The Parameterized Poker Squares
EAAI NSG Challenge

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What is the EAAI NSG Challenge?

- Goal: a fun way to encourage good, faculty-mentored undergraduate research experiences that includes an option for peer-reviewed paper publication and presentation at a major CS conference.
- Students work independently or in teams with a faculty mentor to meet the challenge.
- Challenge submissions and associated papers would be submitted one month before and at the following EAAI paper submission deadline, respectively.
- EAAI-16’s NSG Challenge: Parameterized Poker Squares
Poker Squares (Original)

• Materials:
  – shuffled standard (French) 52-card card deck,
  – paper with 5-by-5 grid, and
  – pencil

• Each turn, a player draws a card and writes the card rank and suit in an empty grid position.

• After 25 turns, the grid is full and the player scores each grid row and column as a 5-card poker hand according to a given point system.
# American Point System

<table>
<thead>
<tr>
<th>Poker Hand</th>
<th>Points</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royal Flush</td>
<td>100</td>
<td>A 10-J-Q-K-A sequence all of the same suit</td>
<td>10♣, J♣, Q♣, K♣, A♣</td>
</tr>
<tr>
<td>Straight Flush</td>
<td>75</td>
<td>Five cards in sequence all of the same suit</td>
<td>A♦, 2♦, 3♦, 4♦, 5♦</td>
</tr>
<tr>
<td>Four of a Kind</td>
<td>50</td>
<td>Four cards of the same rank</td>
<td>9♣, 9♦, 9♥, 9♠, 6♥</td>
</tr>
<tr>
<td>Full House</td>
<td>25</td>
<td>Three cards of one rank with two cards of another rank</td>
<td>7♠, 7♣, 7♥, 8♠, 8♣</td>
</tr>
<tr>
<td>Flush</td>
<td>20</td>
<td>Five cards all of the same suit</td>
<td>A♥, 2♥, 3♥, 5♥, 8♥</td>
</tr>
<tr>
<td>Straight</td>
<td>15</td>
<td>Five cards in sequence; Aces may be high or low but not both</td>
<td>8♣, 9♠, 10♥, J♦, Q♣</td>
</tr>
<tr>
<td>Three of a Kind</td>
<td>10</td>
<td>Three cards of the same rank</td>
<td>2♣, 2♥, 2♦, 5♣, 7♠</td>
</tr>
<tr>
<td>Two Pair</td>
<td>5</td>
<td>Two cards of one rank with two cards of another rank</td>
<td>3♥, 3♦, 4♣, 4♠, A♣</td>
</tr>
<tr>
<td>One Pair</td>
<td>2</td>
<td>Two cards of one rank</td>
<td>5♦, 5♥, 9♣, Q♠, A♥</td>
</tr>
<tr>
<td>High Card</td>
<td>0</td>
<td>None of the above</td>
<td>2♦, 3♣, 5♣, 8♥, Q♣</td>
</tr>
</tbody>
</table>
Scoring Example

Total: 229
Parameterization of Poker Squares

• The American Point System (0, 2, 5, 10, 15, 20, 25, 50, 75, 100) is based on hand rank in Poker.
• The British Point System (1, 3, 6, 12, 5, 10, 16, 30, 30) is based on the difficulty of forming the hands in Poker Squares. (a.k.a. English Point System)
• For our challenge, AI players are given the scoring system at play time with points in the range [-128, 127]. Examples:
  – Ameritish point systems: random variations on American and British systems
  – Single Hand: 1 point for one hand type, 0 points otherwise
  – Hypercorners: all 1 or -1 score values
  – Random: random score system in range [-128, 127]
Structure of the Game

- The game is structured as an alternating sequence of *chance nodes* and player *choice nodes*.
  - Each card draw is a probabilistic event where any remaining card is drawn with equal probability.
  - Each player *action* is a commitment to a card placement.
Game Tree Size

• How big is the Poker Squares game tree?
  – Root chance node: 52 possible cards
  – 52 depth-1 choice nodes: 25 possible placements
  – 52x25 depth-2 chance nodes: 51 possible cards
  – 52x25x51 depth-3 choice nodes: 24 possible placements
  – ...
  – 52!/27! x 25! = 52!/(27x26) ≈ 1.15x10^{65} nodes
  – Although:
    • Different draw/play sequences can lead to the same state.
    • Rows/columns may be reordered without affecting score.
  – Still, we cannot evaluate entire expectimax trees except for much smaller end-game situations.
Evaluation

• Players were evaluated using 12 point systems. For each point system:
  – Players had 5 minutes to process the point system, form strategy, etc.
  – Players then played 100 games with 30 seconds of decision time per game.
  – Total scores were linearly scaled between 0 (min. total score) and 1 (max. total score).
• The player with the maximum sum of scaled total scores is the winner.
**Results**

1. Score: **11.821**; Player: **BMO_V2**; Students: Karo Castro-Wunsch, William Maga; Faculty mentor: Calin Anton; School: MacEwan University

2. Score: **11.763**; Player: **GettysburgPlayer**; Students: Colin Messinger, Zuozhi Yang; Faculty mentor: Todd Neller; School: Gettysburg College

3. Score: **11.334**; Player: **Tiger**; Students: Robert Arrington, Clay Langley; Faculty mentor: Steven Bogaerts; School: DePauw University

4. Score: 11.170; Player: JoTriz; Student: Kevin Trizna; Faculty mentor: David Mutchler; School: Rose-Hulman Institute of Technology

5. Score: 7.149; Player: SRulerPlayer; Student: Zachary McNulty; Faculty mentor: Timothy Highley; School: La Salle University

6. Score: 0.192; Player: MonteCarloTreePlayer; Student: Isaac Sanders; Faculty mentor: Michael Wollowski; School: Rose-Hulman Institute of Technology

7. Score: 0.190; Player: DevneilPlayer; Student: Adam Devigili; Faculty mentor: Brian O'Neill; School: Western New England University
<table>
<thead>
<tr>
<th>Players</th>
<th>Mean Scores by Point System</th>
<th>1.00</th>
<th>0.99</th>
<th>1.00</th>
<th>0.99</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>1.00</th>
<th>11.821</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMO_V2</td>
<td>1.00</td>
<td>0.94</td>
<td>1.00</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
<td>0.97</td>
<td>1.00</td>
<td>0.99</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>11.821</td>
</tr>
<tr>
<td>DevonIIPlayer</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.190</td>
</tr>
<tr>
<td>Gettysburg</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
<td>1.00</td>
<td>0.99</td>
<td>1.00</td>
<td>0.99</td>
<td>0.97</td>
<td>0.94</td>
<td>0.91</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>11.763</td>
</tr>
<tr>
<td>SRulerPlayer</td>
<td>0.34</td>
<td>0.42</td>
<td>0.48</td>
<td>0.42</td>
<td>0.64</td>
<td>0.99</td>
<td>0.93</td>
<td>0.87</td>
<td>0.63</td>
<td>0.53</td>
<td>0.57</td>
<td>0.32</td>
<td>0.32</td>
<td>7.149</td>
</tr>
<tr>
<td>JoTriz</td>
<td>0.92</td>
<td>0.98</td>
<td>0.98</td>
<td>0.81</td>
<td>0.84</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>0.94</td>
<td>0.87</td>
<td>0.97</td>
<td>0.87</td>
<td>0.87</td>
<td>11.170</td>
</tr>
<tr>
<td>Tiger</td>
<td>0.92</td>
<td>1.00</td>
<td>0.99</td>
<td>0.68</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
<td>0.98</td>
<td>0.90</td>
<td>0.99</td>
<td>0.99</td>
<td>0.94</td>
<td>0.94</td>
<td>11.334</td>
</tr>
<tr>
<td>MonteCarloTreePlayer</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
<td>0.04</td>
<td>0.00</td>
<td>0.08</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.192</td>
</tr>
<tr>
<td>RandomPlayer</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.09</td>
<td>0.04</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.153</td>
</tr>
</tbody>
</table>