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Project 2: Research Review
AlphaGo by the DeepMind Team

Paper: Silver, D. et al (2016), Mastering the game of Go with deep neural networks and tree search, *Nature*, 529 (7587), pp. 484-489.

Summary of paper's goals and new techniques
The primary purpose of the research in this paper is to demonstrate the successful development of efficient techniques that utilize deep neural networks (DNNs) and tree search to 'master' a highly challenging game for artificial intelligence like Go. The ultimate intent is to expand AI performance in other complex domains. The name of the program developed by the DeepMind team for this is AlphaGo.

The game of Go is a board game from the ancient east with relatively simple rules but a massive search space. Due to an extremely large branching factor (≈250) and game depth (≈150), traditional AI methods such as alpha-beta pruning and minimax are rendered not feasible to solve in a reasonable amount of time. To successfully build a program that plays Go at a level of a professional human player has been one of AI's grand challenges.

AlphaGo addresses these challenges by introducing a few novel techniques. Firstly, it uses two DNNs to reduce the effective depth and breadth of the search tree. Of these, it uses 'value networks' to evaluate board positions and 'policy networks' to sample actions and select moves. These neural nets are trained using supervised learning from human expert games, and reinforcement learning from games of self-play. Secondly, it combines Monte Carlo Tree Search (MCTS) which has been used by other Go programs, with the aforementioned DNNs. Lastly, AlphaGo utilizes asynchronous multi-threaded search using parallel and distributed computing.

Summary of paper's results
The most noteworthy and widely acclaimed achievement of AlphaGo has been it defeating the human European Go champion, Fan Hui, 5-0 in October 2015. This was the first time a computer Go program had defeated a professional human player on a full-sized board without handicap, at least a decade earlier than the AI community had expected. Furthermore, the search algorithm combination of DNNs and MCTS gave AlphaGo an unprecedented 99.8% winning rate against other state-of-the-art Go programs of the day.

Perhaps the most far-reaching achievement of AlphaGo in its attaining professional level in Go, as concluded in the paper, is the hope it has given to achieve human-level performance in 'other seemingly intractable artificial intelligence domains'.