Evaluating State-Space Abstractions in Extensive-Form Games

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Outline

• Using CFR-BR to evaluate abstractions

• Using imperfect recall in abstractions

• New abstraction features
  – Read our paper!
Extensive-Form Games

Rock Paper Scissors
9 states

Limit Texas Hold'em
$\sim 10^{18}$ states

RTS Games
many states

TOO BIG!
Abstraction

- Combine strategically similar situations to create a smaller (hopefully) strategically similar game.
Evaluating an Abstraction

• Gilpin and Sandholm (AAAI '08) listed three methods for evaluating abstractions
  – One on one comparison
  – Play versus real-game equilibrium
  – Play versus best-response
Evaluating an Abstraction

- One on one comparison
  - Not transitive: cycles of winners
  - Depends on the particular abstract solutions
Evaluating an Abstraction

• Play versus real-game equilibrium
  – Generally intractable
  – Depends on the particular abstract solutions
Evaluating an Abstraction

• Play versus best-response
  – Depends on the particular abstract solutions
  – Does not match observed one-on-on performance
CFR-BR

[Johanson et al. 2012]

CFR-BR finds the least exploitable abstract strategy

Abstract solutions

Abstract game strategies

Real game strategies

Real game solutions
Evaluation using CFR-BR

- CFR-BR (Johanson et al. AAAI '12) can be used to find an abstract strategy with lowest real-game exploitability
Imperfect Recall

Perfect Recall

Imperfect Recall

$N^{\text{Depth}} \text{ information sets}$

$K \text{ information sets}$
## Imperfect Recall

**Texas Limit Hold'em**

<table>
<thead>
<tr>
<th>Round</th>
<th>Chance</th>
<th>Player Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round 3</td>
<td></td>
<td>Player Action</td>
</tr>
<tr>
<td>Round 4</td>
<td></td>
<td>Player Actions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abstraction</th>
<th># Information Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/10/10/10 perfect recall</td>
<td>57,330,780</td>
</tr>
<tr>
<td>10/100/1000/10000 imperfect recall</td>
<td>57,330,780</td>
</tr>
<tr>
<td>169/9000/9000/9000 imperfect recall</td>
<td>57,331,352</td>
</tr>
</tbody>
</table>
Evaluating Imperfect Recall Abstractions

Should we use imperfect recall in an abstraction?
Yes!

<table>
<thead>
<tr>
<th>Abstraction</th>
<th>One-on-One Performance</th>
<th>vs. Best Response</th>
<th>CFR-BR vs. Best Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/10/10/10 PR</td>
<td>-24.8</td>
<td>-282.856</td>
<td>-84.039</td>
</tr>
<tr>
<td>169/9000/9000/9000 IR</td>
<td>24.8</td>
<td>-282.395</td>
<td>≥ -64.820</td>
</tr>
</tbody>
</table>

Comparison of perfect and imperfect recall abstraction of limit Texas Hold'em
All values are big blinds per thousand hands
Summary

• Use CFR-BR to evaluate abstractions
  – Transitive measure
  – Tracks one-on-one performance well
  – Not dependent on a particular strategy

• Use imperfect recall in abstractions
  – More flexibility in abstraction choices
  – Demonstrable improvement in abstraction quality
Thank you!

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