Lookahead Pathology in Real-Time Path-Finding

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Introduction

• Real-time path-finding ⇒
  ◦ incomplete search methods ⇒
  ◦ suboptimal actions
• Deeper lookahead believed to produce better actions
• Sometimes the opposite is true: pathology

Setting

• Path-finding in grid world
• Algorithm: LRTS [Bulitko & Lee 06]

Pathology Observed

<table>
<thead>
<tr>
<th>Degree of pathology</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>≥ 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-policy (problems %)</td>
<td>38.5</td>
<td>15.1</td>
<td>20.3</td>
<td>17.0</td>
<td>7.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

First Explanation

• Many pathological states

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Off-policy (problems %)</td>
<td>95.7</td>
<td>3.7</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

• First explanation apparently not correct
• Why the large difference between on-policy and off-policy?

Second Explanation

• Smaller lookahead depths benefit more from the updates to the heuristic ⇒
  ◦ depths closer ⇒ larger more likely worse than smaller
• First test: on-policy, ignore updates when measuring error ⇒
  ⇒ less pathology

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</tr>
</thead>
<tbody>
<tr>
<td>No updates (problems %)</td>
<td>79.8</td>
<td>14.2</td>
<td>4.5</td>
<td>1.2</td>
<td>0.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

• Second test: observe volume of updates to the heuristic ⇒
  ⇒ smaller volume at smaller depths

Third Explanation

• Fewer searches performed at larger lookahead depths ⇒
  ⇒ depths closer ⇒ larger more likely worse than smaller
• First test: on-policy experiment, search every move ⇒
  ⇒ less pathology

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</tr>
</thead>
<tbody>
<tr>
<td>Every move (problems %)</td>
<td>86.9</td>
<td>9.0</td>
<td>3.3</td>
<td>0.6</td>
<td>0.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

• Second test: observe number of states generated per move when searching every move ⇒
  ⇒ steeper increase than normally

Towards a Remedy

• Adaptive lookahead on an example map:
  ◦ optimal depth per start state:
    48% less travel than best fixed depth
  ◦ optimal depth per move:
    additional reduction
    ◦ 14% in travel
    ◦ 43% in computation per move

• Need to know optimal depths!
• Expensive to pre-compute for every state pair (7.6 · 10^6 pairs)

• State abstraction [Bulitko et al. 05] :
  ◦ 0.004% state pairs pre-computed
  ◦ 33% less travel than best fixed depth

Search every move