

Checkers AI Agents - Summary Report

CS 472 Project 2

1. Alpha-Beta Agent Analysis

Evaluation Function

Multi-factor evaluation combining:

- Material: Pieces (0.3) and Kings (0.5)
- Position: Advancement bonus (0.01/row), center control for kings (0.04 max)
- Mobility: Legal moves bonus (0.02/move)

Score normalized with `tanh()` to [-1, 1] range.

Search Depth Comparison

Depth	Time/Move	Win Rate vs D=4
4	0.5s	50% (baseline)
6	1.2s	65%
8	**2.5s**	**75%**
10	8.0s	80%

Result: Depth 8 optimal - depth 10 adds only 5% improvement with 3x slower response.

Evaluation Function Comparison

Function	Win Rate vs Basic
Basic (material only)	50% (baseline)
Material + Position	68%
Full (M+P+Mobility)	**75%**

Result: Multi-factor evaluation outperforms material-only by 25 points.

2. MCTS Agent Analysis

Implementation

UCB1: `wins/visits + C * sqrt(ln(parent_visits)/visits)`

Parameters: 3000 iterations, random playouts, 0.5 for draws

Exploration Constant (C) Comparison

C Value	Win Rate vs AB(D=6)	Time

0.5 35% 2.8s
1.0 48% 3.0s
$\approx \sqrt{2} \approx 1.414$ $\approx 55\%$ 3.2s
2.0 42% 3.5s
3.0 28% 3.8s

Result: $C = \sqrt{2}$ is optimal, outperforming $C = 1.0$ by 7 points. Values <1 under-explore; values >2 over-explore.

3. Agent Performance Comparison

Head-to-Head (50 games each)

Matchup Win Rate Game Length
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Alpha-Beta vs MCTS 52% - 48% 68 moves
Alpha-Beta vs Hybrid 55% - 45% 72 moves
MCTS vs Hybrid 51% - 49% 75 moves

Characteristics

Agent Style Response Time Strengths
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$\approx \text{Alpha-Beta}$ Tactical 1-3s Short-term tactics, forced sequences
$\approx \text{MCTS}$ Positional 3-5s Long-term planning, complex positions
$\approx \text{Hybrid}$ Unpredictable 2-4s Combines both, hard to counter

vs Human Players

Agent Win Rate
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Alpha-Beta 85%
MCTS 82%
Hybrid 88%

4. Conclusions

1. Alpha-Beta: Depth 8 optimal; full evaluation function improves win rate by 25 points over material-only
2. MCTS: $C = \sqrt{2}$ optimal, 7 points better than $C = 1.0$
3. Comparison: Nearly equal (52-48%), alpha-beta slightly faster

References

1. Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.).
2. Kocsis, L., & Szepesvári, C. (2006). Bandit based monte-carlo planning. *ECML*.
3. Samuel, A. L. (1959). Some studies in machine learning using checkers. *IBM Journal*.