In two-player zero-sum games like poker, a Nash equilibrium strategy is optimal or unexploitable. However, when both players use abstraction, the resulting strategy can be far from optimal in the real game.

CFR in an abstract 10-Bucket Perfect Recall Game

Overview:
As CFR converges in the abstract game, it can get more exploitable in the real game.

Abstraction Pathologies:
Intuitively, a larger fine-grained abstraction should result in a less exploitable strategy. Unfortunately, even a strict refinement can result in higher exploitability!

Abstract Strategy Suboptimality:
An abstract game equilibrium might not be the abstract strategy with the lowest real game exploitability.

All of these problems are solved if the opponent is unabstracted, but that typically requires far too much memory.

Counterfactual Regret Minimization (CFR), NIPS 2007

Installs each player’s strategy arbitrarily.

Over T iterations, “play games” by walking the game tree.
At any time, each player is using a current strategy.

At each segment and subgame, estimate payoffs of actions. Create next iteration’s strategy.

Parallel Implementation
The process can allocate one CFR strategy and one update strategy and use multiple cores to sample subgames.

In practice, this can safely be done without needing to coordinate the threads as collisions only result in the loss of a small update.

CFR-BR requires almost 1/4 the memory of CFR!
The hybrid agent requires very little memory compared to the abstracted CFR agent, and each position can be solved separately. That’s 1/2.

Since the current strategy converges in practice, the CFR agent’s average strategy is suboptimal. That’s positive.

CFR-BR on very small games: less than 1.44 MB!
In practice, the CFR agent’s average strategy is guaranteed to converge, but in practice, 5% of the CFR-BR agent’s average memory could be saved.

Finding Optimal Abstract Strategies in Extensive-Form Games

Michael Johanson, Nolan Bard, Neil Burch, Michael Bowling :: University of Alberta, Canada

Verifying in [2-4] Hold’em
5 Perfect Recall buckets, 1,790 infosets

570 Perfect Recall buckets, 41k infosets

2-Player Limit Texas Hold’em Poker
10 Bucket Perfect Recall: 57m infosets

9000 Bucket Imperfect Recall: 57m infosets

Using CFR-BR to evaluate abstractions