Advanced Topics in Game AI

And Other Interesting Bits

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Table of Contents

Chess AI - Issues

- Huge amount of states (10^{123} game-tree complexity)
- Average Branching Factor = 35
- Time-dependant in most cases
- Many top chess players rely on "intuition" in complex and unclear positions
- Moves may have adverse consequences only many timesteps into the future

Table of Contents

Chess AI - Search Strategy

- Opening Book
  - Draws on 1000 years of "chess wisdom"
  - Borrow stats from thousands of GM games
  - Manually discard refuted openings
  - Constantly updated
- Endgame tables
  - Computed beforehand
  - Computed for all combos of 7 pieces on each side, including kings
- Actual Search (middlegame)

Table of Contents

Chess AI - Middlegame Search

Position Types

- Tactical Positions (require explicit computation, possible very deep)
- Positional Play (no clear best move, calculate, just looking for "intuitive" advantage)
- Discerning between these

Candidate Moves

- Search only the "best" moves in a position
- Specific triggers
- Chess engine designers repeatedly say that this can be as hard as just searching everything

Chess AI - Search Techniques

Search Techniques

- MiniMax
- NegaMax
- NegaMax + Alpha-Beta pruning
- NegaScout
- Transpositional Tables
- Null Move Pruning

Table of Contents

Chess AI - Evaluation Function

A Heuristic!

- Naive approach - material advantage
  - Issue is mating threats, activity of pieces, horizon effect
  - Material more valuable based on position
  - Material guesses not entirely accurate
- Shannon's Approach
  - Include some positional factors as coefficients for mobility and poor placement
  - Give artificial value to game-end condition
  - Suffers from horizon issues, bad coefficients
- Modern solvers use mix of over 1000 factors
  - Piece-Square Tables (placement)
  - Pawn structure
  - King safety
  - Connectivity
  - Tapered Eval & Stages

Chess AI - Search Again

Quiescence Search (Q-search)

- Search to end of exchange until material stabilises
- Hard to detect, often look for large fluctuation in evaluation function
- Razoring with null-move hypothesis

Table of Contents

Assumptions

Assumptions Recap

- NegaMax (zero-sum)
- Null Move Assumption
- Pre-computed opening book and endgame table

Even Bigger Assumptions

- Full observability
- Deterministic Nature

Table of Contents

Approaches

- Simulation Approach
- Machine Learning (parameter tuning)
- Cheating