

6.172 Final Project

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Main results

Player Ranking				
Player	W	L	T	Elo
GuoYaoqiang-ferret00718-xp88ah-pu8H0nqja	1434	610	61	1544
Buad001-Kong8-ent8t9ja	376	495	30	1339
badm0010-jellu-pu8n-ent8t9ja	196	124	12	1309
min8t9ja-8t9n-8t9n-8t9n-8t9n-8t9n	51	32	9	1280
claw001-8t9n-8t9n-8t9n-8t9n-8t9n	114	69	8	1262
andrew001-8t9n-8t9n-8t9n-8t9n-8t9n	857	508	53	1251
reference_8t9n	1668	1669	117	1239
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	175	58	1	1233
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	74	62	6	1220
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	283	243	15	1220
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	53	32	7	1217
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	41	36	5	1214
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	6	4	0	1207
8t9n-8t9n-8t9n-8t9n-8t9n-8t9n	1	1	0	1200

Rating: 1544

Average depth: Blitz: 7.6, Regular: 8.3

Outline

- 1 Bottleneck Improvement
- 2 Openbook
- 3 Constant Optimization
- 4 Strategies without performance gains

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Bottleneck Improvement - scout_search

`scout_search` takes 32.55% of the time and does the following:

- * Get a list of possible moves
- * Sort the moves
- * Check each move in order, do a recursive search if *necessary*

Bottleneck Improvement - scout_search

- * Hash table move from pre-evaluation and killer moves are returned with high probability
⇒ check them first before generating move list
- * A move is ignored if the node is quiescent and there is no victim
⇒ conservatively predict number of victims, exclude moves at quiescent node with no victim from move list
- * About half of the moves have sort key of 0
⇒ move them to end of move list directly and exclude from sorting procedure
- * Maintaining node count introduces true sharing
⇒ remove counting

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Motivation of Openbook

Underlying Assumption:

- * Good AI makes similar moves.
- * Possible good moves for a given game state are limited.

Number of possible openings between two good AIs is reasonably small.

Openbook!

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Openbook!

Justification of Openbook

Validating the idea on real-world data:

- * Downloaded the most recent 83000 games from Scrimmage.
- * Training Set: about 39000 games.
- * Test Set: about 44000 games.
- * Consider the first 5 rounds of game.
- * In Training Set, 782 (2%) openings occurred at least twice.
- * In Testing Set, 2/3 of the openings falls into the 782 openings.

Hits 2/3 of the games with only 782 records!

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Advantage of Openbook

Openbook offers two main advantages:

- * We can search very deep for a good move in openbook.
So for the first several moves, our choice is very optimized.
- * And those moves take no time at all!

If tested using default timing strategy:

- * Hitting 5 rounds: 20s advantage in Regular, 8s advantage in Blitz.
- * Hitting 10 rounds: 38s advantage in Regular, 15s advantage in Blitz.

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Calculating Openbook

Generating popular openings:

- * Used MySQL to manage data set for its convenience and power, and easiness to interact with web applications.
- * Downloaded the most recent 83000 games from Scrimmage.
- * Extracted frequent openings, and stored them into MySQL.
- * Search depth varied from 9 to 11 for each opening move.
- * Openings with higher # of occurrences were calculated with deeper depth, for a possibly better move.

Calculating Openbook

More than 100000 openings generated.

Impossible to calculate all of them with a single machine!

Distributed computing!

- * LAMP (Linux+Apache+MySQL+PHP) web server to distribute down tasks and collect up results.
- * Clients use wget to interact with web server.
- * 150+ CPUs in Microsoft Azure.
- * 15000+ CPU Hours in total.

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Calculating Openbook

Screenshot of our web server:

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Below is current progress.

Depth	Total	Calculating	Completed
9	153857	28	49144
10	64502	290	54012
11	1553	13	1540

Openbook Test Results

Original Version: 50% winrate against ReferencePlus.

Openbook VS Original: 61% winrate.

However..

Openbook VS ReferencePlus: only 45% winrate!

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Openbook Test Analysis

What might have happened?

- * The opening patterns of ReferencePlus are not captured in the data (at the time we capture data ReferencePlus is still not available).
- * A deeper search doesn't guaranteed a better move, but just gives a good move with higher probability. An unlucky bad move in the hotspot of openbook might actually degrade performance.

Experiments shows **both** explanations are correct.

Boosting Openbook

Addressing the problem caused by missing opening patterns:

Add the games played against ReferencePlus into Openbook!

- * Before Boosting: 45% winrate.
- * After Round 1 Boosting (1500 games): 50% winrate.
- * After Round 2 Boosting (1500 games): 56% winrate.
- * After Round 3 Boosting (1500 games): 61% winrate.

Steady increase in winrate!

Boosting Openbook

Addressing the problem caused by popular bad move:

The bot has a largely different winrate between moving first (30%) and moving second (60%).

- * Might the opening move “h4g5” actually be a bad move?
- * Rotate the King in the first move! (h0L)
- * Now the game is very similar to as if we were moving second.

Amazing winrate increase: from 45% to 60%!

Together with boosted openbook: 69% winrate against ReferencePlus!

Boosting Openbook

Is there a better first move?

Experimented with 8 first moves:

- * 5 Pawn moves (considered “good” by Bot heuristic).
- * 3 King moves (considered “bad” by Bot heuristic).

Move	WR	Move	WR	Move	WR	Move	WR
h0h1	83%	f4L	76%	h0L	73%	h4h5	71%

WR based on a better AI, for relative comparison only.

King move “h0h1” has highest winrate.

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- * In the 140000 game records we downloaded, the starting King move “h0h1” (also “h0L”) has never been used by anyone.
- * Yet it yields the highest winrate.
- * Hueristic function and depth are not absolute measurement criteria.

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Openbook Summary

In the end, our openbook:

- * Contains about 200000 game states arose from 140000 games.
- * Almost always hits 6 rounds.
- * With good probability hits 7 or 8 rounds.
- * Can sometime even reach 10 rounds or more.

Openbook Final Results against Refplus

Original (no openbook) against ReferencePlus:

- * Blitz: 74.6%
- * Regular: 67.6%

After equipping openbook:

- * Blitz: 85.9% (+11.3%)
- * Regular: 85.2% (+17.6%)

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Constant Optimization

- * Use `uint64_t` to store cells that are lasered
- * Use two bitmaps to store occupied positions, one for each color
- * Change `ARR_SIZE` to 10
- * Precompute and use constant tables to save repeated computation in `pcentral` and remove divisions
- * Pack `victims_t` in `int16_t` since storing all victims is unnecessary
- * Change the set in transposition table to be 4-way set-associative

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Strategies without performance gains

- * Closebook: rarely used
- * Range tree instead of sorting in `scout_search`