Artificial Intelligence for StarCraft

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University of Alberta
Computing Science
What is StarCraft?

► Blizzard - 1998

► Real-Time Strategy

  ▪ War Simulation

► Typical Game:

  ▪ Gather Resources
  ▪ Build Town / Army
  ▪ Combat With Enemies

► Properties

  ▪ Multi-Unit Control
  ▪ Imperfect Information
  ▪ Simultaneous Actions
  ▪ Real-Time (24fps)
Motivation – Why StarCraft?

► Solving hard AI problems
  ▪ Applicable to other fields

► Game Design / Testing
  ▪ Better single player experience
  ▪ Training for professionals
  ▪ Reduce Human Testers
  ▪ Game Balance

► Creating Strong AI agents
  ▪ Beat the best AI bots
  ▪ Beat the humans!

► Humans are VERY good
Professional Players

300-500 Actions Per Minute (APM)
Blizzard World Championships
#1 Highest Total Prizes Awarded

**StarCraft II**

$9,205,281.61

894 Tournaments

<table>
<thead>
<tr>
<th>Rank</th>
<th>Player</th>
<th>Prize Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MC</td>
<td>$409,221.84</td>
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<tr>
<td>2.</td>
<td>Mvp</td>
<td>$379,290.06</td>
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<tr>
<td>3.</td>
<td>NesTea</td>
<td>$268,394.80</td>
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<tr>
<td>4.</td>
<td>Polt</td>
<td>$241,902.77</td>
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<tr>
<td>5.</td>
<td>Stephano</td>
<td>$232,202.31</td>
</tr>
<tr>
<td>6.</td>
<td>MMA</td>
<td>$220,549.24</td>
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<tr>
<td>7.</td>
<td>Leenock</td>
<td>$213,270.15</td>
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<tr>
<td>8.</td>
<td>DongRaeGu</td>
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<tr>
<td>9.</td>
<td>HerO</td>
<td>$196,835.26</td>
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<tr>
<td>10.</td>
<td>PartinG</td>
<td>$189,718.77</td>
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</tbody>
</table>

*Salary Not Included*
Traditional Game AI

StarCraft is TOO LARGE

- Alpha-Beta
- MCTS
- CFR

$10^{150}$

$10^{170}$

$10^{80}$
How large is StarCraft?

Avg Map Size: 128 * 128

Number of Unit Types: ~50
Number of Units: ~200
How large is StarCraft?

Possible Unit Locations: $10^{1685}$

Does Not Include:
Unit Types, Health, Attacks, Resources, etc
StarCraft
(huge)
High-Level Strategy
Combat Policies
Opponent Modeling
Multi-Agent Pathfinding
Build-Order Planning
Unit Placement
StarCraft
StarCraft Strategy Flow

Initial Strategy → Game Knowledge

Current Strategy → Resource Gathering

Strategy Re-Planning → Build-Order Planning

Opponent Modeling → Information Gathering

Unit Positioning → Unit Production

Combat Scenarios → High-Level Strategy
Build Order Planning

Goal =  

Current Game State

Build Order Search

Build Order Sequence: $A_1, A_2, \ldots$
Build Order Planning

Depth-First Branch & Bound

Real-Time Search

“Build-order optimization in StarCraft” (2011 AIIDE)
Multi-Agent Pathfinding

Surround Enemy

Move As Group
Multi-Agent Pathfinding

StarCraft 1: Single-Agent

StarCraft 2: Flocking (but cheats)
RTS Combat

- Multiple Unit Types
  - HP, Damage
- Individual Unit Control
  - Attack, Move, Reload
- Real-Time
  - 24 FPS
- Simultaneous Moves
- Durative Actions
RTS Combat - Actions

- **Unit Action**
  - # Units = N
  - # Actions = A

- **Player Move**
  - # Player Moves = $A^N$

**Exponential Branching Factor 😞**
Alternating Move Tree Search
Tree Search for RTS Combat
Combat Research: SparCraft

Portfolio Greedy Search and Simulation for Large-Scale Combat in Starcraft
2013 CIG – http://code.google.com/p/sparcraft
UAlbertaBot - Overview

► Uses Protoss Race
► Aggressive Strategy
► CIG Results
  ▪ 2011 CIG – 2nd
  ▪ 2012 CIG – 2nd
  ▪ 2013 CIG – 2nd
► AIIDE Results
  ▪ 2011 AIIDE – 2nd
  ▪ 2012 AIIDE – 3rd
  ▪ 2013 AIIDE – 1st
UAlbertaBot Design

Initial Solution: Hand-Coded Scripts

Open Source: http://code.google.com/p/ualbertabot
UAlbertaBot - CMPUT 350

► University of Alberta CS Course
► 3\textsuperscript{rd} Year Undergraduates
► Beginning of Course
  - No C++ knowledge
  - No AI knowledge
► End of Course Project
  - Modify UAlbertaBot
  - Compete in Class Competition
► We use their improvements in UAlbertaBot
AIIDE
StarCraft AI Competition
2013 StarCraft AI Competition Files (BroodWar 1.16.1, BWAPI 3.7.4)

<table>
<thead>
<tr>
<th>Bot Name</th>
<th>Author</th>
<th>Affiliation</th>
<th>Race</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiur</td>
<td>Florian Richoux</td>
<td>University of Nantes</td>
<td>Protoss</td>
<td>bot / replays</td>
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<tr>
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- 2013 Official Results
- 2013 Competition Map Pack
2013 StarCraft AI Competition

- Hosted at U of A
  - Computing Science Department
- Blizzard provides prizes for winners
- 8 Participants
  - 2012 – 10, 2011 - 13
- Round Robin Format
  - 6000 games played = 200 Rounds
  - Games played up to 64x ‘human’ speed
- Penalties for slow computations
AIIDE StarCraft AI Competition

► Most AI bots written in C++
  ▪ Can be written in Java as well

► BWAPI Library used for StarCraft interface
  ▪ API created through reverse engineering
  ▪ Blizzard does not support BWAPI
  ▪ Lets us use it for academic competitions

► StarCraft 2 not allowed
Tournament Environment

- UofA Computer Lab
- 20 Intel E8500 CPU
  - 2.4ghz Dual Core
  - 4 GB of RAM
- Read/Write specific folders for learning
- Duration
  - 200 Rounds
  - 24 hours for 4 days
Tournament Software

StarCraft AI Competition - Tournament Manager Software

- Software Download
- Tournament Manager Introduction
  - Server
  - Client
- Software Instructions
  - Prerequisites
  - Download
  - Compile
  - Initial Server Setup
  - Running Server Software
  - Initial Client Setup
  - Running Client Software

Software Download

You can download the Tournament Manager Software here: TournamentManager.7z (447246)

The tournament manager software download includes precompiled server and client jar files, as well as the complete Java 7 runtime code. It also includes several required files for setup such as the blansembler and necessary Windows .dll files which will automatically be configured and run for you. Also included are the bots and maps from the 2013 AISDE StarCraft AI Competition. With these files you should be able to run a tournament as quickly as you can install StarCraft on all of your client machines.

Bug Reporting

Please report any bugs in this software to me at dave.churchill@gmail.com. I will answer any questions you have about the software, fix bugs, or add (reasonable) features upon request.

Disclaimer

Keep in mind that this is not retail software, and I am not responsible for any negative effects it has on your
# Participants

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## 2013 Results

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<th>Games</th>
<th>Win</th>
<th>Loss</th>
<th>Win %</th>
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</thead>
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<tr>
<td>UAlbertaBot</td>
<td>1400</td>
<td>1154</td>
<td>246</td>
<td>82.43</td>
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<tr>
<td>Skynet</td>
<td>1399</td>
<td>1018</td>
<td>381</td>
<td>72.77</td>
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<tr>
<td>Aiur</td>
<td>1400</td>
<td>844</td>
<td>556</td>
<td>60.29</td>
</tr>
<tr>
<td>Ximp</td>
<td>1400</td>
<td>774</td>
<td>626</td>
<td>55.29</td>
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<tr>
<td>Xelnaga</td>
<td>1399</td>
<td>699</td>
<td>700</td>
<td>49.96</td>
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<tr>
<td>ICEStarCraft</td>
<td>1399</td>
<td>669</td>
<td>730</td>
<td>47.82</td>
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<tr>
<td>Nova</td>
<td>1398</td>
<td>384</td>
<td>1014</td>
<td>27.47</td>
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<tr>
<td>BTHAI</td>
<td>1399</td>
<td>55</td>
<td>1344</td>
<td>3.93</td>
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<tr>
<td><strong>Total</strong></td>
<td>5597</td>
<td>5597</td>
<td>5597</td>
<td>N/A</td>
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Win Percentage Over Time
Past Results

- 2011 – Skynet, UAlbertaBot, Aiur
- 2012 – Skynet, Aiur, UAlbertaBot
- 2013 – UAlbertaBot, Skynet, Aiur

What Changed in UAlbertaBot?

- Bug fixes in UAlbertaBot behaviour
- Improved Combat Simulation
- If (Skynet) DarkTemplarRush();
Man vs. Machine

► 2012 / 2013
  - *Bakuryu* (Germany)
  - ICCup: A- Zerg
  - Top 20 Non-Korean

► Humans Dominate
  - Bots exploited easily
  - Human strategies are very strong
  - Bots cannot adapt
  - Bots lack global game context, too local
Man vs. Machine
Additional Discussion

► When will we beat humans?
  ▪ My Estimate: 10 years
  ▪ Will humans still play StarCraft in 10 years?

► What improved this year?
  ▪ Progress in research, but not bot strength
  ▪ Aiur learned well

► What needs work?
  ▪ Bots exploited by humans easily
  ▪ Bad overall strategy selection

► WE NEED TO COLLABORATE
Collaboration

- **UAlbertaBot**
  - Combat Simulation
  - Build-Order Planner

- **Skynet**
  - Good Path-finding
  - Solid Mid-Game Strategy

- **Aiur**
  - Many Strategies
  - Good Learning

- **BroodwarBotQ**
  - Opponent Modeling

- **Nova**
  - Kiting
Resources

► StarCraft AI Competition & Software
  ▪ www.StarCraftAICompetition.com

► UAlbertaBot Project
  ▪ http://code.google.com/p/ualbertabot

► SparCraft Project
  ▪ http://code.google.com/p/ualbertabot

► My Website
  ▪ http://www.cs.ualberta.ca/~cdavid/
Thank You!
ありがとう