A Review of "DeepStack: Expert-Level Artificial Intelligence in Heads-Up No-Limit Poker"

The paper introduces a new general-purpose algorithm, Deep Stack, for sequential games with imperfect information. Games with imperfect information are games where the players don't have the same information about the state of the game. Because of its nature, imperfect informations games requires a more elaborated reasoning process as opposed to perfect information games. The algorithm is applied in the context of poker games, where the player strategy must combine public information available to all players, private information about its cards and must infer the private information of other players, by analyzing their prior actions, considering too, that their strategy depends on considerations that they have about the private information that other players have. In the ultimate sense, the objective of DeepStack is to approximate Nash equilibrium(of game theory) in the sense of minimizing the exploitability of the outcome of the player actions.

DeepStack introduces three key concepts to achieve its goals: continual re-solving, intuitive local search and sparse lookahead trees.

- **Continual Re-solving** : uses an adaptation of counterfactual regret minimization algorithm to handle information asymmetry. The algorithm is used to compute a strategy considering only the current state of the game and limiting computation beyond a certain depth with a approximate estimate(its “intuition”). The strategy of the player is reconstructed at each iteration, considering the new perceptions(new public informations and actions of other players) of the game. This limit the capability of other players exploit its strategy.

- **Intuitive local search**: uses an heurístic approximation of the private information of other players, to limit reasoning to the end of the game. The heuristic approximation is computed automatically by means of machine learning, using a deep neural network. The network was trained with millions of computer generated artifitial games, that in the end gives a good approximation of the game state, to be used in the decision of the player strategy.

- Sparse lookahead trees: the algorithm restricts the number of actions that are considered in the construction of game state trees. This allow the algorithm to play at human level speeds.

The DeepStack algorithm was capable of defeating professional "Texas hold 'em" poker players, with statistical significance. Given that the size of the game is comparable to the game of Go, that is a remarkable achievement, even more considering that the game presents asymmetric information, and that achieves its goals with little domain knowledge and training from expert human players. That is an evidence of the soundness of the algorithm. DeepStack was the first successful application of heuristic search in imperfect information games, being able to reduce the gap between the largest solved perfect and imperfect information games(in the case, Go and Poker "Texas hold 'em" variant).