

NSG Challenge: Parameterized Poker Squares Results

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Introduction

The inaugural EAAI NSG Challenge¹ was to create AI to play a parameterized form of the game Poker Squares. We here describe the game of Poker Squares, our parameterization of the game, and the results of the competition.

Poker Squares

Poker Squares² (a.k.a. Poker Solitaire, Poker Square, Poker Patience) is a folk sequential placement optimization game³ appearing in print as early as 1949, but likely having much earlier origins. Using a shuffled 52-card French deck, the rules of (Morehead and Mott-Smith 1949, p. 106) read as follows:

Turn up twenty-five cards from the stock, one by one, and place each to best advantage in a tableau of five rows of five cards each. The object is to make as high a total score as possible, in the ten Poker hands formed by the five rows and five columns. Two methods of scoring are prevalent, as follows:

HAND	ENGLISH	AMERICAN
Royal flush	30	100
Straight flush	30	75
Four of a kind	16	50
Full house	10	25
Flush	5	20
Straight	12	15
Three of a kind	6	10
Two pairs	3	5
One pair	1	2

The American system is based on the relative likelihood of the hands in regular Poker. The English system is based on the relative difficulty of forming the hands in Poker Solitaire.

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¹Whereas DARPA has its “grand challenges”, ours are not so grand.

²<http://www.boardgamegeek.com/boardgame/41215/poker-squares>, <http://cs.gettysburg.edu/~tneller/games/pokersquares>

³<http://www.boardgamegeek.com/geeklist/152237/sequential-placement-optimization-games>

You may consider that you have “won the game” if you total 200 (American) or 70 (English).

Note that the single remaining Poker hand classification of “high card”, which does not fit any of the above classifications, scores no points.

Parameterized Poker Squares

As David Parlett observed, “British scoring is based on the relative difficulty of forming the various combinations in this particular game, American on their relative ranking in the game of Poker.” (Parlett 2008, pp. 552–553) We observe that different point systems give rise to different placement strategies.

For example, in playing with British or American scoring, one often has a row and column where one dumps unwanted cards so as to form higher scoring combinations in the other rows and columns. However, a very negative score (i.e. penalty) for the “high card” category would discourage leaving any such row or column without a high probability of alternative scoring.

In our parameterization of Poker Squares, we parameterize the score of each of the 10 hand categories as being an integer in the range [−128, 127]. Given a vector of 10 integers corresponding to the hand classification points as ordered in the table above, the player then plays Poker Squares according to the given point system.

The goal is to design Poker Squares AI with high expected score performance across the distribution of possible score parameters.

The EAAI NSG Challenge

Since the purpose of this contest is to promote undergraduate student-faculty research collaboration, each contest team included a full-time undergraduate and a college faculty member. Contest point systems consisted of the following types:

- American - (given above)
- English (a.k.a. British) - (given above)
- Ameritish - a randomized hybrid of American and British point systems; includes American and English systems
- Random - points for each hand category are chosen randomly in the range [−128, 127]

- Hypercorner - points for each hand category are chosen with equal probability from $\{-1, 1\}$
- Single Hand - only one hand category scores 1 point; all other categories score no points

Hand categories are decided according to the rules of Poker, with higher ranking hand categories taking precedence. For example, a three of a kind also contains one pair, but for scoring purposes will be counted as a three of a kind, even if one pair scores more points than three of a kind. Note that the high card hand category may be awarded points in non-Ameritish systems.

Java Contest Code

Entrants provided code implementing the `PokerSquaresPlayer` Java interface. Full Javadoc documentation and Java contest code is available online⁴.

For each point system tested in contest evaluation, each `PokerSquaresPlayer` was given the point system and 5 minutes to perform preprocessing before beginning game play. For each game, each player was given 30 seconds of total time for play decision-making. A player taking more than 30 seconds of total time for play decision-making or making an illegal play scored 10 times the minimum hand point score for the game.

For each point system tested, each player's scores were summed to a total score and this total was normalized to a floating point number ranging from 0 (lowest score of all players) to 1 (highest score of all players). Players were ranked according to the sum of their normalized scores across all point system tests. All testing was performed on a Dell Precision M4800 running Windows 7 (64-bit) with an Intel Core i7-4940MX CPU @ 3.1GHz, 32 GB RAM, and running Java version 1.8.0_51. Results of the contest can be seen in Figure 1.

Non-fixed point systems were generated with contest random seed 34412016. The twelve point systems used for contest evaluation included American, Ameritish, British, Hypercorner, Random, and the following seven Single-Hand systems: High Card, One Pair, Two Pairs, Three of a Kind, Straight, Flush, and Full House.

Final contest standings were as follows:

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: xRandomRolloutPruningPlayer; 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

⁴<http://cs.gettysburg.edu/~tneller/games/pokersquares/eaii>

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 Devigli; Faculty mentor: Brian O'Neill; School: Western New England University

As a benchmark, a random player was evaluated alongside contestants, scoring 0.153 tournament points. We first note that a cluster of 4 players scored close to the tournament maximum possible score of 12, i.e. 4 of the 7 entries had similar excellent performance. We might conjecture that these are successively better approximations to optimal play that may not be far beyond in performance. The two bottom entries scored only slightly better than random play.

We look forward to learning more about the best entries through team papers submitted to EAAI-2016. It would be interesting to see if either a hybrid approach combining the strengths of the best players, or an ensemble approach combining the player recommendations might yield even greater performance.

Conclusion

The inaugural EAAI NSG Challenge was reported to be a very positive experience by both students and faculty. Informal evaluation indicates that more than half of entries perform well beyond human-level play, and most were densely clustered at the top of the distribution, lending confidence to a conjecture that optimal play is not far beyond the performance observed.

References

- [Morehead and Mott-Smith 1949] Morehead, A. H., and Mott-Smith, G. 1949. *The Complete Book of Solitaire & Patience Games*. Grosset & Dunlap, 1st edition.
 [Parlett 2008] Parlett, D. 2008. *The Penguin Book of Card Games*. Penguin Books, updated edition.

Parameterized Poker Squares Results

Players Mean Scores by Point System													
	American	Ameritish	British	Hypercorner	Random	High Card	One Pair	Two Pair	3 of a Kind	Straight	Flush	Full House	
BMO_V2	125.27	105.54	54.50	1.10	437.77	9.37	9.12	4.46	3.20	2.97	3.43	1.82	
DevneilPlayer	14.36	15.27	7.51	-9.52	-86.92	5.22	4.10	0.45	0.21	0.04	0.05	0.03	
Gettysburg	123.94	110.28	53.38	1.24	429.89	9.37	9.17	4.47	3.02	2.71	3.46	1.93	
SRulerPlayer	51.83	55.39	30.29	-5.10	242.85	9.34	8.84	4.04	2.10	1.58	1.98	0.61	
JoTriz	116.75	109.03	53.59	-0.78	351.07	9.31	9.15	4.59	3.03	2.59	3.36	1.67	
xRandomRolloutPruningPlayer	116.12	111.26	53.92	-2.20	411.78	9.35	9.16	4.52	2.89	2.94	3.41	1.82	
MonteCarloTreePlayer	15.47	15.31	7.61	-9.30	-86.83	4.80	4.53	0.45	0.20	0.05	0.02	0.00	
RandomPlayer	14.25	15.67	7.71	-9.66	-106.80	5.20	4.31	0.42	0.23	0.01	0.01	0.01	
Max	125.27	111.26	54.50	1.24	437.77	9.37	9.17	4.59	3.20	2.97	3.46	1.93	
Min	14.25	15.27	7.51	-9.66	-106.80	4.80	4.10	0.42	0.20	0.01	0.01	0.00	
Normalized Scores													
												Total	
BMO_V2	1.00	0.94	1.00	0.99	1.00	1.00	0.99	0.97	1.00	1.00	0.99	0.94	11.821
DevneilPlayer	0.00	0.00	0.00	0.01	0.04	0.09	0.00	0.01	0.00	0.01	0.01	0.02	0.190
Gettysburg	0.99	0.99	0.98	1.00	0.99	1.00	1.00	0.97	0.94	0.91	1.00	1.00	11.763
SRulerPlayer	0.34	0.42	0.48	0.42	0.64	0.99	0.93	0.87	0.63	0.53	0.57	0.32	7.149
JoTriz	0.92	0.98	0.98	0.81	0.84	0.99	1.00	1.00	0.94	0.87	0.97	0.87	11.170
xRandomRolloutPruningPlayer	0.92	1.00	0.99	0.68	0.95	1.00	1.00	0.98	0.90	0.99	0.99	0.94	11.334
MonteCarloTreePlayer	0.01	0.00	0.00	0.03	0.04	0.00	0.08	0.01	0.00	0.01	0.00	0.00	0.192
RandomPlayer	0.00	0.00	0.00	0.00	0.00	0.09	0.04	0.00	0.01	0.00	0.00	0.01	0.153

Figure 1: Results of Contest Evaluation.