Final Project Update

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Project Overview

No-limit texas hold'em is one of the most popular versions of poker played around the world today. The game begins with every player being dealt two cards (unlike other popular variants where players are dealt 4 or 5 cards), and after several rounds of betting, the winner is the player who can make the best five card hand using the two cards that were dealt to them, and five cards that are "community" cards (via the flop, turn, and river). The game is highly strategic, as everyone's cards are hidden from each other. Unlike a game like chess, poker is not a game of perfect information (this is the primary source of uncertainty). With most of the cards on the table being hidden (all of the opponent cards), one must make the best decisions they can make under high degrees of uncertainty.

In my project, my goal was to build a solver (a program that understands the best decision making) for a subvariant of texas hold'em called heads-up texas hold'em, which is texas hold'em played between two players. This subvariant has a substantially different dynamic than six (most commonly played online) or nine (most commonly played in-person) player hold'em because instead of having to beat five or eight other people, you only have to beat one other person, which at the end of the day means you have to have better cards than them, or get them to fold.

Progress

So far, the majority of my research has involved looking into solving algorithms, making key problem scope reductions, and implementing some of the algorithms that I have researched. In particular, the goal of a solver is to find a strategy that achieves Nash Equilibrium, which is a fancy way to say that a player can't improve their strategy unless their opponent's strategy is also changed. This always starts from a completely random/uniform strategy (similar to some of the problems we have seen in our other projects), iterating through the game, computing how much "regret" one has, and changing one's strategy to minimize their regret. This algorithm gets repeated until the Nash Equilibrium is found -- until regret can no longer be minimized.

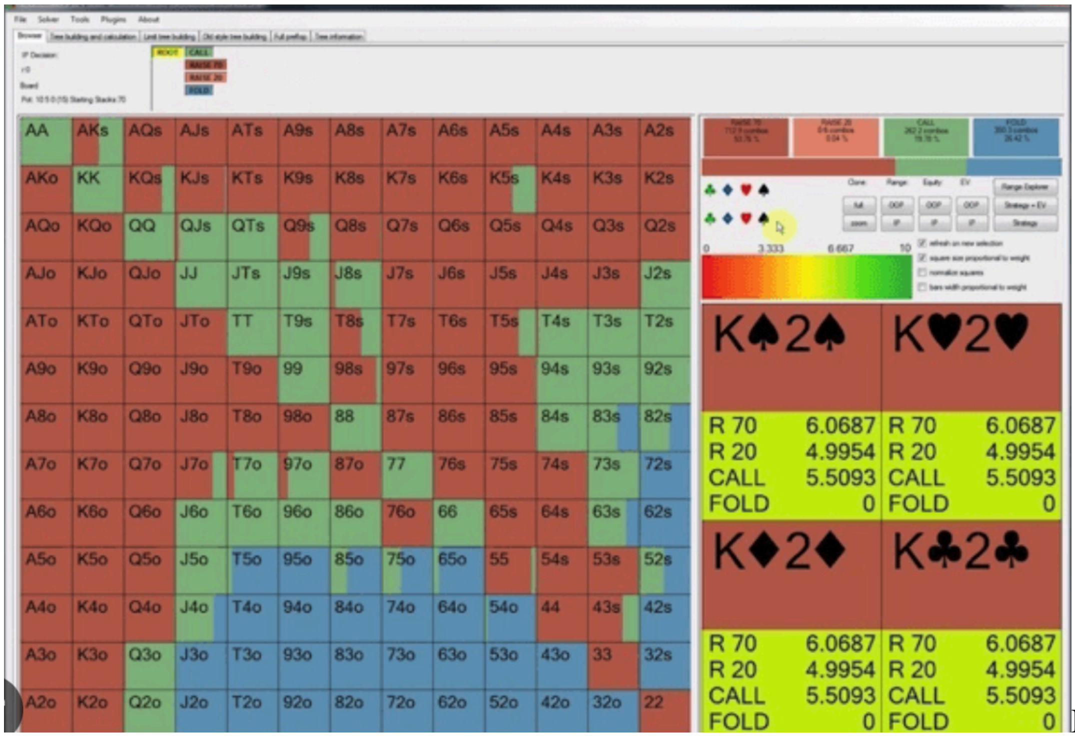
As I briefly mentioned before, there are "meta" decisions to be made about what kind of problem we will be using the solver to solve, given that the Poker game tree can be so big. I have made the following decisions:

1. I'll be assuming that stacks sizes are 100BB (100 big blinds). This is important because decisions change massively in poker depending on stack sizes because of implied odds (the idea that even if you don't have the *pot* odds, you may be able to get all of your opponent's stack in if you make the hand you are trying to make).

2. The solver will be limited to five bet size decisions. 1/4 pot, 1/2 pot, 3/4 pot, pot, and 2x pot. Some

modern solvers have shown that a polarizing overbet (2x pot) strategy can be very succesful, so I want to incorporate that idea into my solver.

As far as concrete progress, I have implemented most of the structure for visualizing the solver results (see the picture below for the desired visualization), as well as implemented most of the CFR minimization (Counterfactual Regret Minimization) algorithm, which will allow my program to find solutions to the game.



AA	AKs	AQs	AJs	ATs	A9s	A8s	A7s	A6s	A5s	A4s	A3s	A2s
AKo	KK	KQs	KJs	KTs	K9s	K8s	K7s	K6s	K5s	K4s	K3s	K2s
AQo	KQo	QQ	QJs	QTs	Q9s	Q8s	Q7s	Q6s	Q5s	Q4s	Q3s	Q2s
AJo	KJo	QJo	JJ	JTs	J9s	J8s	J7s	J6s	J5s	J4s	J3s	J2s
ATo	KTo	QTo	JTo	TT	T9s	T8s	T7s	T6s	T5s	T4s	T3s	T2s
A9o	K9o	Q9o	J9o	T9o	99	98s	97s	96s	95s	94s	93s	92s
A8o	K8o	Q8o	J8o	T8o	98o	88	87s	86s	85s	84s	83s	82s
A7o	K7o	Q7o	J7o	T7o	97o	87o	77	76s	75s	74s	73s	72s
A6o	K6o	Q6o	J6o	T6o	96o	86o	76o	66	65s	64s	63s	62s
A5o	K5o	Q5o	J5o	T5o	95o	85o	75o	65o	55	54s	53s	52s
A4o	K4o	Q4o	J4o	T4o	94o	84o	74o	64o	54o	44	43s	42s
A3o	K3o	Q3o	J3o	T3o	93o	83o	73o	63o	53o	43o	33	32s
A2o	K2o	Q2o	J2o	T2o	92o	82o	72o	62o	52o	42o	32o	22

K♠2♠		K♥2♥	
R 70	6.0687	R 70	6.0687
R 20	4.9954	R 20	4.9954
CALL	5.5093	CALL	5.5093
FOLD	0	FOLD	0

K♦2♦		K♣2♣	
R 70	6.0687	R 70	6.0687
R 20	4.9954	R 20	4.9954
CALL	5.5093	CALL	5.5093
FOLD	0	FOLD	0

Example Solver Output from Popular Solver PioSolver

Next Steps/Revised Timeline

1. The primary next step is to get the final parts of the CFR algorithm working, and working with my visualization software. While part of the goal of this project was to do research, it would also be cool if my program had practical value, so I want to make sure that the users can elegantly visualize the results.

2. Game state combination -- Poker is a massively complex game, and it would be incredibly difficult for a human to memorize the correct bet sizing on all hole card - board runout combinations. The goal of this would be to try to come up with a few game states that have similar solver solutions so that one could memorize those solver solutions, and use them on similar boards in practice.