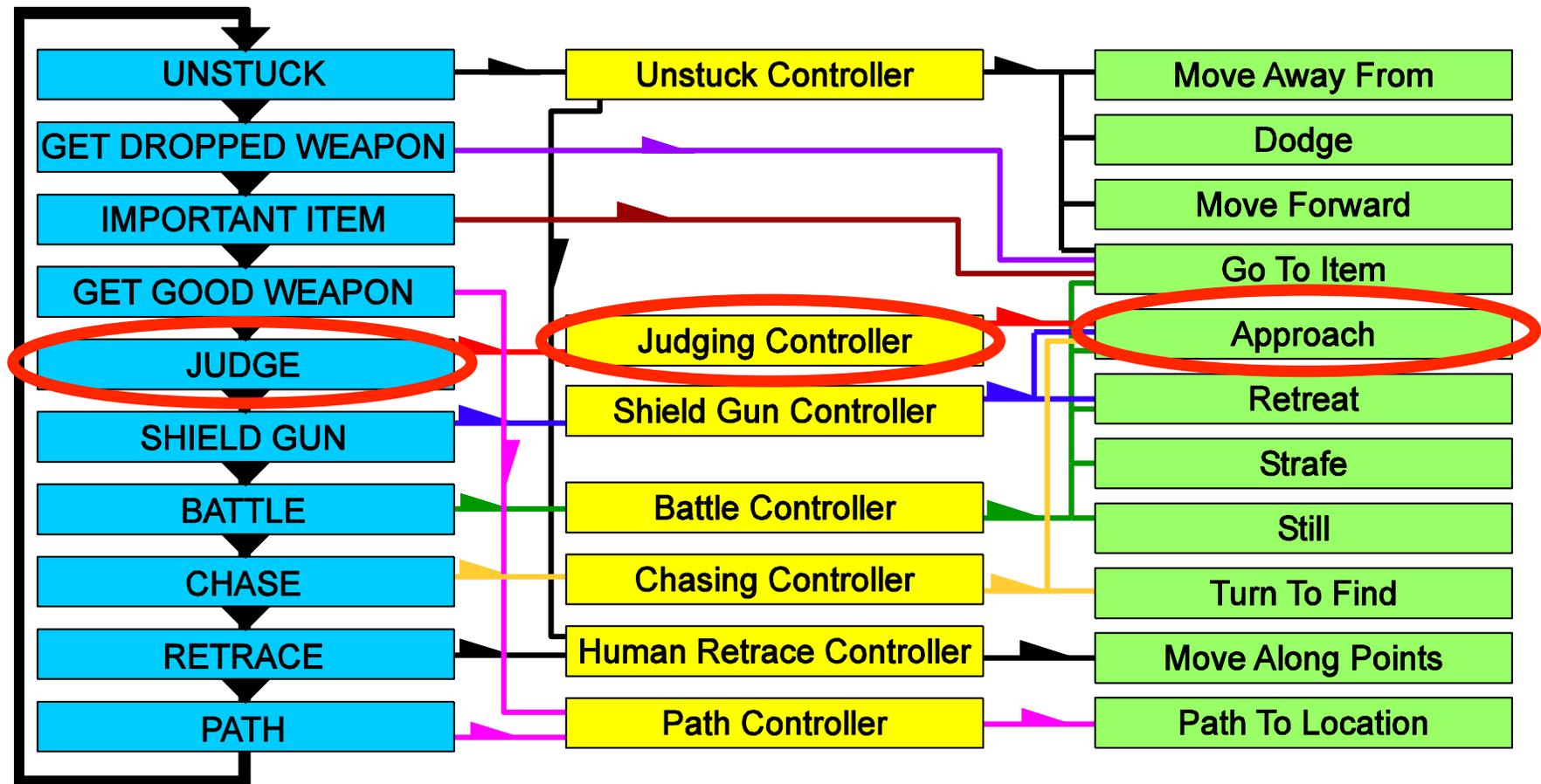


Evolving Battle Controller

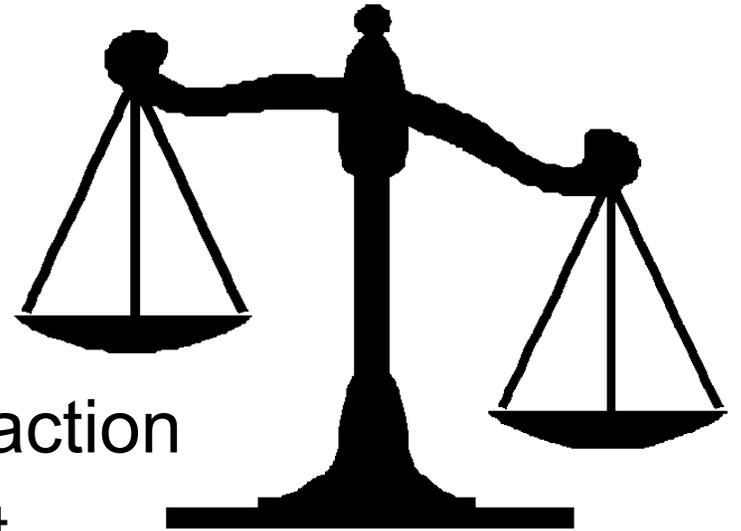
- Used NSGA-II with 3 objectives
 - Damage dealt
 - Damage received (negative)
 - Geometry collisions (negative)
- Evolved in DM-1on1-Albatross
 - Small level to encourage combat
 - One native bot opponent
- High score favored in selection of final network
- Final combat behavior highly constrained



Playing the judging game



Judging



- When to judge
 - More likely after more interaction
 - More likely as time runs out
 - Judge if successful judgment witnessed
- How to judge
 - Assume equal # humans and bots
 - Mostly judge probabilistically
 - Assume target is human if it judged correctly

Results

Most human bots

bot name	humanness %
Conscious-Robots	30.0000 %
ICE-CEC2011	26.3158 %
UT^2	10.5263 %
Knightbot	10.0000 %

Most human humans

player name	humanness %
Martin	88.2353 %
Dan	84.6154 %
phi	68.7500 %
Sisko	52.9412 %

Most human epic bots

skill level	humanness %
2	50.0000 %
3	33.3333 %
4	22.2222 %
5	0.0000 %

Best bot judges

bot name	accuracy %
UT^2	91.6667 %
Conscious-Robots	50.0000 %
ICE-CEC2011	38.4615 %

Best human judges

human name	accuracy %
Sisko	84.2105 %
Dan	84.2105 %
Martin	68.0851 %
phi	56.0000 %

Judges' Comments

- Bot-like
 - Too quick to fire initially after first sight
 - Ability to stay locked onto a target while dodging
 - Lots of jumping
 - Knowledge of levels (where to go)
 - Aggression with inferior weapons
 - Aim is too good most of the time
 - Crouching (Native bots)

Judges' Comments

- Human-like
 - Spending time observing
 - Running past an enemy without taking a shot
 - Incredibly poor target tracking
 - Stopping movement to shoot
 - Tend to use the Judging Gun more

Insights

- Judges expect opponents of similar skill
 - Our bot was too skilled
 - Humans are fallible
 - **Would mimicry help?**
- Human judges like to observe
 - Playing the judging game
 - Plan to judge in advance
 - **Expecting bots to be like judges**

Most human epic bots

skill level	humanness %
2	50.0000 %
3	33.3333 %
4	22.2222 %
5	0.0000 %



Previous Insights

- Botprize 2008, 2009: No judging game
 - Judges set traps: follow me, camping, etc.
- Botprize 2010: Judging game
 - Snap decisions were sometimes correct: how?
 - Still setting traps



What's Going On?

- Humans have always been more human
 - Why?!
- We're not getting better
- Need better understanding
- Native bots are better!
 - Botprize 2010: 35.3982% humanness
 - CEC 2011:

Botprize 2008	2/5 fooled
Botprize 2009	1/5 fooled
Botprize 2010	31.82% humanness
CEC 2011	30.00% humanness

Most human epic bots

skill level	humanness %
2	50.0000 %
3	33.3333 %
4	22.2222 %
5	0.0000 %



Future Competitions

- How does judging game complicate things?
 - Should human-like = judge-like
- What is our goal?
 - Human-like players for games?
 - But the native bots are already better!
 - Bots that deliberate/observe/ponder?
 - But at the expense of playing skill





Questions?

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