6.189 IAP 2007

Student Project Presentation

Backgammon Tutor
How to play
Goals

- Implement the rules of backgammon
- Create/Find a function that evaluates how “good” a board is
- Parallelize the evaluation of future board states in order to determine help determine what the best move is this turn
- Teach the player by suggesting a better move and explaining why it is a better move
Board Evaluation

- **Static Evaluator**
  - Linear sum of weighted board features
  - 1979 – BKG 9.8 (Hans Berliner – CMU) beat ruling world champion
    - Adjusted weights as game progressed

- **Neural Nets**
  - Traditionally most successful
  - Trained over 100,000+ games
  - Pubeval – Gerry Tesauro, IBM Research 1993
    - Released as benchmark evaluator that produces play at the intermediate level
Search

- Look at future turns in order to choose best move now
- Large Branching Factor
  - Checkers 10
  - Chess 35-40
  - Backgammon 400
- Uncertainty of future dice rolls (21 possible combinations)
- Pubeval is not zero-sum
- Does searching deeper produce a better play?
  - Most papers say search is less important than a good evaluator
  - Search produces slightly better play – Can still make a big difference
X’s Turn

O’s Roll

O’s Move

X’s Roll

X’s Move

X picks his best Move

~20+ Moves

Expected = \sum \text{pr(child)} \times \text{child}

21 Dice Combos

O Chooses his best Move for a Given Roll

~20+ Moves

Expected = \sum \text{pr(child)} \times \text{child}

21 Dice Combos

X Chooses his best Move for a Given Roll

~20+ Moves

X picks his best Move for a Given Roll

5 Million Boards!
Parallelizing Board Evaluation

- Millions of leaf nodes that each represent a board state
- Attempt to split evenly between SPUs
- Each has a multiple of 4 boards
- All boards (~170,000 in benchmarks) can’t go over to the SPU at once
- SPU knows how much it has to process, takes as much as it can, evaluates, returns, and gets more
- Each should finish at roughly the same time
- SIMDize code to evaluate 4 boards at once
- Double buffer so we can DMA and compute at the same time
Performance – Evaluating 1 Million Boards

![Graph showing performance evaluation over SPU counts.](image-url)
Speedup – Evaluating 1 Million Boards
Development Techniques

- Get sequential code working correctly on single core
  - Squash bugs and memory leaks

- Implement parallel code as sequential code to make sure algorithm works

- Convert parallel code to run on 1 SPU

- Get code working on all 6 SPUs

- Most debugging done with printf statements
Challenges

- We aren’t backgammon experts or even intermediate players
- Getting the game to a playable state took a good chunk of our total time
- Managing search tree
- Memory management
- Cell Debugging
- Bit packing the boards so when we are storing millions of them they fit into memory
Future Work

- Finish move tree traversal after board evaluation
- Move tree pruning (beam search)
- Parallelize move tree creation and traversal
- SIMDize and buffer board evaluation
- Training Board Evaluators
- Monte Carlo approach to finding the best move
- Explaining in English why one move is better than another