

# 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%
<b>8</b>	<b>2.5s</b>	<b>75%</b>
10	8.0s	80%

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

#### Evaluation Function Comparison

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

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

### 2. MCTS Agent Analysis

#### Implementation

UCB1:  $\text{wins}/\text{visits} + C \times \sqrt{(\ln(\text{parent\_visits})/\text{visits})}$

Parameters: 3000 iterations, random playouts, 0.5 for draws

#### Exploration Constant (C) Comparison

C Value	Win Rate vs AB(D=6)	Time
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0.5   35%   2.8s
1.0   48%   3.0s
$\sqrt{2} \approx 1.414$   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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<b>Alpha-Beta</b>   Tactical   1-3s   Short-term tactics, forced sequences
<b>MCTS</b>   Positional   3-5s   Long-term planning, complex positions
<b>Hybrid</b>   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*.