14. Sampling

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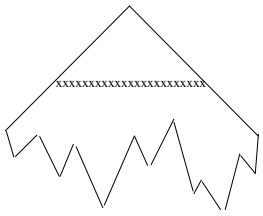
Imperfect Information

- What do you do when you have imperfect information?
- Poker [1], bridge [2] (don't know the opponent's cards)
- Scrabble [3] (don't know the opponent's tiles)
- Regular search gives rise to too many possibilities

Choices?

- Alpha-beta? Don't know what moves the opponent might have.
- *-Minimax? Could have a large branching factor, meaning little search depth
- How do you get meaningful results when there can be stochastic events and hidden information?

Traditional Search

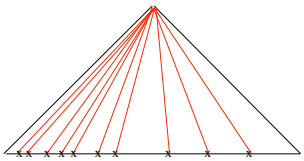


All nodes at a fixed search depth.

Solution?

- Sample from the space of possibilities!
- If you get “enough” samples, then you may have a good approximation to the real value.

Sampling Search



Some nodes at a deep search depth.

1. Sample

- Construct a plausible scenario from the current state to a desirable (possibly goal) state
- Compute the value of this sequence of moves
- E.g. in poker, compute a plausible sequence of actions from the current state to the end of the game

2. Statistical Sampling

- For each move choice at the root node
  - Gather samples
  - Compute performance metric (e.g. average score achieved)
- Repeat until resources are exhausted (usually time)

3. Choose Action

- Choose move with the best statistical outcome
- Poker: betting choice leading to best average winnings
- Scrabble: move that leads to best average number of points
- Bridge: move that leads to the most tricks won on average

How Many Samples?

- Iterate until time runs out
- Iterate until statistically confident
- Iterate until one move choice is significantly better than the alternatives
- Smart sampling can be used to help reduce the number of samples needed to converge to a useful result [4]

Selective Sampling

- Don't want want random sequences
- Need to bias play along lines likely to occur
- All scenarios are not equal; use all available information to bias the sampling in proportion to likely scenarios
- E.g. Bridge: bias play to be consistent with the bidding

Advantages of Sampling

- Simple search algorithm!
- Can realize complex behaviors with no explicit knowledge
- Lessens dependence on expert knowledge

Disadvantages of Sampling

- May not converge to a clear "winner"
- To get useful results may need to include "opponent modeling"
  - Observe opponent to determine their likely move choices
  - Opponent modeling is a hard problem!

Results?

- Improved play in poker
- World championship caliber play in Scrabble
- Strong play in bridge
- Also used in backgammon to compute expected outcomes (rollouts)

Monte Carlo…or…Alpha-Beta?

- Statistical sampling has been used as a replacement for alpha-beta search in computer Go.
- Play sequences of Go moves and then compute the value at the end of the line
- Enhance sampling to rule out "weak" moves
- Plays at a reasonable level of play!

References (incomplete)

1) D. Billings et al, AAAI, 1999, see me.
2) M. Ginsberg, IJCAI 1999.
3) B. Sheppard, "Towards Perfect Play at Scrabble", Ph.D. thesis, 2002.
4) B. Sheppard, ICGA Journal, 2004.
5) B. Bouzy, "Monte Carlo Go", 2003.