

The Poker Squares Challenge

Todd W. Neller

What is the Poker Squares Challenge?

- A semester-long contest where Gettysburg College students (individuals and/or teams) compete to develop the best time-limited Poker Squares playing program.
- Outline:
 - Learn how to play
 - Play
 - Discuss strategy
 - Present possible computational approaches
 - Contest details

Poker Squares

- 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 the American point system.

American Point System

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

Scoring Examples

PySol - Poker Square

File Select Edit Game Assist Options Help

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Royal Flush	100	1
Straight Flush	75	0
Four of a Kind	50	0
Full House	25	2
Flush	20	3
Straight	15	0
Three of a Kind	10	1
Two Pair	5	1
One Pair	2	2

WON

Total: 229

100 20 20 20 2

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PySol - Poker Square

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Royal Flush	100	0
Straight Flush	75	1
Four of a Kind	50	2
Full House	25	0
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20 0 75 20 0

1:37 25/25 151: 92/59

Let's Play!

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Straight Flush	75	Five cards in sequence all of the same suit	A♦, 2♦, 3♦, 4♦, 5♦
Four of a Kind	50	Four cards of the same rank	9♣, 9♦, 9♥, 9♠, 6♥
Full House	25	Three cards of one rank with two cards of another rank	7♠, 7♣, 7♦, 8♥, 8♠
Flush	20	Five cards all of the same suit	A♥, 2♥, 3♥, 5♥, 8♥
Straight	15	Five cards in sequence; Aces may be high or low but not both	8♣, 9♠, 10♥, J♦, Q♣
Three of a Kind	10	Three cards of the same rank	2♠, 2♥, 2♦, 5♣, 7♠
Two Pair	5	Two cards of one rank with two cards of another rank	3♥, 3♦, 4♣, 4♠, A♣
One Pair	2	Two cards of one rank	5♦, 5♥, 9♣, Q♠, A♥
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Strategy Discussion

PySol - Poker Square

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PySol - Poker Square

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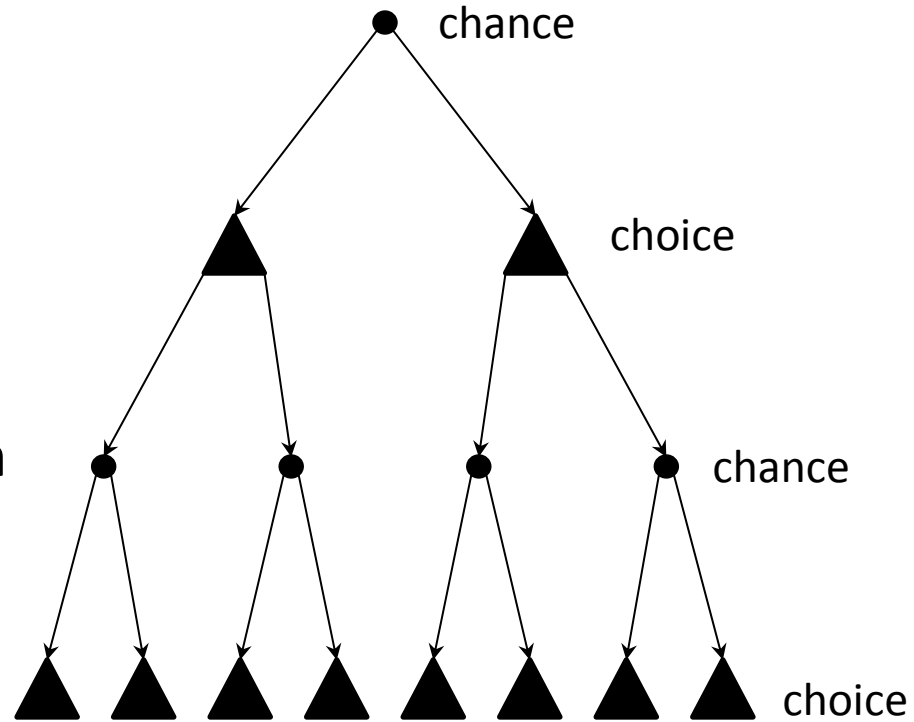
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Possible Computational Approaches

- Rule-based: hard code an algorithm (e.g. decision tree) for the placement of cards
 - Example: Place cards so as to maximize potential column flushes and row rank repetitions
- Simple Monte Carlo:
 - For each possible play, shuffle remaining cards and simulate a number of random/rule-based playouts.
 - Choose the play that yields the best average result.
- More complex Monte Carlo play is possible.

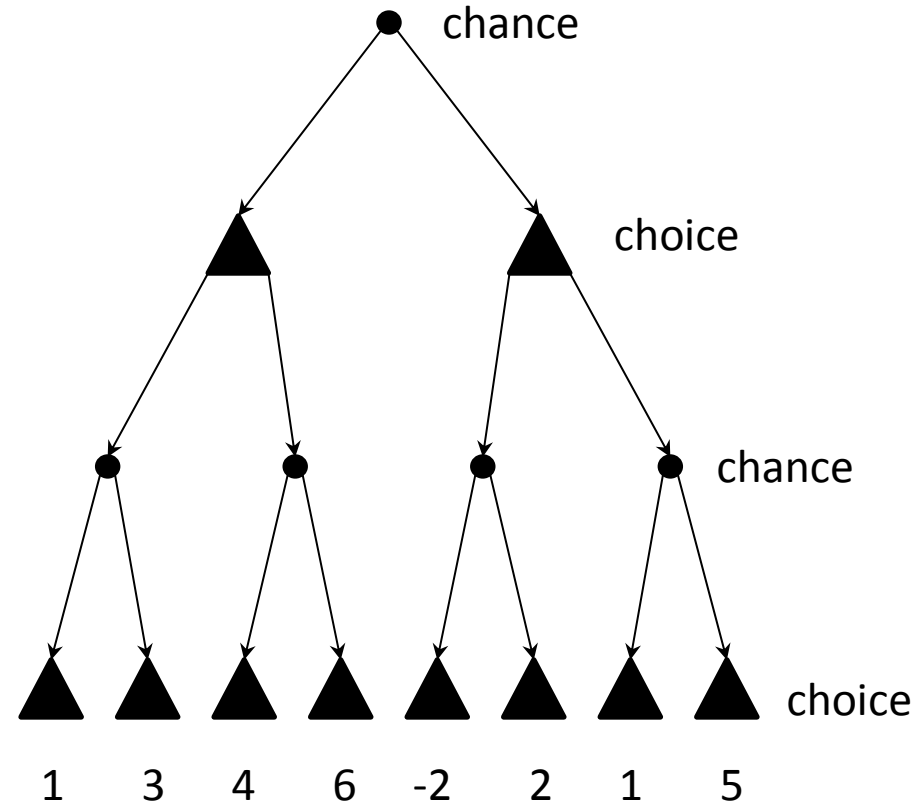
Structure of the Game

- 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.



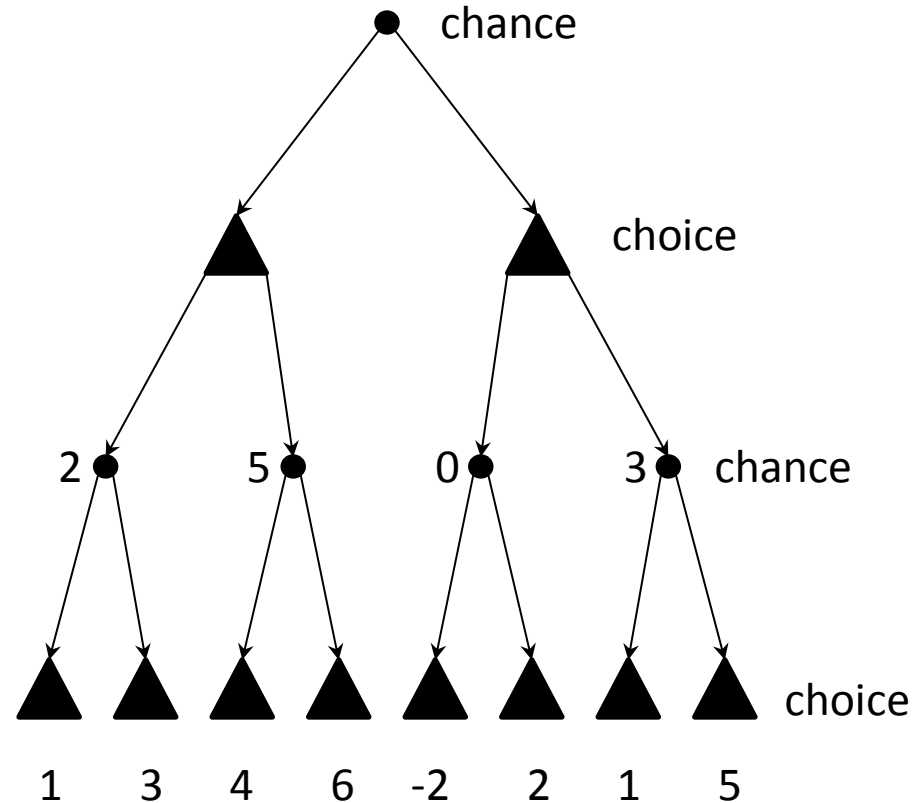
Expectimax Example

- Assume:
 - all chance events are equiprobable
 - numbers indicate node utility (e.g. score)
- What is the expected value of the root chance node?



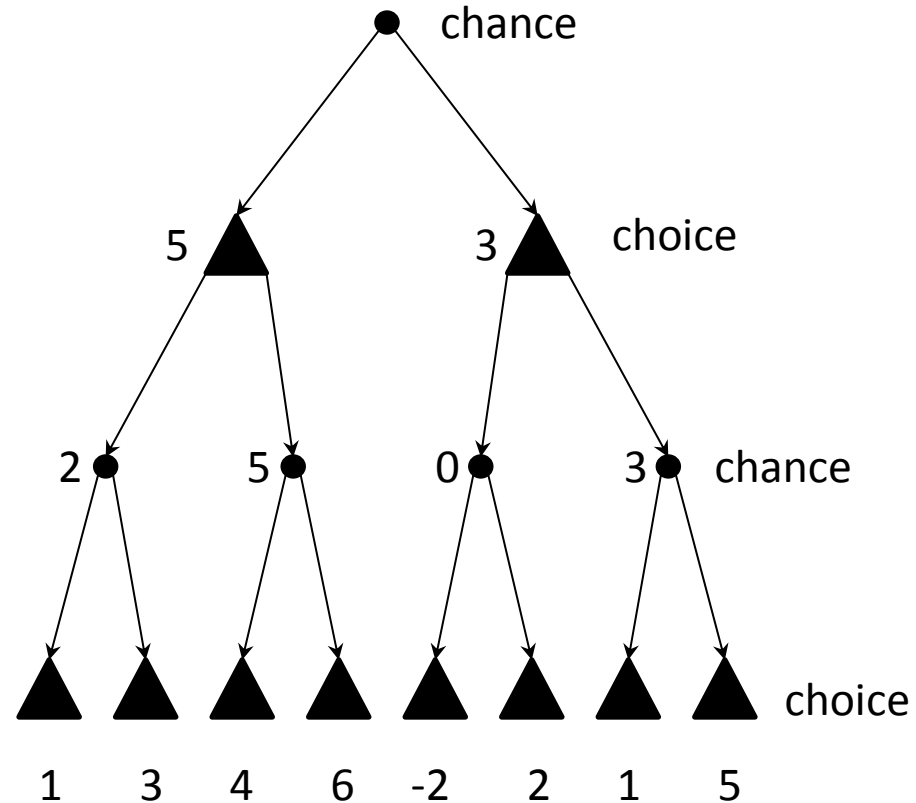
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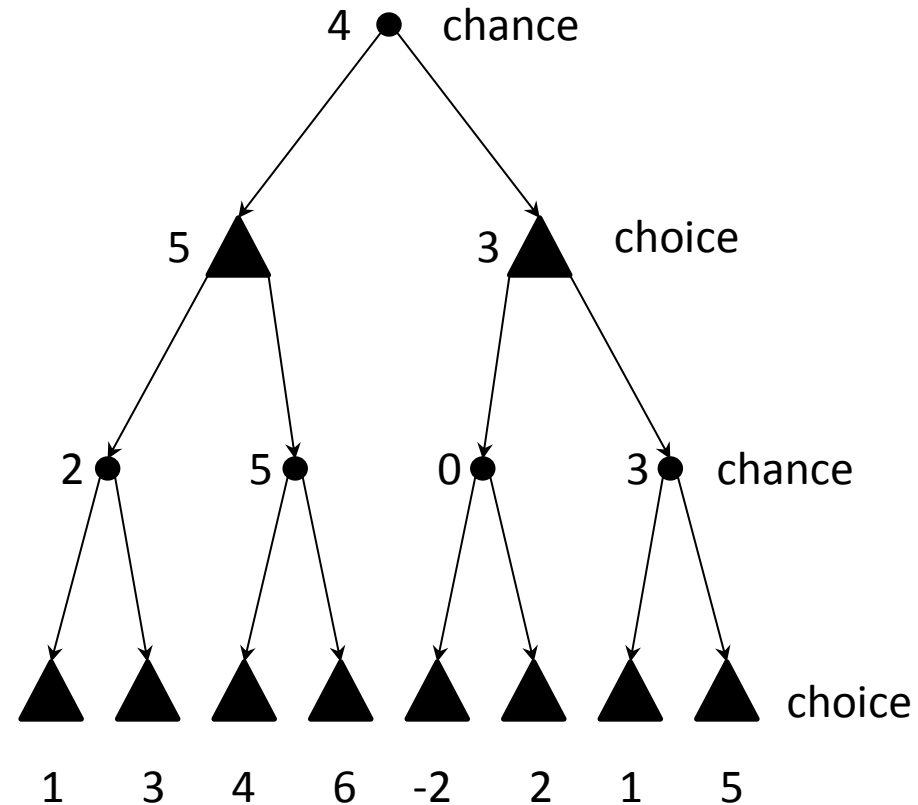
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Game Tree Size

- 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
 - ...
 - $52!/27! \times 25! = 52!/(27 \times 26) \cong 1.15 \times 10^{65}$ nodes
 - Although:
 - Different draw/play sequences can lead to the same state.
 - Rows/columns may be reordered without affecting score.
 - Still, we will not be able to evaluate entire expectimax trees except for much smaller end-game situations.

Static Evaluation

- Another approach: optimize static evaluation
 - Static evaluation: a measure of the relative goodness/badness of a partially filled grid.
 - Simple depth-1 greedy play: place a card so as to achieve the best static evaluation of the resulting board
 - More generally, compute depth- n expectimax for small n , using static evaluation at the depth limit.
 - Still, n must remain small for fast tree evaluation.

Monte Carlo Sampling

- We can reduce the branching factor and evaluate more deeply and approximately by *sampling*.
- Chance events and/or actions may be sampled:
 - At each chance node, average a sample drawn from the given probability distribution.
 - At each choice node, maximize a sample of the possible actions.
- However, we'd like to sample better plays more often to discern which is the best.

Monte Carlo Tree Search (MCTS)

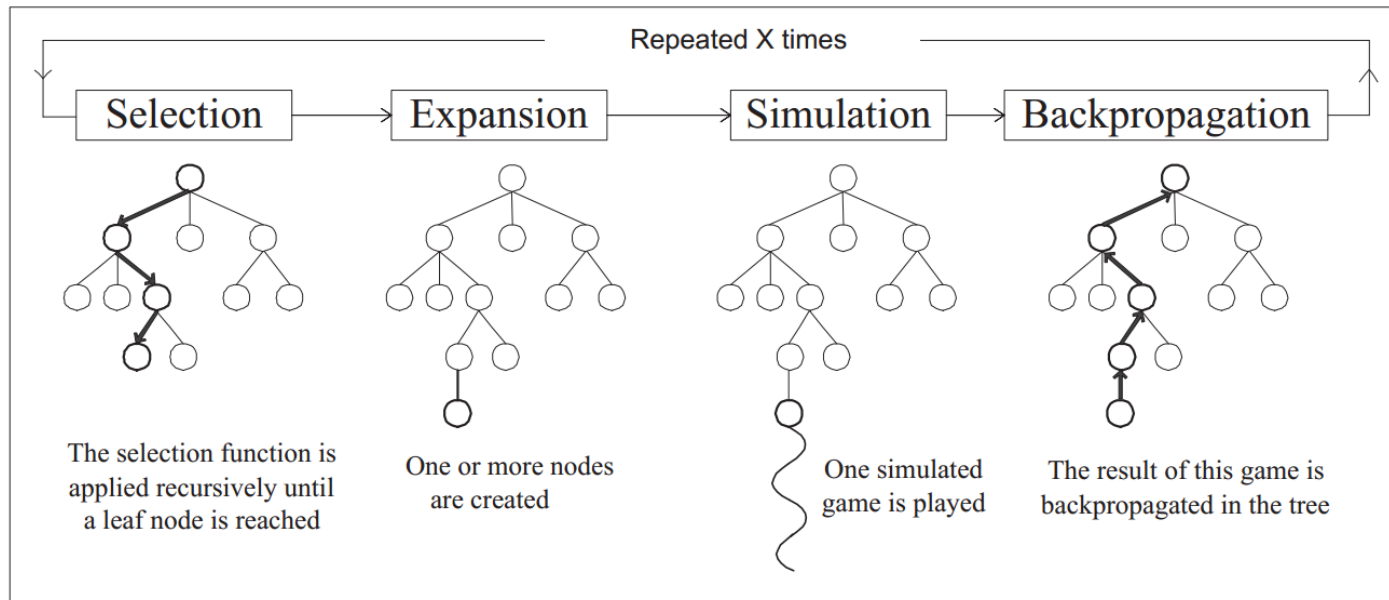


Figure from <http://www.personeel.unimaas.nl/g-chaslot/papers/newMath.pdf>

- Monte Carlo Tree Search details are beyond the scope of this talk, but
 - UCT is a popular form of MCTS: L. Kocsis, C. Szepesvari. [Bandit based Monte-Carlo Planning.](#)
 - Richard Lorentz has recently had success adapting UCT to a game with similar structure: R. Lorentz. *An MCTS Program to Play EinStein Würfelt Nicht!*

Combining Static Evaluation and MCTS

- One can also combine the ideas of static evaluation and MCTS by
 - Limiting depth of MCTS playouts, and
 - Using static evaluations instead of terminal evaluations
- Many different approaches are possible
 - The better the static evaluation, the less the need for tree search.
 - Perfect static evaluation → use simple greedy play!

Contest Details

- From <http://tinyurl.com/pokersqrs>, download:
 - Card.java: basic card object
 - PokerSquares.java: game simulator, player tester
 - PokerSquaresPlayer.java: simple player interface
 - RandomPokerSquaresPlayer.java: random player
- Run RandomPokerSquaresPlayer to see random game.
- Run PokerSquares to see RandomPokerSquaresPlayer test.
 - Mean score: 14.4, standard deviation: 7.6
- Each game is limited to 1 minute. A player taking longer than 1 minute on a game scores 0 for that game.

Dickinson Contest Suggestion

- Mid-semester trial contest:
 - Submissions due before spring break to local coordinator, results available after break.
- End-semester contest:
 - Submissions due at the end of the 2nd-to-last week of classes, results available in the last week of classes.
- Prizes?

Be Encouraged

- Don't let the complexity of some of these approaches discourage you from trying. This is an open problem; the best approach is unknown. Remember the **KISS principle**.
- Recall that random play has a mean score of 14.4 with a standard deviation of 7.6.
- A *very* simple player of mine with a **15-line** `getPlay` method has a **mean score of 81.1** with a standard deviation of 16.8. Can you guess what it does?

Resources and References

- Gettysburg College Poker Squares Page:
<http://tinyurl.com/pokersqrs>
 - References
 - Rules and play grids
 - Contest code
- Monte Carlo Tree Search (MCTS):
 - L. Kocsis, C. Szepesvari. [*Bandit based Monte-Carlo Planning.*](#)
 - <http://www.mcts.ai/?q=mcts>
- MCTS application to similar problem: R. Lorentz.
An MCTS Program to Play EinStein Würfelt Nicht!