AlphaStar: Mastering the Real-Time Strategy Game Starcraft II

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Content

• Introduction
• Part I – 2017: The Beginning
  • Framework
  • Mini-Games
  • Evaluation
• Part II – 2019: The Mastery
  • AlphaStar
Starcraft II

- Real-Time Strategy
- Made by Blizzard Entertainment
- Sci-Fi Theme
- 3 Races with completely different playstyles
- Competitive Scene
Protoss
Zerg & Terran
Google Deepmind Team
Oriol Vinyals

• Part of Google Brain before
• His research is used in Google Translate, Text-To-Speech and Speech recognition
• Cited over 43000 times
David Silver

• Professor of Computer Science of University College London
• Lead researcher of AlphaGo/AlphaZero
• Cited over 29000 times
Why Starcraft?

- **Real time**: Continuous Action required
- **Imperfect information**: Only part of the game state visible
- **Long term planning**: Early actions may payoff later
- **Large action space
- **Game theory**: There is no single superior strategy (rock-paper-scissors)
SC2LE – Starcraft 2 Learning Environment [7]
Observations I

• Use feature layers instead of 3D image
  • Main map
  • Minimap
  • Interface
Observations II
Actions

<table>
<thead>
<tr>
<th>Human Actions</th>
<th>IDLE</th>
<th>Left_Click_Hold (p1)</th>
<th>Press B + S</th>
<th>Release (p2)</th>
<th>Left_Click (p3)</th>
<th>IDLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent Actions</td>
<td>no_op</td>
<td>select_rect(p1, p2)</td>
<td>build_supply(p3)</td>
<td>no_op</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Available Actions:
- Base action Point Point
- no_op rectangle select
- no_op rectangle select
- no_op rectangle select
- Build supply
- Build supply

[7]
Mini Games

• **MoveToBeacon**: Get score for reaching a beacon with a unit (+1)

• **FindAndDefeatZerglings**: Move units and defeat enemies (+2)

• **BuildMarines**: Build workers, collect resources, build Supply Depots, build Barracks, and then train marines. (+1)
Baseline Agents

• **Atari-net Agent**: Also used for Atari Benchmark. CNN + FC

• **FullyConv Agent**: Similar architecture, but preserving spatial structure

• **FullyConv LSTM Agent**: Add a LSTM for memory
Baseline Agents
Performance on Mini Games

- **MoveToBeacon**
- **FindAndDefeatZerglings**
- **BuildMarines**

Graphs showing performance metrics for different mini games.
Performance on Mini Games

<table>
<thead>
<tr>
<th>Agent</th>
<th>Metric</th>
<th>Move to Beacon</th>
<th>Collect Mineral Shards</th>
<th>Find and Defeat Zerglings</th>
<th>Defeat Roaches</th>
<th>Collect Minerals and Gas</th>
<th>Collect Minerals and Banlings</th>
<th>Build Marines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random Policy</strong></td>
<td>Mean Max</td>
<td>1</td>
<td>17</td>
<td>4</td>
<td>1</td>
<td>23</td>
<td>12</td>
<td>&lt; 1</td>
</tr>
<tr>
<td><strong>Random Search</strong></td>
<td>Mean Max</td>
<td>25</td>
<td>32</td>
<td>21</td>
<td>51</td>
<td>55</td>
<td>2318</td>
<td>8</td>
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<tr>
<td><strong>DeepMind Human Player</strong></td>
<td>Mean Max</td>
<td>26</td>
<td>133</td>
<td>46</td>
<td>41</td>
<td>729</td>
<td>6880</td>
<td>138</td>
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<tr>
<td><strong>StarCraft GrandMaster</strong></td>
<td>Mean Max</td>
<td>28</td>
<td>177</td>
<td>61</td>
<td>215</td>
<td>727</td>
<td>7566</td>
<td>133</td>
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<tr>
<td><strong>Atari-Net</strong></td>
<td>Best Mean Max</td>
<td>25</td>
<td>96</td>
<td>49</td>
<td>101</td>
<td>81</td>
<td>3356</td>
<td>&lt; 1</td>
</tr>
<tr>
<td><strong>FullyConv</strong></td>
<td>Best Mean Max</td>
<td>26</td>
<td>103</td>
<td>45</td>
<td>100</td>
<td>62</td>
<td>3978</td>
<td>3</td>
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<tr>
<td><strong>FullyConv LSTM</strong></td>
<td>Best Mean Max</td>
<td>26</td>
<td>104</td>
<td>44</td>
<td>98</td>
<td>96</td>
<td>3351</td>
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</table>

[7]
Learning from Replays - Value Predictions

- Supervised Learning
Learning from Replays - Policy Predictions

<table>
<thead>
<tr>
<th></th>
<th>Top 1 Accuracy</th>
<th></th>
<th>Top 5 Accuracy</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Action</td>
<td>Screen</td>
<td>Minimap</td>
<td>Action</td>
</tr>
<tr>
<td>Atari-net</td>
<td>37.8%</td>
<td>1.2%</td>
<td>19.8%</td>
<td>87.2%</td>
</tr>
<tr>
<td>FullyConv</td>
<td>37.9%</td>
<td>9.5%</td>
<td>25.7%</td>
<td>88.2%</td>
</tr>
<tr>
<td>arFulyConv</td>
<td>37.7%</td>
<td>10.5%</td>
<td>25.9%</td>
<td>87.4%</td>
</tr>
<tr>
<td>Random</td>
<td>4.3%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>29.5%</td>
</tr>
</tbody>
</table>
Part II
What has happened? – A new star is born

• December 10\textsuperscript{th} 2018: AlphaStar beats the best DeepMind Starcraft player

• December 12\textsuperscript{th} 2018: AlphaStar beats Dario “TLO” Wünsch, a Pro Starcraft Player
  • BUT: TLO plays Zerg normally

• December 19\textsuperscript{th} 2018: AlphaStar beats Grzegorz “MaNa” Komincz, a Pro Starcraft Protoss Player
AlphaStar — What is inside? [10]

- Deep LSTM Core: sequence modelling, natural language processing (NLP) [14]
- Transformer Architecture: Attention mechanism, parallel computation [15]
  - Pointer Network: Use attention as pointer to input [16]
- Auto-regressive Policy: Use previous observations for next prediction [7]
- Centralised Value Baseline instead of a Multi-Agent system [17]
AlphaStar Training
Evolving Strategies

Units Counts of Nash of AlphaStar League

- 50 Stalkers made on average
- 2 Adepts made on average
- 2 Disruptors made on average

Training Days
Nash distribution in AlphaStar League
Training the League

- 14 days of training
- 16 TPUs per agent
  => up to 200 years of Starcraft play per agent
Example
Comparison to Human Play

[Diagram showing mean APM for different AI models compared to human play]
Comparison to Human Play

![Comparison of Interfaces for Training](chart.png)
• Announced yesterday: AlphaStar will play online in competitive ladders in Europe [18]
  • All races (Terran, Zerg, Protoss)
  • Camera-like view
  • Anonymously 😊

• => Go play Starcraft (It’s free!)

• Future: AlphaStarZero?
More about AlphaStar

AlphaStar – Inside Story

AlphaStar Demonstration
THANK YOU FOR YOUR ATTENTION!

ANY QUESTIONS?
References

• [19] https://www.youtube.com/watch?v=UuhECwm31dM
• [20] https://www.youtube.com/watch?v=cUTMhmVh1qs