

poker has such high variance, a near-optimal strategy is likely to perform extremely close to an optimal strategy against other non-optimal opponents.

2.5 Other Poker Research

Besides Texas Hold'em, there has been work on other Poker variants such as Five-Card Draw. Five-Card Draw poker is not as strategically complex as Texas Hold'em or 7-card Stud.

Nicolas Findler did early work on this game, intermittently over a twenty year period [18]. His main objective was not to achieve a high level of play, but to model human cognitive processes. His program was able to learn, and was moderately successful.

In the 1970's and 1980's some research was done in exploring production systems for Five-Card Draw strategies. Waterman developed a program which was able to learn the production rules through three different methods – advice (expert rules), analysis (post-game), and adaptation (opponent modeling) [53]. Smith later developed a different production system that learned rule sets by using a genetic algorithm [46]. Smith's program was able to win against Waterman's program, which was considered to play at the level of an experienced human player.

Five-Card Draw poker has been recently studied using Bayesian models with mixed results [26, 12].

2.5.1 Evolutionary Methods

Recently, evolutionary algorithms have been applied to game theory and to poker. Genetic algorithms have been suggested as a way to discover local, and possibly global, Nash-equilibria in game-theoretic domains [16]. A population of co-evolving strategies will eventually converge to a local optimum with respect to the population of competing strategies.

Because of poker's game-theoretic underpinnings, a similar approach has been applied to evolve strategies for ten-player Texas Hold'em [33]. Simplified strategies are described by a small array of values. A regular co-evolutionary genetic algorithm (GA) starts with a population of randomly generated strategies. The strategies are then evaluated by having them compete against one another. The highest scoring strategies are reproduced with some random variation (usually by small perturbations of the values in the strategy). Once a new population has been constructed, the process repeats. The selection pressure steers the random search towards higher scoring strategies, until the population converges on a local optimum.

The method of selecting the surviving strategies from a population determines how the population will evolve, and towards which local equilibrium it will converge. Using ideas from game theory, a more robust method of selection in co-evolving

populations can be used. Pareto co-evolution [17] is a new method of selection based on the concept of Pareto optimality. A strategy Pareto-dominates another if it is at least as good as the other strategy over all dimensions, provided it is strictly better in at least one dimension. A Pareto-optimal strategy would be a strategy that Pareto-dominates all other existing strategies. This idea is applied to co-evolution as a way to select for Pareto-dominating strategies. The dimensions of evaluation become the strategy's performance against the other strategies in the population itself. The other strategies are, in a sense, the dimensions for evaluation.

This changes the selection pressure substantially. It selects the more robust strategies, that do well against a larger set of the opponents. The early research indicates that the Pareto co-evolution outperforms the standard selection method of choosing the n strategies with the highest gross scores.

Currently, however, no evolutionary computation methods have been applied to generate high-performance betting strategies for poker. It is likely that the complexity of Texas Hold'em is too great for a naive evolutionary algorithm to tackle effectively.