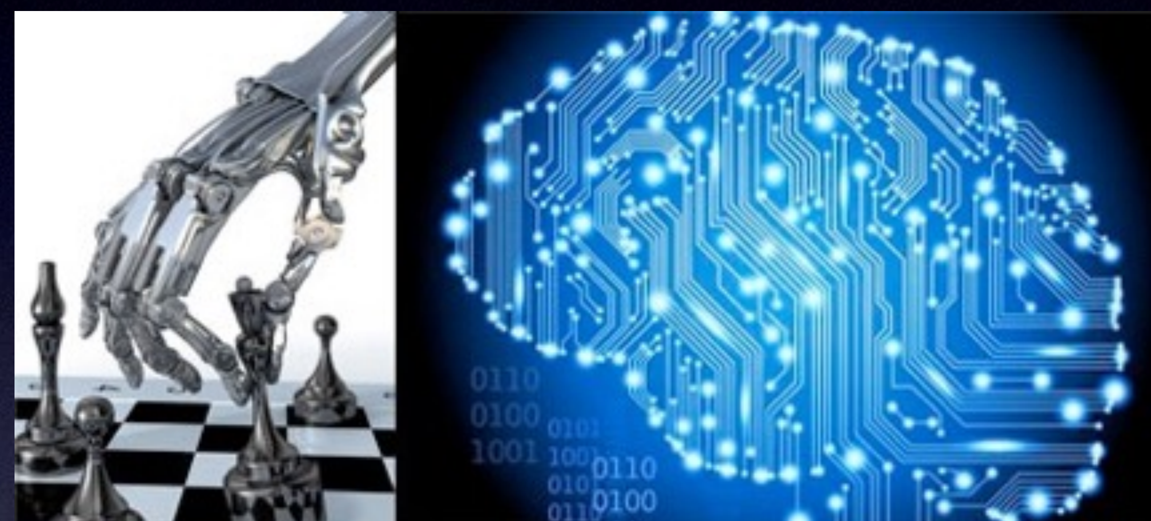
Artificial Intelligence

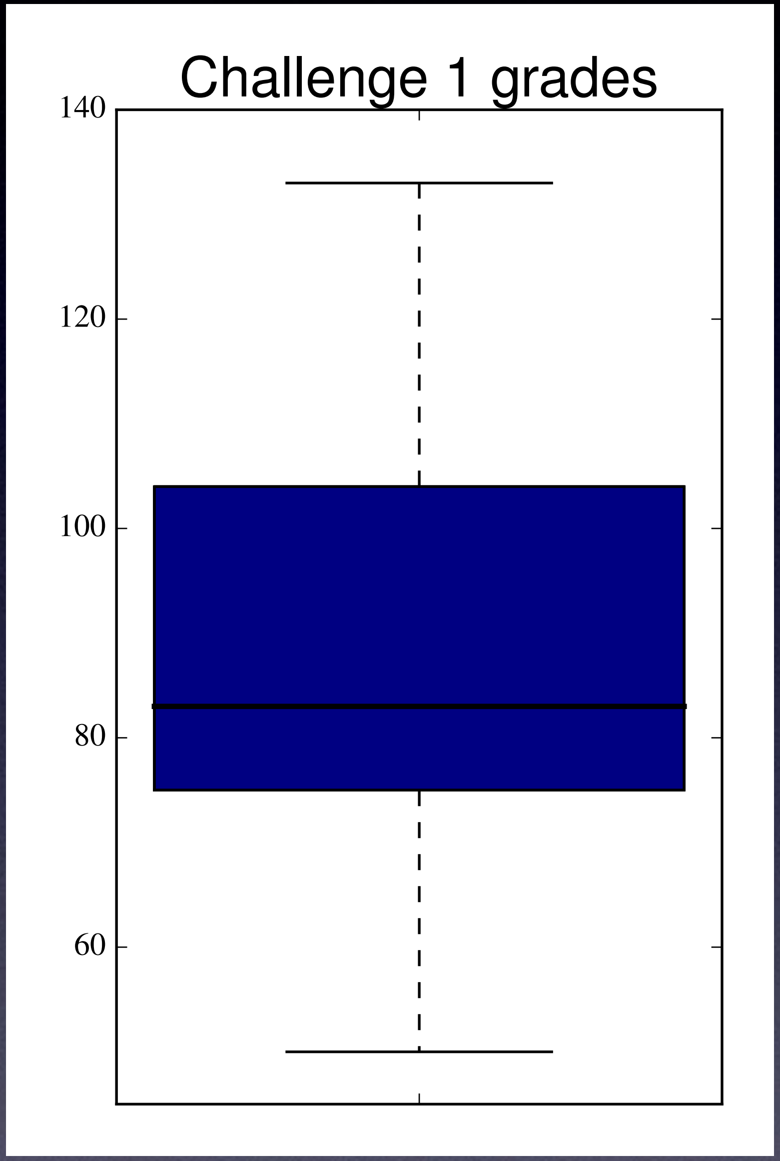


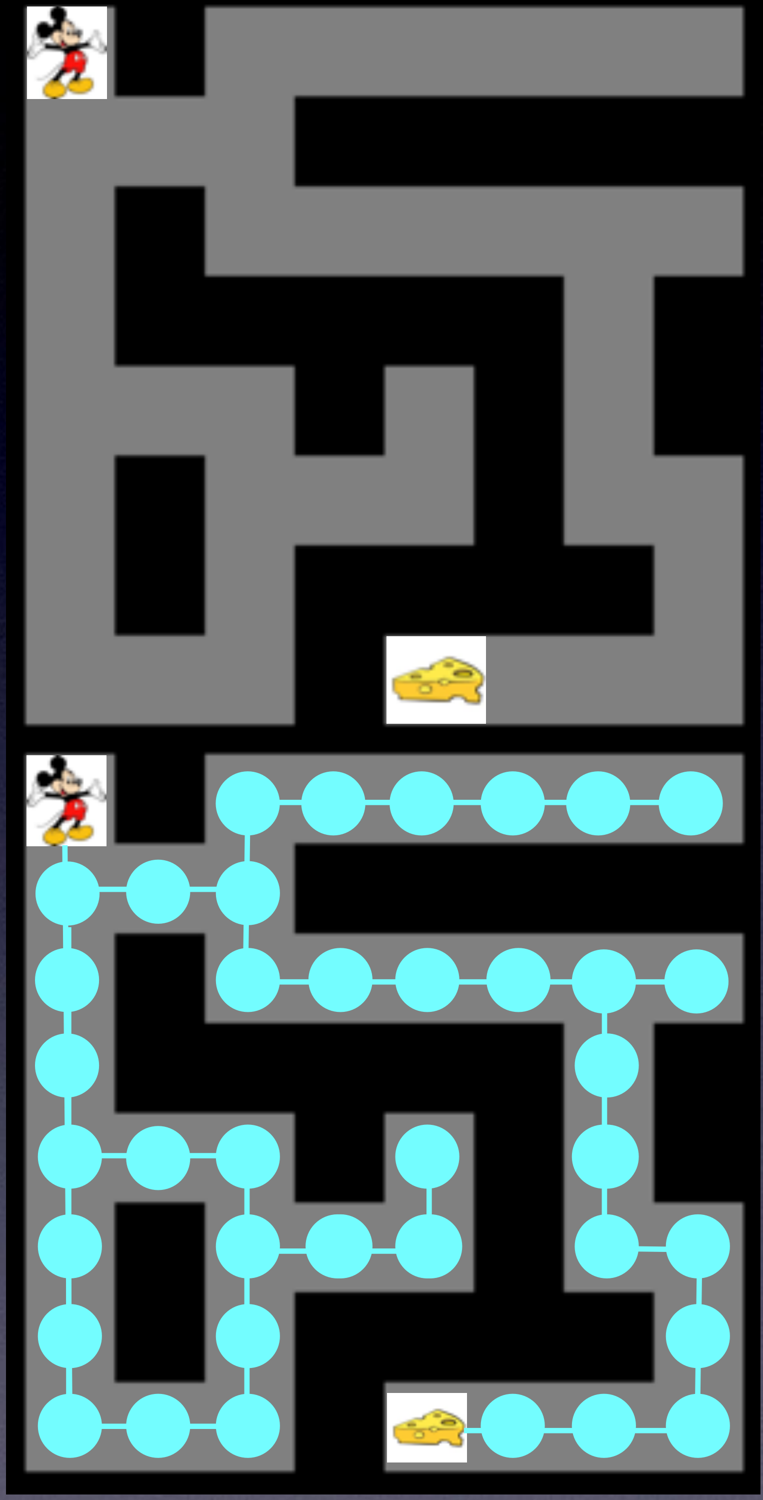
Jeff Clune

Assistant Professor
Evolving Artificial Intelligence Laboratory

University of Wyoming

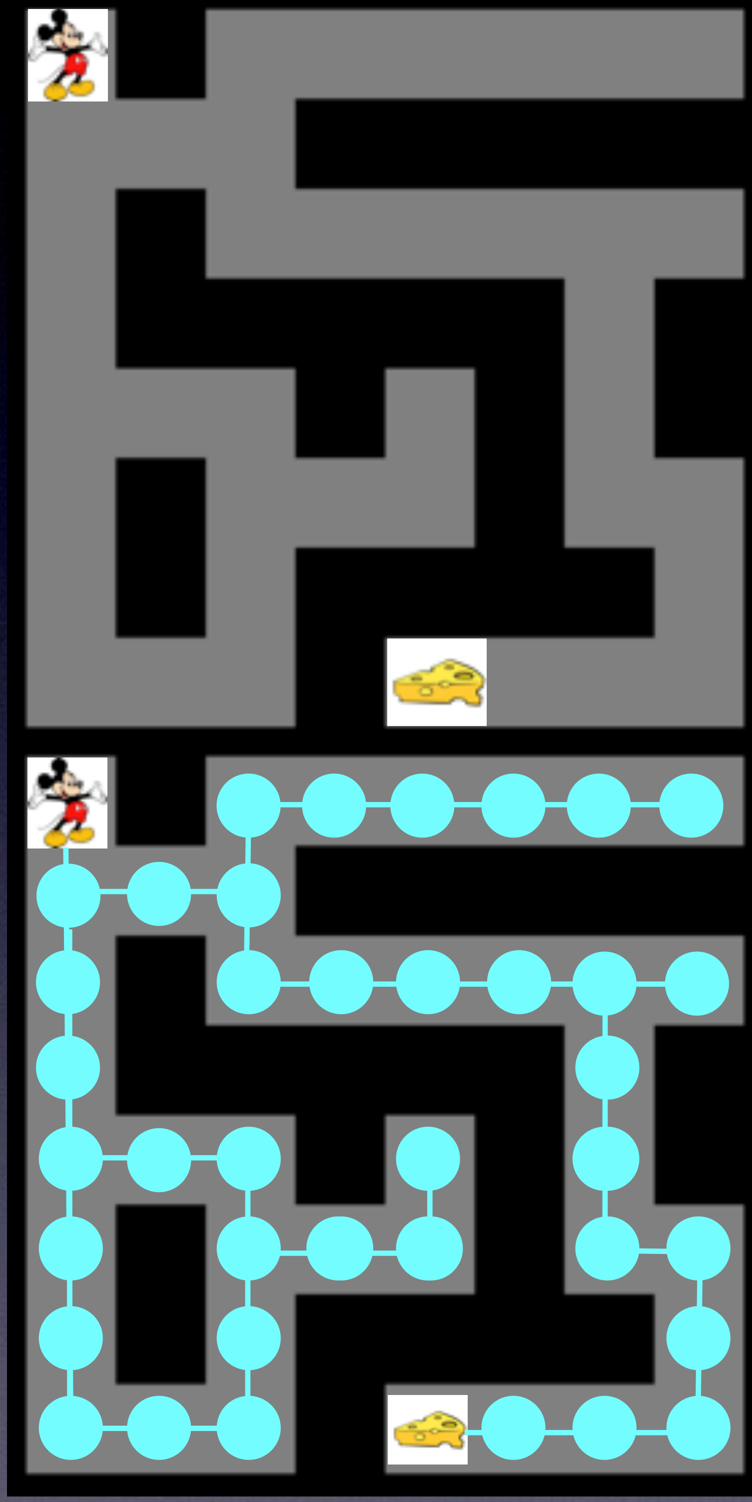
AI Challenge One





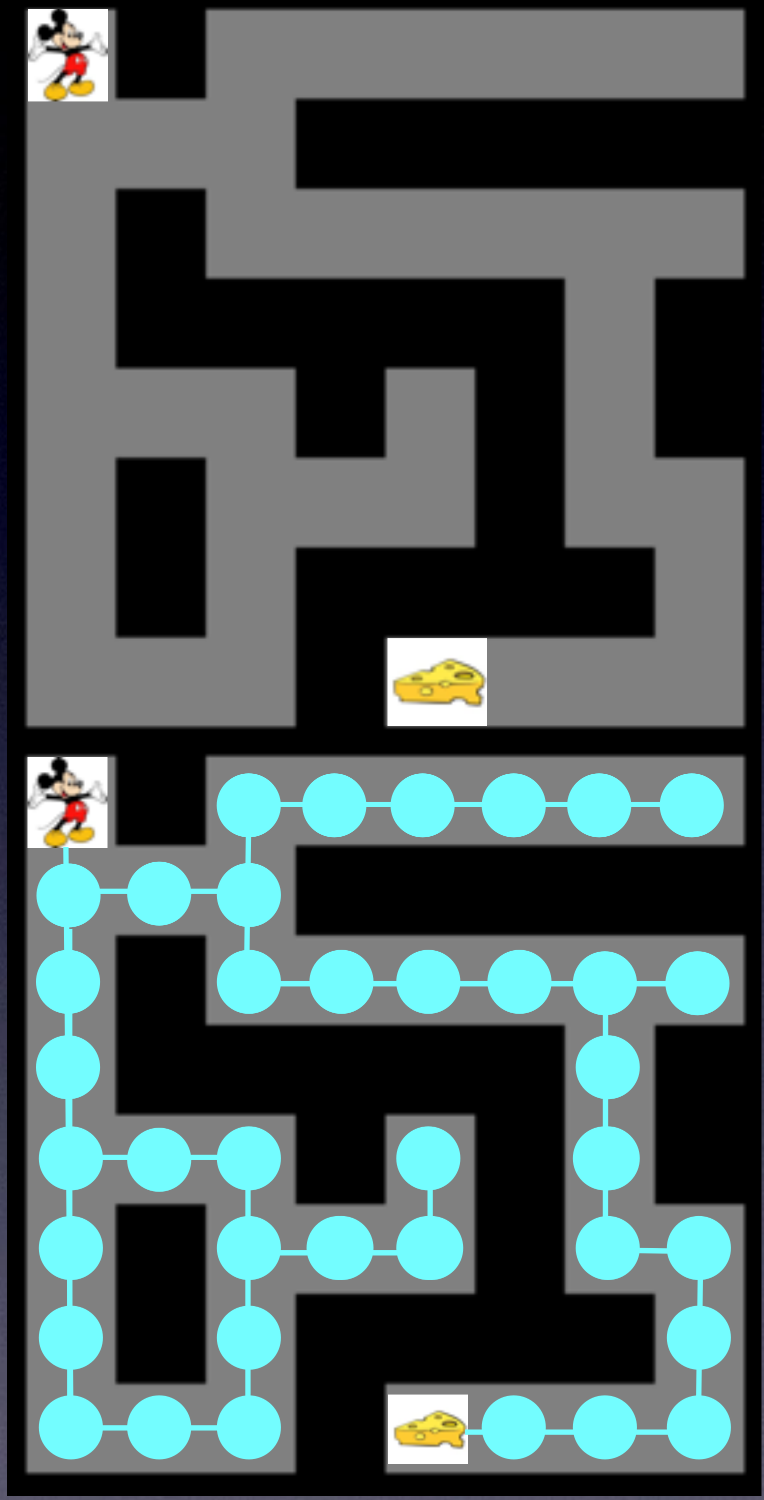
AI Challenge One

- Transform to graph
- Explore the graph, looking for?
  - dust
  - unexplored squares



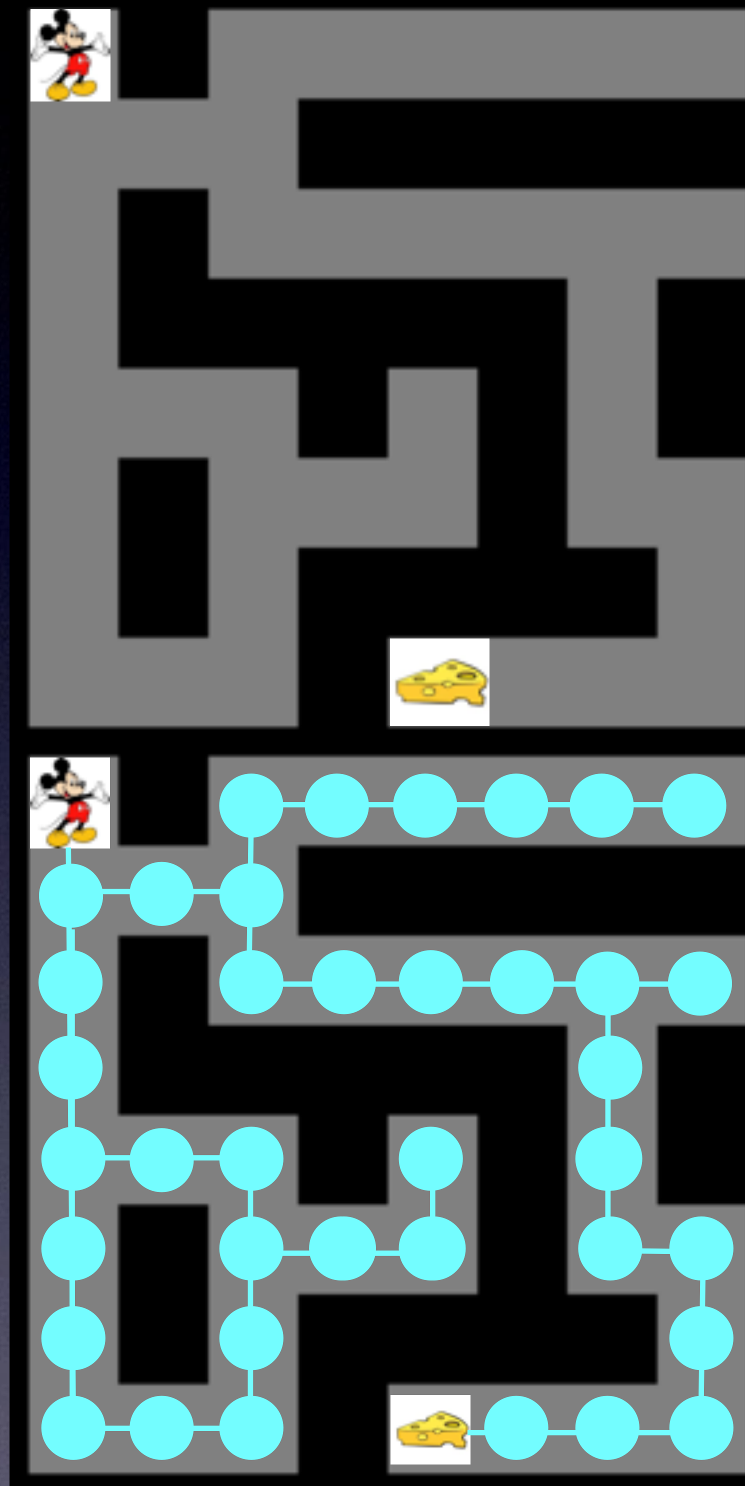
AI Challenge One, Question 2

- Some good solutions
  - 2013 champ: 0.97
    - Move greedily towards dust or unexplored tiles in sensor range.
    - Otherwise start a BFS toward nearest unexplored tile.
  - 2014 champ: 0.98
    - BFS with a maximum depth of 2 towards either dust or unexplored tile
    - If nothing found: run simple reflex agent (move randomly for the most part)
  - 2015: 0.998 (!)
    - Uniform Cost Search (effectively BFS) toward dust first, if no known dust UCS toward unexplored tile instead
  - 2016: 0.9992 (!!!) & 0.9988 (!!)



AI Challenge One, Question 2

- Records broken this year on Q1 and Q3 too
- Nice work!



AI Challenge Three!

- Due: Sept. 25th
- This Sunday!

Evaluation Functions

- alpha-beta still needs to find leaves of the tree
  - too deep in many cases
- workaround: don't go to leaves, but instead estimate the expected value of an intermediate state

Value of these states?

Evaluation Functions

- humans use them
  - no one can “see ahead” to terminal states in chess
- effect of evaluation functions is large
  - a bad one will lead to bad play and vice versa
- must be fast
  - (that’s the point…to save computation)
- Example from chess:
  - Sum of: Pawns (1), knight/bishop (3), rook (5), queen (9).
    - Possibly add “good pawn structure” (0.5), castle (0.5), etc.
  - Called “features”

Evaluation Functions

- Must decide what to conflate
  - learn value of each board state
  - vs. counting pieces
    - assumes layout doesn't matter
- Often a weighted linear sum is used:
  - E.g. value = 9*numQueen+5*numRook+1*numPawn…
  - assumes contributions are independent/non-interacting/non-epistatic
    - to include interactions a non-linear function can be used

Evaluation Function

- Note: They are not part of the rules, must be learned
- Can be learned!
  - How would you do it?
  - In groups come up with as many ways as you can (and pick the one you'd recommend)

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    - Ideas we won't talk about in detail
      - Evolve the weights in the linear weighted sum
      - Deep learning

Evaluation Function

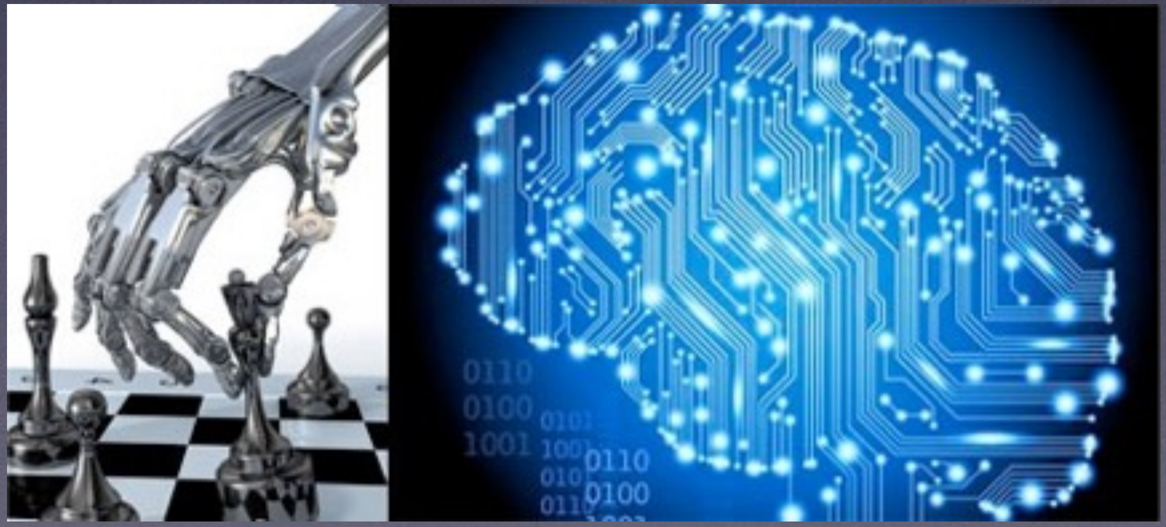
- Monte Carlo ("rollouts")
  - random play to the end repeated N times to estimate state value
  - works pretty well with random play, though would be better with intelligent play
- UCT: more intelligent play
  - increasingly focuses search on promising areas discovered during random play

Evaluation Functions + Alpha Beta

- Can use Alpha Beta out of the box with evaluation functions
  - just pick a max-depth or other stopping criterion
  - or pick maxTimeAllowed and run iterative deepening until you run out of time

Lookup

- Silly to search millions of nodes to pick the opening move
- Can just lookup what to do in common situations
  - openings and endgames
    - read book for fascinating discussion of how much better AI is than humans at endgames
    - one series requires 517 moves but leads to a guaranteed checkmate!
- Usually after 10 moves the board state is rare enough that AI has to switch from lookup to search



Deep Blue

- regularly got to 14 ply
  - some forcing sequences went to 40ply
- 30 billion positions per move
- evaluation function had 8000 features!
- 4000 position opening book
- 700,000-game library of games to learn from
- all 5, and most 6-piece endgames solved
- nowadays better algos mean standard PCs can play well

Humans Can No Longer Win At...

- Humans can no longer win at...
  - Checkers (solved)
  - Chess
  - Othello
  - Scrabble
- Tie
  - backgammon
- Humans better at
  - Go
  - Hopscotch

Is this out of date?
If so, email me.

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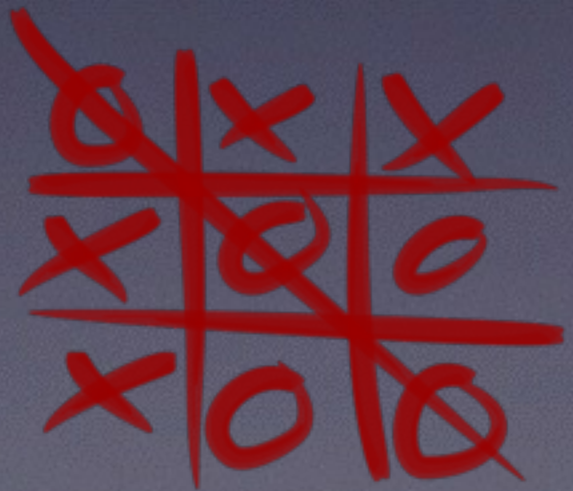
Go

- Branching factor too large: ~250 to ~361 (depending on source)
  - and games go for ~350 moves
- Evaluations to hard (so far!):
  - UCT
    - with extra tricks to suggest which plays to explore
      - (similar to killer move heuristic)
- Current programs can only compete on smaller boards

Wrong! Time to rewrite the textbooks!

Adversarial Search: Key concepts

- Pruning
- Evaluation function
  - evaluate intermediate game states since optimal search is impossible
- Minimax
- Alpha-beta pruning
  - saves time, without any cost in game performance
  - killer heuristic



Stochastic Games

- Examples?

Stochastic Games

- Instead of a minimax value, we calculate expected value
  - (value of each node) * (chance of that node occurring)
  - Which has higher expected utility/value?
    - Option 1: 50% chance of payoff=10, 50% chance of payoff=1
    - Option 2: 90% chance of payoff=6, 10% chance of payoff=0

Partially Observable Games

- E.g. war, bridge, etc.
  - my favorite is Stratego
- Gathering info becomes a move in some games
  - scouts/spies
- Bluffing is important

Ch. 13: Uncertainty

- Uncertainty is pervasive in the world
  - e.g. diagnosing an illness
- Goal: maximize expected utility/value
- Probability Theory is our best tool
  - Lots of help with basic equations & notation in the book

Bayesian Statistics

- Very important in AI
- Allow you to
  - have prior knowledge about the world
    - e.g. phones don’t have cameras
  - update your knowledge of the world
    - e.g. now they do!
- Most of the important info is in Ch. 13.

Bayesian Statistics

- Priors
  - aka “unconditional probabilities” or “prior probabilities”
  - belief before seeing evidence
    - e.g. most phones don’t have cameras (belief in 2000)
    - P(mostPhonesHaveCameras)
- Posterior
  - aka “conditional probabilities” or “posterior

Bayesian Statistics

- Prior
  - P(two dice sum to 12) = ??
- Posterior
  - P(two dice sum to 12 | Die1=6) = ??

Reminder About Probability

Mathematically speaking, conditional probabilities are defined in terms of unconditional probabilities as follows: for any propositions a and b, we have

$$P(a \mid b) = \frac{P(a \wedge b)}{P(b)}, \qquad (13.3)$$

Note: $\wedge$ means "and"

which holds whenever $P(b) > 0$. For example,

$$P(doubles \mid Die_1 = 5) = \frac{P(doubles \wedge Die_1 = 5)}{P(Die_1 = 5)}.$$

The definition of conditional probability, Equation (13.3), can be written in a different form called the **product rule**:

$$P(a \wedge b) = P(a \mid b)P(b),$$

The product rule is perhaps easier to remember: it comes from the fact that, for a and b to be true, we need b to be true, and we also need a to be true given b.