Monte Carlo Sampling

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- to use randomness to solve problems that might be deterministic in principle.

Usefulness

- System too complex for analytical sols
- Need to clearly define probability distributions
- Understand uncertainty and variability explicitly
- Real-world data too expensive and complex to be collected

Example 0.0.1. Use MC Sampling to estimate pi

0.1 AI related

Example 0.1.1. AlphaGo: MC+CNN+RL

MC Tree Search

Selection

- Traverse the tree using MCTS
- Nodes evaluated and selected based on UCB formula
- Always select the child node with highest UCB value

Expansion

- Add a new child node

Simulation (Roll-out)

- Conduct MC simulations from the expanded nodes
- Uses uniform random outcomes (+1 fro win, −1 for loss)
- Mimic how experts mentally evaluate potential future outcomes

Backpropagation

- Update parent nodes' value based on accumulated simulation rewards
- Node values calculated as (total simulatin rewards)/(total visits)
- Helps identify promising nodes (**exploitation**) or nodes needing further **exploration**

> **Remark**. Finite Two Person Zero-Sum Sequential Game: Selection → Expansion → Simulation → Backpropagation

0.2 Pros and Cons

Pros

- No prior knowledge required
- End anytime and return current best estimation
- Asymmetric tree, flexible for games with **large branching numbers**

Cons

- Large memory required