

Rummy 500 With Symbolic AI Opponent

By Matthew Grzenda





Overview

What ways are there to implement an opponent in a game?

- Background on heuristics and Rummy 500
- Approach and knowledge representations for this project
- Explainable AI and its implementation in this project
- Extensions and elaborations



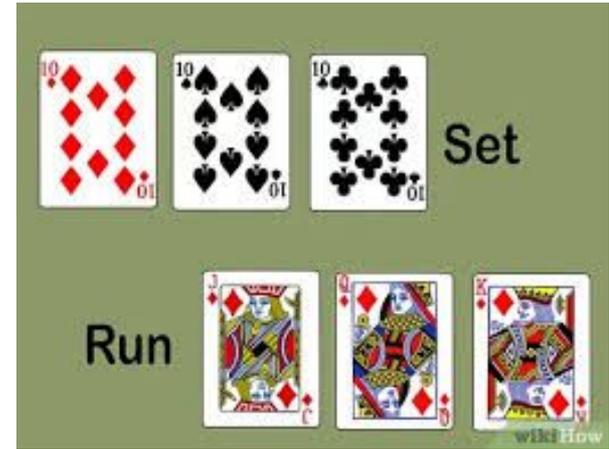
How Humans Play Games

- “Humans tend to be heuristic problem solvers.” (H. A. Simon and A. Newell)
- Develop heuristics as a game is repeatedly played
- More heuristics developed and known heuristics updated
- Heuristics stored for later use



Rummy 500

- Classic card game played by 2 - 8 people
- Players draw a card, play melds, and discard on each turn
- Players score points based on the melds they play
- First player to 500 points wins!
- Chosen for research due to unique challenges and sentimental value





Approach

- Prolog
- Rule based heuristic architecture
- Representations for each card, deck, discard pile, player
- Start with simple player and evolve



Game with only Sets

```
Deck: [3H,9S,8H,5H,8S,9C,7D,3S,10H,10S,AS,KH,QS,6C,JS,2C]
Discard Pile: [QC,4S,4H,4D,KC,QH,6H,JH,8C]

Player 1 turn!
HAND BEFORE TURN: [10C,8D,AH,6S,9H,KD,AH,KS,3C,3D]
MELDS BEFORE TURN: [[5C,5S,5D]]

DRAWING FROM DECK: [3H]
LOOKING FOR SETS...
SET FOUND: [3H,3C,3D]
DISCARDING: [9H]

HAND AFTER TURN: [10C,8D,AH,6S,KD,AH,KS]
MELDS AFTER TURN: [[3H,3C,3D],[5C,5S,5D]]
```

Game with only Runs

```
Player 2 turn!
HAND BEFORE TURN: [AC,2H,2S,3D,5C,5H,7D,7H,8C,9H,10D,QD,QC]
MELDS BEFORE TURN: []

DRAWING FROM DECK: [6H]
LOOKING FOR RUNS...
RUN FOUND: [5H,6H,7H]
DISCARDING: [QC]

HAND AFTER TURN: [AC,2H,2S,3D,5C,7D,8C,9H,10D,QD]
MELDS AFTER TURN: [[5H,6H,7H]]
```

One of Each

```
Deck: [AH,9C,10S,6D,AS,4H,5S,9D,7H,KS,7S,7D,KC,6S,8C,4D,8H,4S]  
Discard Pile: [8D,3H,8S,3D,2D,2H,7C]
```

Player 1 turn!

```
HAND BEFORE TURN: [AH,2S,9H,9S,JD,JH,QD,QC,4C,AC]
```

```
MELDS BEFORE TURN: [[5C,5H,5D]]
```

```
DRAWING FROM DECK: [AH]
```

```
LOOKING FOR SETS...
```

```
SET FOUND: [AH,AH,AC]
```

```
DISCARDING: [4C]
```

```
HAND AFTER TURN: [2S,9H,9S,JD,JH,QD,QC]
```

```
MELDS AFTER TURN: [[AH,AH,AC],[5C,5H,5D]]
```

Player 2 turn!

```
HAND BEFORE TURN: [2C,3C,3S,6C,6H,10D,10C,10H,JC,JS,QH,QS,KH]
```

```
MELDS BEFORE TURN: []
```

```
DRAWING FROM DECK: [9C]
```

```
LOOKING FOR RUNS...
```

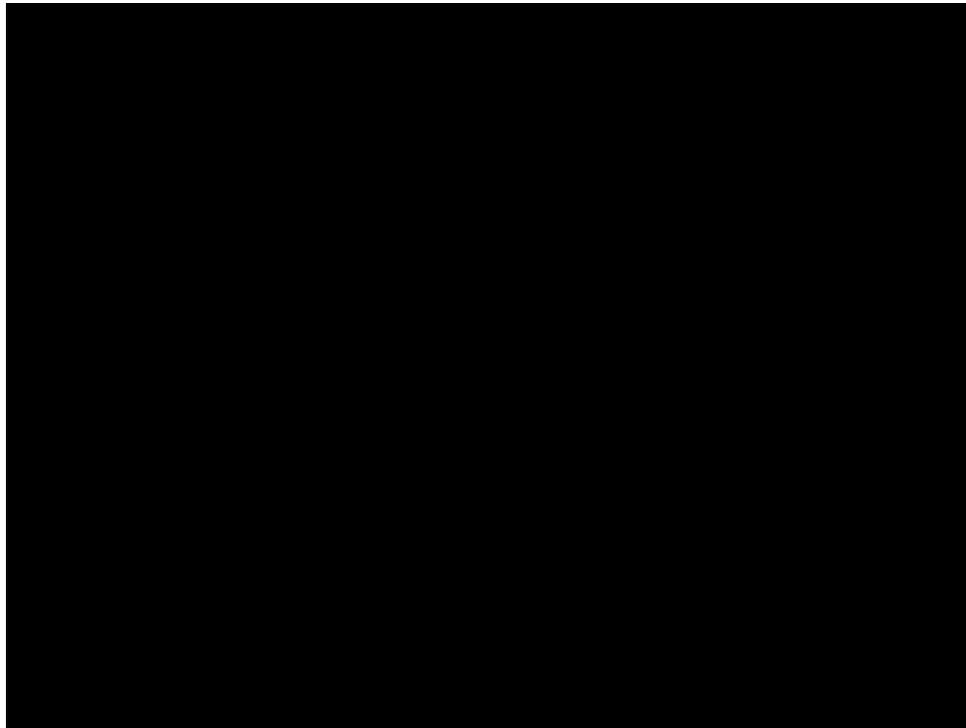
```
RUN FOUND: [9C,10C,JC]
```

```
DISCARDING: [2C]
```

```
HAND AFTER TURN: [3C,3S,6C,6H,10D,10H,JS,QH,QS,KH]
```

```
MELDS AFTER TURN: [[9C,10C,JC]]
```

Both Sets and Melds Played





Knowledge Representation

- Rules encoded in *if -> then* style architecture
- Rules examined by the order that would occur in a Rummy 500 turn
- Rules to evaluate melds are a special case



English Explanations

- Explainable AI is in increasing demand
- The architecture of this game allows for explanations
- For every action taken by the program, an explanation is given

```
Deck: [10H,KS,AH,3C,8H,5D,5S,6S,7H,5C,JS,7C,9H,3D,KD,5H]
Discard Pile: [2D,7S,KH,3H,6H,9S,4S,9D,8C]

Player 1 turn!
HAND BEFORE TURN: [3S,4D,4C,4H,9C,JC]
MELDS BEFORE TURN: [[2H,2S],[6D,7D,8D],[QD,QS]]

LOOKING FOR SETS...
SET FOUND: [4D,4C,4H]
LOOKING FOR RUNS...
NO RUNS FOUND.

HAND AFTER TURN: [9C,10H,KS]
MELDS AFTER TURN: [[4D,4C,4H],[2H,2S],[6D,7D,8D],[QD,QS]]

Player 2 turn!
HAND BEFORE TURN: [6C,8S,JD,QC,KC]
MELDS BEFORE TURN: [[AC,AH,AS],[JH,QH],[10D,10C,10S]]

LOOKING FOR SETS...
NO SETS FOUND
LOOKING FOR RUNS...
NO RUNS FOUND.

HAND AFTER TURN: [3C,6C,8S,JD,QC]
MELDS AFTER TURN: [[AC,AH,AS],[JH,QH],[10D,10C,10S]]
```



Current State of Project

```
Deck: [4D,7S,9C,3H,10C,3S,5C,8H,4C,8D,2H,5H,5S,K5,7H,3D,10H,2S,AH,5D,9H,9S,3C,8S]  
Discard Pile: [QS]
```

```
Player 1 turn!  
HAND BEFORE TURN: [QC,10S,6H,3H,QD,2C,AS,7D,JS,2D,QH,KD,3D]  
MELDS BEFORE TURN: []
```

```
DRAWING FROM DECK: [4D]  
LOOKING FOR SETS...  
SET FOUND: [QC,QD,QH]  
LOOKING FOR RUNS...  
RUN FOUND: [2D,3D,4D]  
DISCARDING: [3H]
```

```
HAND AFTER TURN: [AS,2C,6H,7D,10S,JS,KD]  
MELDS AFTER TURN: [[2D,3D,4D],[QC,QD,QH]]
```

```
Player 2 turn!  
HAND BEFORE TURN: [JC,4S,10D,7C,6D,AH,6C,9D,6S,KH,AC,KC,8C]  
MELDS BEFORE TURN: []
```

```
DRAWING FROM DECK: [7S]  
LOOKING FOR SETS...  
SET FOUND: [6D,6C,6S]  
LOOKING FOR RUNS...  
NO RUNS FOUND.  
DISCARDING: [10D]
```

```
HAND AFTER TURN: [AC,AH,4S,7C,7S,8C,9D,JC,KC,KH]  
MELDS AFTER TURN: [[6D,6C,6S]]
```

- Opponent can detect any melds in a hand and play them
- Draws from deck, discarding done randomly
- All actions explained



Extensions and Elaborations

- More game play heuristics
- Human Opponent
- Program which learns heuristics



References

1. Matthew L. Ginsberg. 1999. GIB: Steps Toward an Expert-Level Bridge-Playing Program. In *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence (IJCAI '99)*. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 584–593.
2. . K. Došilović, M. Brčić and N. Hlupić, "Explainable artificial intelligence: A survey," 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), Opatija, Croatia, 2018, pp. 0210-0215, doi: 10.23919/MIPRO.2018.8400040.
3. A. Newell, J. C. Shaw, and H. A. Simon. 1957. Empirical explorations of the logic theory machine: a case study in heuristic. In *Papers presented at the February 26-28, 1957, western joint computer conference: Techniques for reliability (IRE-AIEE-ACM '57 (Western))*. Association for Computing Machinery, New York, NY, USA, 218–230. DOI:<https://doi.org/10.1145/1455567.1455605>
4. von Neumann and O. Morgenstern, *Theory of Games and Economic Behavior*, Princeton University Press, 1944.



Acknowledgements

I would like to thank Prof. Dan Schlegel and Prof. Craig Graci for their advisement on this project.