Automated Heads-Up Poker Player

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November 13, 2014

1 Introduction

Implementing an automated poker player is challenging since poker involves elements of uncertainty, randomness, strategic interaction, and game-theoretic reasoning. Heads-up poker is a form of Texas Hold'em poker that is played between two players. In this project, we aim to discuss implementing an automated heads-up poker player. Our approach to this problem is breaking the problem into a sequence of simplified problems.

The rest of this progress report is organize as follows: in §2 we describe the rules of heads-up poker and the dynamics of the game. In §3 we will demonstrate the hierarchy of simplified problems and their complexity. §4 contains our main model for the project and §5 describes our implementation so far. Finally, a discussion on our roadmap and future work is brought in §6.

2 Rules

We are going to build our model based on *Doyle's game* which was used in the 2007 Association for the Advancement of Artificial Intelligence (AAAI) Computer Poker Competition. The game is played between two players that we will call player A and player B.

- **Blinds:** Every hand, both players start with 1000 chips. In odd hands (every other hand), player A is the *small blind* and contributes 1 chip to the pot, while player B is the *big blind* and contributes 2 chip to the pot. In even hands the role of two players is reversed.

- **Pre-flop:** Two players are dealt random cards (face down) which are called *hole cards*. Then the small blind can either *fold* (*i.e.*yield all the chips in the pot to the other player), *call* (contribute chips to the pot such that the number of contributed chips from two players are equal), or *raise* (contributing more chips to the pot than the opponent). Notice that the famous *all-in* action is a especial case of raising. The betting process goes on until one player stops raising (and folds or simply calls).

- **Flop:** Three community cards from the rest of the deck are shown. Starting from the big blind, the betting process starts over similar to pre-flop. Unlike pre-flop where the players are only using their hole cards to make actions, here the players are getting more information about the community cards.
- **Turn:** A fourth community card dealt face up. The betting process is similar to flop.
- **River:** A fifth (and last) community card is shown. A final round of bets takes place similar to flop and turn.
- **Show down:** In the event that none of the players fold until the end of river round, two players make the best combination of five cards out of seven cards (two hole cards and five community cards). The player with a better combination wins the pot. In the case of two equally ranked hands, the pot is split.

3 Literature review

Poker is one of the most popular card games played around the world. It has a rich story of study among game theorists, mathematicians, and economists. Recently, there has been lots of research into developing strong programs for playing poker. In [1] authors introduced the Bayesian Poker Program (BPP), which uses a Bayesian network to model poker hands and the opponent's playing behavior. In [2] an algorithm to compute the approximate jam/fold equilibrium strategies in tournaments with three players has been developed. In a jam/fold strategy, all players can only fold or go all in (jam). This strategy known to be the near-optimal in the two player tournaments. A heads-up no-limit Texas Hold'em poker player called Tartanian, has been introduced in [3]. Tartanian uses a discretized betting model to reduce the size of the strategy space. It also, benefits from a card abstraction model to decrease the problem size. In [4] a poker program called Poki has been developed. Poki uses reinforcement learning techniques to explore and construct statistical models for each opponent, and exploit based on the observed patterns.

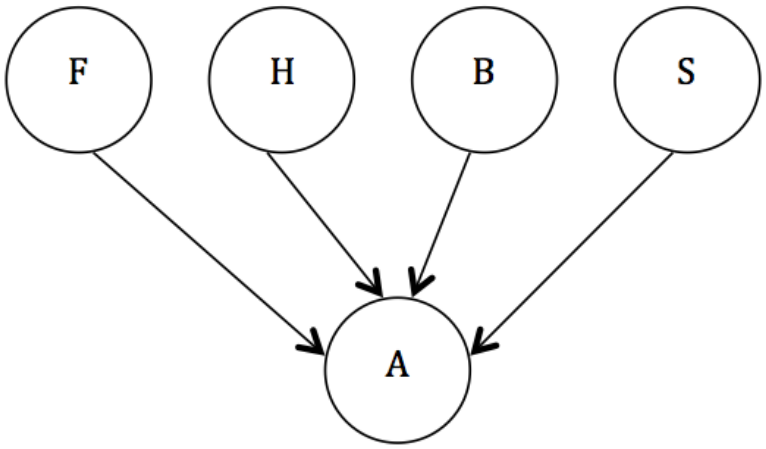
4 Implementation0

In this project we will implement the limited Texas Hold'em heads-up poker. As we described in section 2, every hand proceeds in four states {`pre-flop`, `folp`, `turn`, `river`}. In each state of a hand, there will be a bidding action between agents, then if they concur on the bidding value, the hand will step into the next state. In the limited poker, the set of all valid actions for agents is {`fold`, `check`, `bet`}. In our model, for each agent we define two hidden random variables F, and H, which are not revealed to the opponent. F, is a feature vector representing the agent's properties, i.e. her level of aggression. Note, that F can be quite complicated, to incorporate the agent's way of playing in all levels. In our model we only consider one feature to represent how much aggressive/conservative the agent is. H is

a random variable representing the agent's hole cards. Note that H is unique for each hand of the game and F is unique for each agent.

How the agent play poker?

The agent will consider the hidden random variables H and F for the opponent and tries to update her beliefs about them as she plays. Figure (1) shows the PGM model for each state of a particular hand that the agent uses to update her bleifs. In this model, B represents the dealt cards so far on the board, S is the story of the hand so far (i.e. the actions in the previous states of the hand), and A is the opponent's action. Note that B, S, and A are observed to the agent, and she should use them to update her beliefs about hidden random variable H.



5 Implementation

We use Python for our implementation. We have a class `pokerCards` that consists two subclasses `card` and `deck`. Each `card` has two parameters rank and suit. Rank is a number in $\{2, 3, \cdots, 14\}$ (where 14 means Ace) and suit is a number in $\{1, 2, 3, 4\}$. The `deck` has methods like pop and shuffle.

We also have another class `handEvaluator` that contains functions to evaluate poker hands. In particular, the method we use is inspired by [1]. The idea here is to assign scores to sets of five, six, or seven cards such that the hand with higher rank has a higher score and equally-ranked hands have the exact score. Specifically, `handEvaluator` function receives the hole cards and the board (with three to five cards) as its arguments and assigns a real number in $[0, 1]$ to the union of hole cards and the board. If `handEvaluator(h1,b) > handEvaluator(h2,b)`, it means that the rank of best five cards in `h1`$\cup$`b` is higher than the best five cards in `h2`$\cup$`b`. Notice that this doesn't mean the `h1` does not have any chance to win.