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*Love letter*

An Implementation using Artificial Intelligence

Love Letter – AI Implementation

**Literature Review**

Introduction

Love Letter is a game of risk, deduction, and luck for 2-4 players. The goal is to get your love letter into the Princess’s hands while deflecting the letters from competing suitors. From a deck of only **16 cards,** each player starts with a state of only one card in the hand. On each turn, you are supposed to draw one card and then remove/play one card, using the effects of that card played. Each card has different effects and values when played and will affect the other opponents depending on each card played. The goal is to expose others and knock them out of the game by knowing their cards in hand and playing moves accordingly.

Love letter is a card came with **incomplete information**. Each player is able to view their own hand, but not others (some exceptions). In order for a player/agent to win a game, the player needs to know or guess the hidden cards of the other opponents first. Once an idea is created as to what an opponent may have, a game state is created so that the player can try and win the game, by knocking out the players with known/guessed cards. This paper discusses some of the strategies that you can apply to deal with the limitations of incomplete information.

Ways to figure out what players may have, would be to play cards (such as the guard or priest etc) and figure out what the players do and don’t have. Also, as there are only 16 cards in a deck, a realistic probability of how many of each specific card that each player may have can be calculated (card counting).

If the agent has complete access to view all the opponent’s cards, then there would need to be less moves played to reach a desired goal. However, with incomplete information about the game state and opponents’ cards, there is some uncertainty applied and there could be many possible game worlds.

* At the start of the game, everything is based on luck, because there is no knowledge of other players cards and their values. There are too many different game scenarios to be played extrapolating from the start.

However, we can assume that at least 1 player has a high value card, as we start from a 16-card deck.

* As more cards are played, some data can be recorded as to what cards each member may have. For example, In each turn, as players show their cards, become immune to some plays, or holds onto cards for a long period of time (such as high value cards which shouldn’t be used, like the Princess) then more of an idea of the game states and cards held can be formed. Every turn that is played, it could give one or two new pieces of information for the agent.

Humans are able to alter their perception of their hand and note which cards are seemingly worthless or have high value, based on the behaviour of others. An agent does not necessarily have this sense.

**Rule Based Approach**

Makes pre-defined decisions based on a set of rules to follow, depending on the game state/situation. If the game is in the favour of the agent, where it knows another players card, or it can guess another player unseen card with high probability, it will execute that decision.

Epistemic logic is useful and not infeasible in this case, because this game has a high amount of uncertainty. Predicting other people’s cards, and then trying to eliminate them based on their card is a good rule for the game.

The agent has been given a set of rules to follow, which upon playing a card, will retain the highest value card in the hand as possible, and using the effects of the smaller card. The agent will try to aim for the highest value hand before the end of the game, and the secondary objectives given will be to eliminate other players so that they can’t get to the princess first. To do this, the agent will make use of the seen and played cards (in the discarded stack)

Thus, the agent has been given a set of obligations and goals (make it to the end of the game without being eliminated, using the highest card in hand). With the belief that if the agent has a higher value hand then it will win (if two cards, discard the smaller value) and secondary intentions being the elimination of other players and not oneself (by the known card, or highest probable card strategy)

As this game has incomplete information, this agent will use epistemic logic to determine the cards belonging to other players.

When playing ‘Love Letter’ there are a number of rules/strategies that people unconsciously follow when playing the game:

* Discard/Play the lower value cards, and keep the higher value ones until the end of the round
* If the player has seen another person’s card and knows their card value, you can play a guard or baron and try to eliminate them
* When taking an un-informed guess using a guard, count the discarded guard deck, and find the card which has been played least and has the greatest number of cards left (i.e. greatest number of unseen cards).
* If you know that another player has a high value card, use prince on them to make them discard theirs. If you have a low value hand, then discard your deck.
* If a player has played a countess, then most likely (not always) they have a prince or king. Choose prince because there are two in the deck (king only 1)

The above strategies were used in the implementation of this rule based, reflex agent.

It is easy to see that This technique of rule-based decision was chosen because there are not many other ways to have an edge/advantage in this game. The only advantages gained may be in the case where you can remember the cards already played (card counting) and guess a probability/take into consideration the seen cards (using the priest).

This implemented agent makes use of these strategies and can make informed decisions based on memory. It will also follow other important logical rules like comparing the drawn card and hand card and keeping the higher value one (something which a random agent can’t do). This strategy is superior to the random agent, as it can understand the current state of the world. The scope of observation from the random agent is within its own cards, but the rule-based strategy expands the scope outside towards the observations of other players.

**Monte-Carlo Tree Search (MCTS)**

MCTS is a heuristic based algorithm which expands the nodes which have the highest probability of returning a good outcome first (but also explores other possibilities that don’t look favourable). MCTS involves Selection, Expansion and Simulation (and Backpropagation).

In the case of love letter, we would use a (Single Observer) SO-MCTS algorithm, as the agent doesn’t know the values of other players cards. MCTS works the best of the entire state of the game, and possible plays of the opponent’s card is known, but in love letter, this is not the case.

A node is traversed from the root node to a leaf node, the child (move in Game) that maximises the UCB1 formula is selected.

When a leaf node is reached, the expansion stage adds all the legal and valid actions as children. Simulation stage will play out a round of the game and determine its probable result. This result is used to update information along all nodes, from node to the root (backpropagation).

MCTS is efficient in being able understand the current state of the game in ‘Love Letter’. If you can run MCTS for a long period of time, then it will give greater reliability, but it can still be stopped at any time and return its best move so far.

**Rationale and Selection of Agents**

The first agent is a smarter form of the Rule Based agent and can make intelligent decisions as to which target the agent should choose to play their card on.

In this strategy, the agent memorises the deck of unseen cards. The agent considers two scenarios to guess a player’s card. Firstly, it takes into account both the number of unseen cards, and then it acknowledges that the target player will likely keep the higher valued cards over the smaller ones. For example, if there is 1 unseen Baron and 1 unseen King in the deck, the selection criteria would be skewed towards the King. These scenarios help the agent to determine the probability of what the target may have in his hand and play a card accordingly.

Some strategies are:

References:

Rule Based Agents, Compliance, and Intention – Antonino Rotolo

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