Applying AI Techniques to Ramsey Games

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How the Game is played:

1. Initial Board: Graph with \( n \) nodes, NO edges.
2. Players alternate turns:
   - Player I connects two nodes with a RED edge.
   - Player II connects two nodes with a BLUE edge.
3. First player to get a triangle in their color WINS.
Three Problems:

1. Compare AI game techniques.
   1.1 Mini-max: use Alpha-Beta to Prune Game Tree.
   1.2 Monte Carlo Methods: Play move with highest prob of winning.

2. For each $n$ what is outcome (wins, lose, or draw).

3. If both players play random, then what is prob of win, lose, or draw.
Can we evaluate the entire Game tree? TOO BIG. Instead:

1. Figure out how to STATICALLY evaluate a position.
2. Look ahead a fixed number of moves.
3. Work backwards to make best move.
4. Be clever about what nodes NOT TO look at.
For each move $m$ we wonder- is it a good move? To find out we:

1. Make move $m$ and then both play RANDOMLY who wins?
2. Repeat this LOTS of times.
3. Be clever about what nodes TO look at.

THEN we Pick move $m$ with the highest prob of WINNING.
Random and Non-Random

Eighten Nodes, want $K_4$. Alpha-Beta.

Depth 3 beats Depth 1 10 out of 11 times (literally)
Six Nodes, want triangle:

1. If both Players play **Perfect** then Player I wins.
2. If both Players play **Random** then Player I wins 60%.

Eighteen Nodes, want $K_4$:

1. If both Players play **Perfect** then Player I wins.
2. If both Players play **Random** then Player I wins 50%.

**Upshot:** Last result might lead to interesting mathematics.
Monte Carlo RULES!

Player I and II both play Monte Carlo on 6 node game.

<table>
<thead>
<tr>
<th>number of simulations per move</th>
<th>Percent of WINS for player I</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>75%</td>
</tr>
<tr>
<td>400</td>
<td>80%</td>
</tr>
<tr>
<td>600</td>
<td>83%</td>
</tr>
<tr>
<td>800</td>
<td>85%</td>
</tr>
<tr>
<td>1000</td>
<td>85%</td>
</tr>
<tr>
<td>1200</td>
<td>86%</td>
</tr>
<tr>
<td>1400</td>
<td>95%</td>
</tr>
</tbody>
</table>

UPSHOT: Mo’ simulations, Mo’ wins!

UPSHOT: Big jump at end– Interesting! Why?