# CS 6364: AI Project Report

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## **Output:**

Comparison of 6 different scenarios is shown here:

1. MiniMaxOpening VS ABOpening
2. MiniMaxGame VS ABGame
3. MiniMaxOpening VS MiniMaxOpeningImproved
4. MiniMaxGame VS MiniMaxGameImproved
5. MiniMaxOpening VS MiniMaxOpeningBlack
6. MiniMaxGame VS MiniMaxGameBlack

### 1. MiniMaxOpening VS ABOpening:

Case 1:

**MiniMaxOpening:**

Input : WxxBxxxxBBBWWWxxxxxWB
Depth:3
---
Board Position : WxxxxxxxBBBWWWWxxxxWB
Position Evaluated by Static Estimation : 3990
Minimax Estimate : 2
---

**ABOpening:**

Input : WxxBxxxxBBBWWWxxxxxWB
Depth:3
---
Board Position : WxxxxxxxBBBWWWWxxxxWB
Position Evaluated by Static Estimation : 1232
AB Estimate : 2
---

Case 2:

**MiniMaxOpening:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxxxxxxBBBWWWWxxxxxx
Position Evaluated by Static Estimation : 261
Minimax Estimate : 0
---

**ABOpening:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxxxxxxBBBWWWWxxxxxx
Position Evaluated by Static Estimation : 99
AB Estimate : 0
---

## 2. MiniMaxGame VS ABGame:

Case 1:

**MiniMaxGame:**

Input : WxxBxxxxBBBWWWxxxxxWB
Depth:3
---
Board Position : xWxBxxxxBBBWWWxxxxxWB
Position Evaluated by Static Estimation : 1189
Minimax Estimate : -1008
---

**ABGame:**

Input : WxxBxxxxBBBWWWxxxxxWB
Depth:3
---
Board Position : xWxBxxxxBBBWWWxxxxxWB
Position Evaluated by Static Estimation : 653
AB Estimate : -1008
---

Case 2:

**MiniMaxGame:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxxxxxxBBBxWWWxxxxxx
Position Evaluated by Static Estimation : 508
Minimax Estimate : -45
---

**ABGame:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxxxxxxBBBxWWWxxxxxx
Position Evaluated by Static Estimation : 164
AB Estimate : -45
---

## 3. MiniMaxOpening VS MiniMaxOpeningImproved:

Case 1:

**MiniMaxOpening:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:4
---
Board Position : WxxxxxWxBBBWWWxxxxWWB
Position Evaluated by Static Estimation : 69488
Minimax Estimate : 3
---

**MiniMaxOpeningImproved:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:4

---
Board Position : WxxxxxxxBBBWWWxWxxWWB
Position Evaluated by Static Estimation : 69488
Minimax Estimate : 5
---

Case 2:

**MiniMaxOpening:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:3
---
Board Position : xxxxxxxxBBBWWWWxxxxxx
Position Evaluated by Static Estimation : 4114
Minimax Estimate : 1
---

**MiniMaxOpeningImproved:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:3
---
Board Position : xxxxxxxxBBBWWWWxxxxxx
Position Evaluated by Static Estimation : 4114
Minimax Estimate : 2
---

## 4. MiniMaxGame VS MiniMaxGameImproved:

Case 1:

**MiniMaxGame:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:3

---
Board Position : WxxBxxxxBBBWxWxWxxWWB
Position Evaluated by Static Estimation : 1815
Minimax Estimate : 992
---

**MiniMaxGameImproved:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:3

---
Board Position : xWxBxxxxBBBWWWxxxxWWB

Position Evaluated by Static Estimation : 1815
Minimax Estimate : 2993
---

Case 2:

**MiniMaxGame:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxxxxxxBBBxWWWxxxxxx
Position Evaluated by Static Estimation : 508
Minimax Estimate : -45
---

**MiniMaxGameImproved:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:2
---
Board Position : xxxBxxxxBBBxWWxWxxxxx
Position Evaluated by Static Estimation : 508
Minimax Estimate : -12
---

## 5.MiniMaxOpening VS MiniMaxOpeningBlack

Case 1:

**MiniMaxOpening:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:2
---
Board Position : WxxxxxWxBBBWWWxxxxWWB
Position Evaluated by Static Estimation : 320
Minimax Estimate : 2
---

**MiniMaxOpeningBlack:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:2
---

Board Position : xxxBxxxxBBBWWWxxxBWWB
Position Evaluated by Static Estimation : 333
Minimax Estimate : -1
---

Case 2:

**MiniMaxOpening:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:1
---
Board Position : xxxxxxxxBBBWWWWxxxxxx
Position Evaluated by Static Estimation : 17
Minimax Estimate : 1
---

**MiniMaxOpeningBlack:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:1
---
Board Position : xxxBxxxxBBBxWWxxxBxxx
Position Evaluated by Static Estimation : 16
Minimax Estimate : 3
---

## 6.MiniMaxGame VS MiniMaxGameBlack

Case 1:

**MiniMaxGame:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:2
---
Board Position : xWxBxxxxBBBWWWxxxxWWB
Position Evaluated by Static Estimation : 145
Minimax Estimate : -10
---

**MiniMaxGameBlack:**

Input : WxxBxxxxBBBWWWxxxxWWB
Depth:2

---
Board Position : WxxBxxxxBBBxWWxxxBWWx
Position Evaluated by Static Estimation : 146
Minimax Estimate : -14
---

Case 2:

**MiniMaxGame:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:1
---
Board Position : xxxBxxxxxBBxWWWxxxxxx
Position Evaluated by Static Estimation : 45
Minimax Estimate : -43
---

**MiniMaxGameBlack:**

Input : xxxBxxxxBBBWWWxxxxxxx
Depth:1
---
Board Position : xxxBxxxxBxBWWWBxxxxxx
Position Evaluated by Static Estimation : 8
Minimax Estimate : 958
---

We can easily see that the improved static evaluation performed better than the AB pruning in the cases mentioned above.
Alpha beta pruning offers the same estimate value as MiniMax, as well as it was able to yield the value in less positions than MiniMax.
i.e AB Pruning evaluates less nodes as compared to MiniMax

## Improved Static Evaluation Function VS Normal Static Evaluation Function:

There were 2 separate static functions which were used in the Opening and MidGame/EndGame.
Opening Phrase : (pieces_of_white-pieces_of_black)
Midgame Phrase:
if (pieces_of_white ≤ 2)
return(10000)
else if (pieces_of_white ≤ 2)
return(-10000)

else if (pieces_of_white ==0)
return(10000) else
return ( 1000(pieces_of_white − pieces_of_black) - numBlackMoves)

In the revised version, we explore the case of creating a mill by giving greater weight to the positions that lead to mill formation, lowering the steps size required to win the match. As a result, while deciding on the next move, the position that creates a mill is preferred which improves the chances of winning the match.

## References:


1. https://en.wikipedia.org/wiki/Nine_men%27s_morris
2. https://www.thesprucecrafts.com/nine-mens-morris-board-game-rules-412542
3. Handouts given in class by the professor.