

## **Research Review:** **“Superhuman AI for heads-up no-limit poker: Libratus beats top professionals”**

Udacity Artificial Intelligence Nanodegree

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### **Abstract**

No-limit hold 'em is the poker form most commonly found in televised tournament poker and is the game played in the main event of the World Series of Poker. Despite AI successes in perfect-information games, the private data and enormous game tree has made no-limit poker a challenge to solve. Carnegie Mellon's computer science department has debuted Libratus, an artificial intelligence computer program designed to consistently win no-limit Texas hold 'em Poker, including an epic match against four of the world's best professional poker players (Jason Les, Dong Kim, Daniel McAulay and Jimmy Chou).

To ensure that the outcome of the competition is not due to luck, the four pros will be paired to play duplicate matches — Player A in each pair will receive the same cards as the computer receives against Player B, and vice versa. One of the players in each of these pairs will play on the floor of the casino, while his counterpart will be isolated in a separate room.

### **Goals and Techniques**

Carnegie Mellon's approach focused on a combination of three modules: an algorithm for computing a blueprint with abstractions, an algorithm to identify key subgames that are reached during the game, and a self-improving algorithm that will pivot the player's strategy based on the possibility of the opponent altering their strategy.

- *Building a Blueprint Strategy* - the first module computes an abstraction of the game, which is smaller and easier to solve, and then computes game-theoretic strategies for the abstraction. Theorizing the entire game as a whole, rather than just pieces of it would be impossible in the time limits allowed.
- *Nested Safe Subgame Solving* - the second module of Libratus builds a more finite abstraction for that subgame and solves it in real time. Unlike perfect-information games, Libratus does not solve the subgame abstraction in solitude. It ensures that the subgame solution fits within the larger blueprint strategy of the whole game.
- *Self Improvement* - the last module analyzes the missing branches in the abstraction and computes a theoretical strategy for those branches. Libratus uses the known opponent's moves to limit down the possibilities on the gametree. If a weakness is identified, Libratus will run a computational analysis using the Pittsburgh Supercomputing Center to alter its course.

### **Results**

Libratus, in a 120,000-hand competition, defeated four top human specialist professionals in heads-up no-limit Texas hold'em, the standard challenge problem in imperfect-information game solving. During the tournament, if Libratus located a weakness in its own strategy, by the next day, the weakness would

disappear. Furthermore, Libratus has succeeded in mastering a game where bluffing and correctly interpreting misleading information is a main strategy.

CMU researchers say that the techniques utilized are not uniquely applicable to poker and could apply to a broad range of imperfect-information games. They plan on writing proposals to apply the system to real-world problems, including cybersecurity, business negotiations, or medical planning.

## **References**

"Artificial Intelligence Wins \$800,000 Against 4 Poker Masters- Interesting Engineering". 27 January 2017.

Brown, Noam, and Tuomas Sandholm. "*Superhuman AI for Heads-up No-Limit Poker: Libratus Beats Top Professionals.*" Science, 2017, doi:10.1126/science.aao1733.