

# GRP 17: Euchred?

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# Abstract

This modeling project aims to model whether or not a euchre can occur in the popular card game Euchre. Based on the outcome of the first three tricks in a hand of euchre, the trump suit, and the team that called trump, our model will analyze game play of tricks 4 and 5 to see if a Euchre takes place.

# **Propositions**

- Called Trump  $Q_i$ : This is true when team X has called trump. Subscript indicates which player called trump
  - $-Q_1 \vee Q_2$
- Trick  $T_{i,j}$ : This is true when player i is on team x and has won the trick j.
  - $-C_1, v, n \vee C_3, v, n$
- Win  $W_t$ : This is true when team X has won  $\geq 3$  tricks t.
  - $-W_3 \vee W_4 \vee W_5$
- Euchre E: This is true when  $W \neq Q$ 
  - $-W_t \wedge \neg Q_i$
- Player  $P_i$ : This is true when player i is on team X and holds the winning card for trick T
  - $-P_1 \vee P_3$
- Card  $C_t, v, n$ : This is true when a card of type t(trump/off suit led/off suit)(1-Trump, 2-off suit led, 3-off suit) and rank(1-6 for off suit 9 through Ace and 1-7 for Trump 9 through right Bauer) v is winning a trick n(4 or 5).
  - Ex.  $C_{1,7}$ ,  $4 \lor C_{3,2}$ ,  $4 \lor C_{1,2}$ ,  $4 \lor C_{1,4}$ ,
- Lead  $L_i$ : This is true when team X won trick 3 or 4, i corresponds to the player, j corresponds to the trick
  - $-L_{1,3} \lor L_{3,3}$
- Suit  $S_{i,j}$ : This is true when a card played is off suit, i corresponds to whether or not it was lead(1 = lead, 2 = not led), j corresponds to whether or not it's the same suit that was led(1 = same, 2 = not).
  - $-S_{1,1} \vee S_{2,1} \vee S_{2,2}$
- $\bullet$  Trump B: This is true when a card played is of trump.

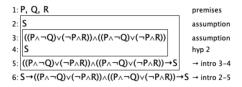


Figure 1: A euchre can only take place if the team that did not call trump wins the round.

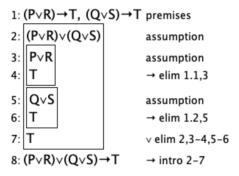


Figure 2: A team can only win a trick if their player holds the winning card.

## Constraints

• A euchre can only take place if a team wins a round and also did not call trump:

$$- (W \land \neg Q) \lor (\neg W \land Q)$$

• A team can only win a round if they win  $\geq 3$  tricks  $T_i$ :

$$-(t_1 \wedge t_2 \wedge t_3) \vee (t_1 \wedge t_2 \wedge t_4) \vee (t_1 \wedge t_2 \wedge t_3 \wedge t_4 \wedge t_5) \vee ...etc$$

• A team can only win a trick if their player holds the winning card:

$$-(P_1 \vee P_3) \vee (P_2 \vee P_4)$$

• A card is only winning if it is the possible highest trump or the Highest suited card if no trump is played

$$-C_{1,v} \vee (\neg C_{1,v} \vee c_{2,v})$$

- Only a player who leads can determine the Suit:
  - $-\ L_{i,j}$ Player i leads trick j

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1: P(x) \rightarrow ((T(x) \land Q(x)) \lor (T(x) \land \neg S(x))), P(x) premises

2: (T(x) \land Q(x)) \lor (T(x) \land \neg S(x)) \rightarrow elim 1.1,1.2

3: T(x) \land Q(x) assumption

4: T(x) \wedge elim 3

5: T(x) \land \neg S(x) assumption

6: T(x) \wedge elim 5

7: T(x) \vee elim 2,3-4,5-6

8: T(x) \land P(x) \wedge intro 7,1.2
```

Figure 3: A card played is valid only if the card follows suit or a players hand does not contain an on suit card.

# Model Exploration: Explanation

Our initial interpretation for modeling the game of euchre was to examine the state of the game after a hand had been played, with conditions for who called trump, played each card to determine who had won a hand that already happened. However, we pivoted away from this concept to make it more challenging; we looked at the results of the first 3 tricks, then determined whether or not a euchre can occur based on the information of the hand. Once we had all our propositions and constraints in our Python file, we were able to write an example theory to explore random hands and their results. Our example theory included functions for dealing out hands and randomizing the results of the first 3 tricks to provide a new set of initial conditions every run, testing our constraints against each set.

# Model Exploration: Results

Now with working test code, we could successfully run multiple test cases to verify our models ability to determine whether a euchre has occurred in a variety of cases.

#### Case 1 - No Euchre Occurs

In this case, the conditions were:

## TeamX Hands:

- Player 1: Nine of Diamonds, Jack of Hearts
- Player 3: Ten of Spades, Queen of Spades

### TeamY Hands:

- Player 2: Ten of Hearts, Ten of Diamonds
- Player 4: Nine of Clubs, Ace of Diamonds

#### **Initial State:**

- TeamX had won 3 tricks
- TeamX called trump

- Trump Suit: Spades
- Player 3 led Trick 4

#### The play proceeded with:

- 1. Player 3 leading the Ten of Spades,
- 2. Player 4 playing Nine of Clubs,
- 3. Player 1 playing Nine of Diamonds
- 4. Player 2 playing Ten of Hearts.
- 5. Player 3 won this trick with the Ten of Spades (trump). In Trick 5, Player 3 led with Queen of Spades and ultimately won that trick as well.

```
Player: History of Spaces, Duesn of Spaces
Player: This of Player of Players
Player: This of Player of Players
Teach has wen a tricks.
Called: Teach called trum
Trus Suit Spaces
Player: A player of Player
Player: Player: Player
Player: Player play Fine of Spaces as the lead card.
Player: A player player bloom of Spaces
Player: A player player bloom of Spaces
Player: A player player bloom of Spaces.
Player: A player player bloom of Spaces.
Player: A player player player from Teams with Ten of Spaces.
Player: A player play
```

Figure 4: Euchre did not occur

As shown in the output screenshot above, we can see that the model successfully determined that a euchre would not occur because the team that called trump won that hand.

#### Case 2 - Euchre Occurs

#### TeamX Hands:

- Player 1: King of Hearts, Ace of Spades
- Player 3: Nine of Clubs, Nine of Diamonds

#### TeamY Hands:

- Player 2: Nine of Hearts, Nine of Spades
- Player 4: Ten of Hearts, Jack of Spades

#### **Initial State:**

- TeamX had won 1 trick
- TeamY had won 2 tricks
- TeamY called trump
- Trump Suit: Spades
- Player 1 led Trick 4

The play sequence showed Player 1 leading with King of Hearts, followed by matching suit plays. Player 1 won Trick 4 with the King of Hearts. However, in Trick 5, despite Player 1 leading with Ace of Spades, Player 4 won with the Jack of Spades (trump).

```
Team Hands:

Player's Nide of Clubs, Nine of Spades
Player's Nide of Clubs, Nine of Spades
Player's Nide of Harts, Nine of Spades
Player's Nide of Harts, Nine of Spades
Player's Nide of Harts, Nine of Spades

Initial Tracks:
Team has we not tricks.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with King of Hearts.
Trick of Minner: Players from Team with Lack of Spades.
Min Instance created with tricks of Players.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance created with tricks (False, False, Time, 1, 0)
Team was tricks. It is Player.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance created with tricks (False, False, Time, 1, 0)
Team was tricks.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance created with tricks (False, False, Time, 1, 0)
Team was tricks.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance created with tricks (False, False, Time, 1, 0)
Team was tricks.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance Created with Tricks (False, False, Time, 1, 0)
Team was tricks.
Trick of Minner: Players from Team with Jack of Spades.
Min Instance Created with Tricks (False, False, Time, 1, 0)
Team was tricks.
Trick of Minner: Players of Spades.
Minner: Players of Spades.
Players of Spades.
Trick of Minner: Players of Spades.
Minner: Players of Spades.
Trick at was not a spades.
Trick at was not a spades.
Trick at was
```

Figure 5: Euchre occured

As shown in the screenshot above, this test case demonstrates our model's ability to correctly identify a euchre situation where the team calling trump fails to win three tricks.

# **Conclusion:**

Based on this, our model can successfully track and validate card plays according to euchre rules, correctly implement trump suit hierarchy, properly count tricks won by each team, and putting it all together, accurately determine when a euchre occurs based on the relationship between who called trump and who won the majority of tricks.

## First-Order Extension

Predicate logic could allow for a more expressive analysis of the state of the game. By using quantifiers, we could potentially model situations that hold

for any trick. For example if **there exists** a player on the non trump calling team who has won 3 tricks, a euchre has already occurred. Or if **there exists** a player on the non trump calling team who has won two tricks, a euchre can occur. Below are some predicates we could use.

C(a,b,x,y) as an effective way to represent cards in a player's hand, where a and b are card 1 and card 2 rank, while x and y are the suit.

Or where a trick is won by Team X W(t) with t being the trick number. As in: A=1,2,3,4,5

 $W=1,\!3,\!4$ 

That is, team X won tricks 1, 3, and 4.