Alpha/Beta Game Tree Search

Frank Pfenning

15-150, April 14, 2020

Learning Objectives

- Resource limitations
  - Cut off search using value estimators
- Algorithmic or implementation improvements exploiting problem-specific properties
  - Alpha/beta pruning

Outline

- Bounding search with estimators
- Review minimax search
- Alpha/beta pruning

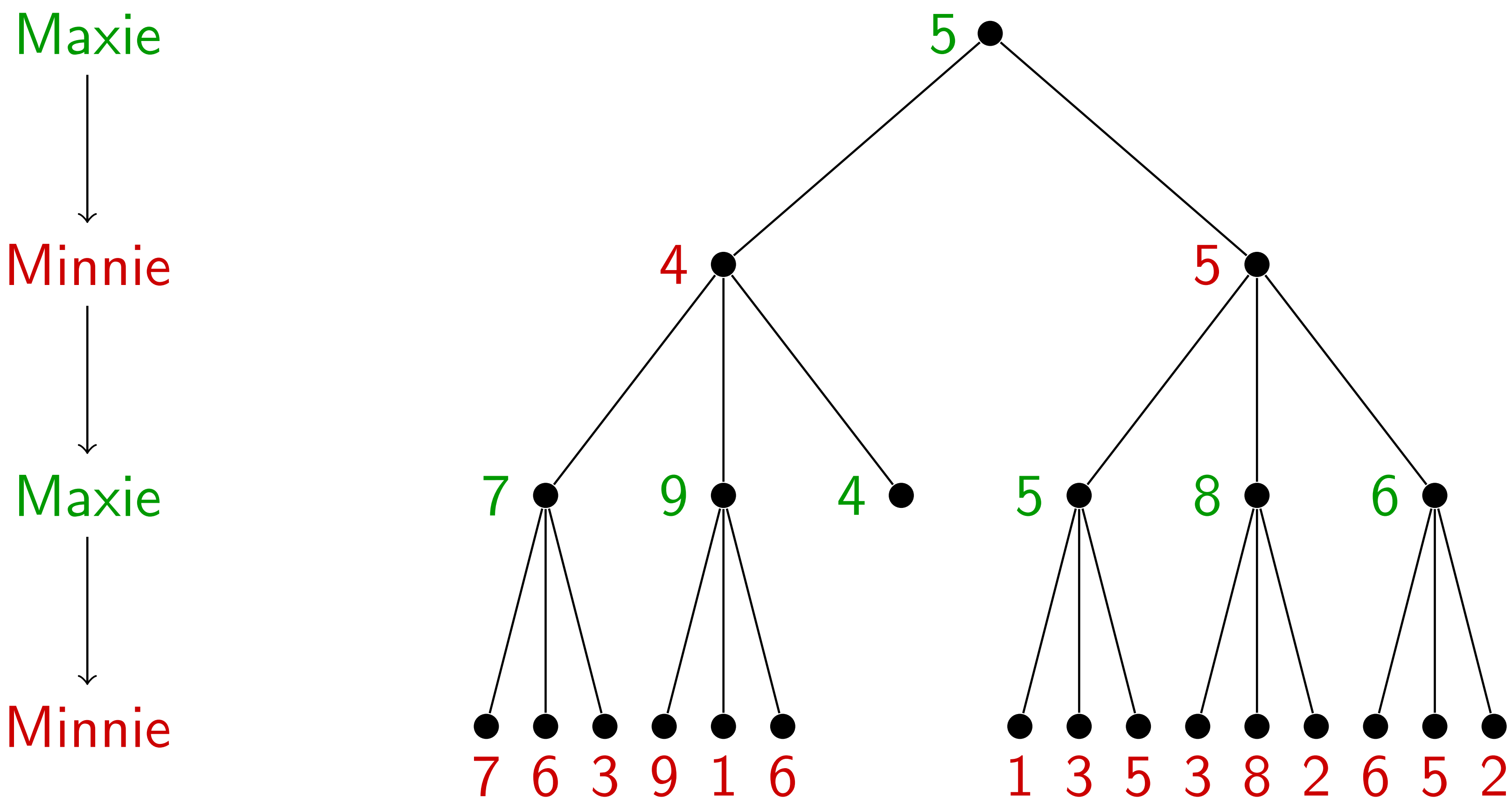
Classes of Games

- 2-player, alternating turns
- Deterministic (no dice)
- Perfect information (no hidden state)
- Zero-sum (A wins iff B loses, or tie)
- Finitely branching
- Examples: tic-tac-toe, connect4, checkers, chess, go, ...

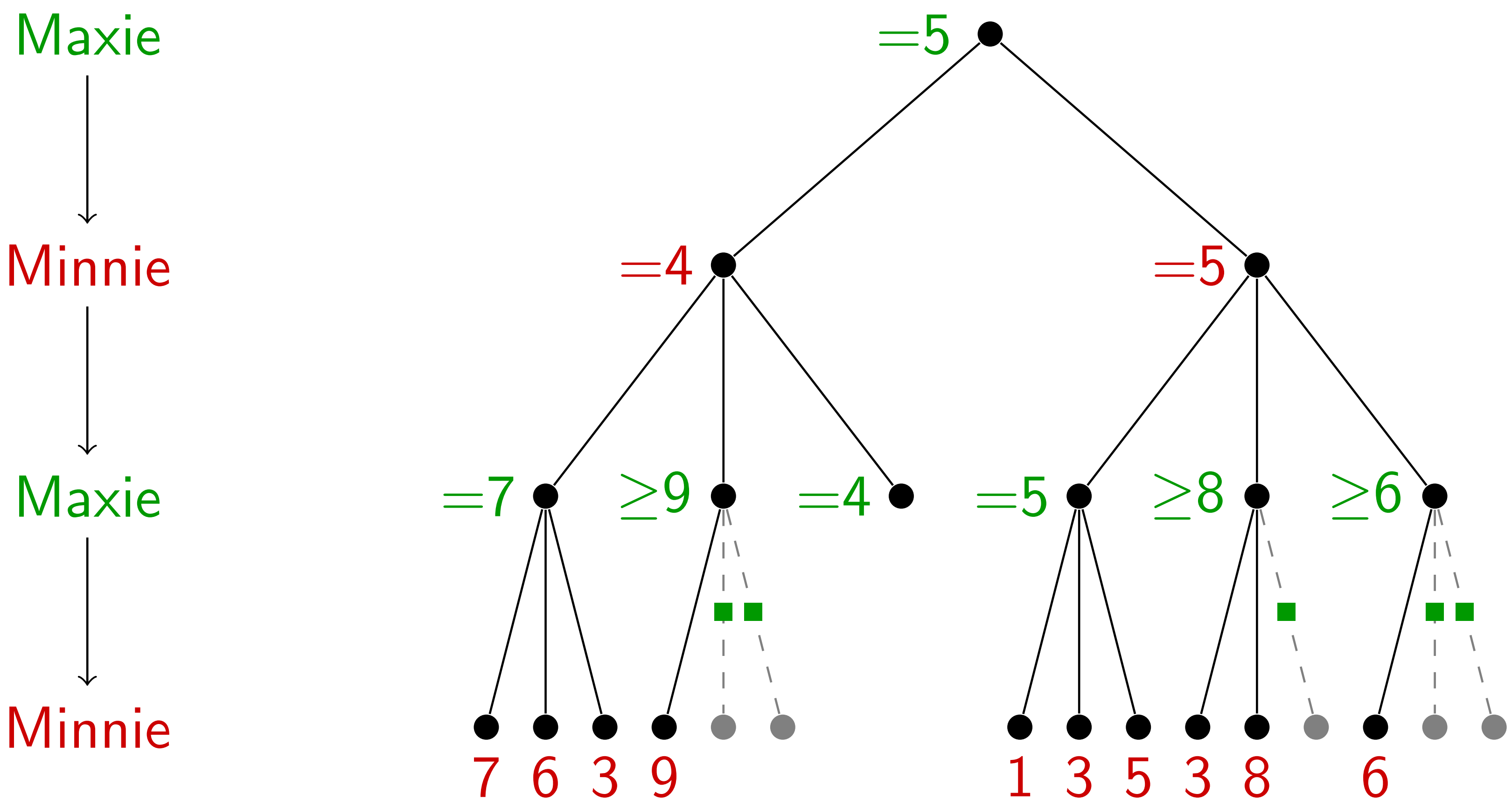
Estimators

- In practice, we cannot explore the full tree for interesting games
- We cut off exploration (based on various criteria) and estimate the value of the position
- Propagate the value up the tree
- Better estimators (generally) result in better players
- Let's review some code ...

Minimax Search



Alpha/Beta Search

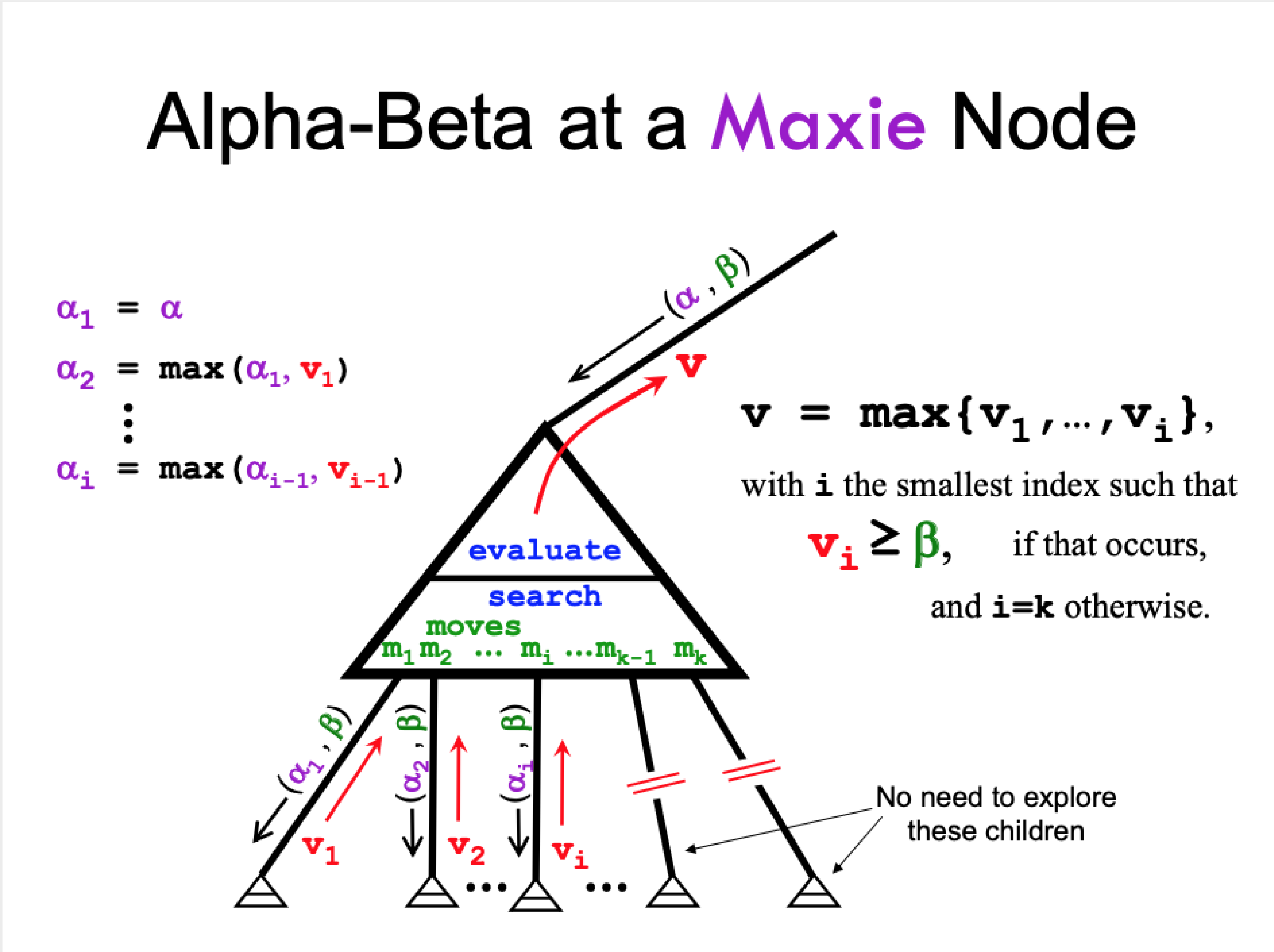


- We need to pass information *down* the tree during search
  - Minnie sets an *upper bound* (e.g., ≤5)
  - Maxie sets a *lower bound* (e.g. ≥4)
- Pass interval (α, β)!
  - Maxie cuts off search if value is greater than β
  - Minnie cuts off search if value is less than α

Alpha/Beta Pruning

- We pass interval (α, β) down during search (with $\alpha < \beta$)
- α is the best (largest) Maxie can achieve (so far)
- β is the best (smallest) Minnie can achieve (so far)
  - If Maxie sees a move to a node with value $v \geq \beta$ stop searching from current node
  - Minnie would never choose the current node, because it can already do better
- Conversely:
  - If Minnie sees a move to a node with value $v \leq \alpha$ stop search from the current node
  - Maxie would never choose the current node, because it can already do better

Zoom in on Maxie Node



Parallelism Revisited

- Sometimes, optimization enhance parallelism
  - From insertion sort to merge sort
- Sometimes, optimization reduce parallelism
  - From minimax to alpha/beta game tree search

Summary

- Bounding search with estimators
- Review minimax search
- Alpha/beta pruning