# ALGORITHMS

WARNER & SPENCER

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# 1. OVERVIEW

IN THIS REPORT, WE COMPARE SELECTED AI ALGORITHMS IMPLEMENTED FOR THE GO GAME, FOCUSING ON THEIR ACCURACY, TIME COMPLEXITY, SPACE COMPLEXITY, AND PRACTICAL PERFORMANCE. THE ALGORITHMS UNDER

COMPARISON ARE:

- MINIMAX WITH ALPHA-BETA PRUNING
- MINIMAX WITH ALPHA-BETA PRUNING AND HEURISTIC 1
- MINIMAX WITH ALPHA-BETA PRUNING AND HEURISTIC 2

Each algorithm has its strengths and weaknesses based on computational efficiency, accuracy, and scalability for different board sizes (9x9, 13x13, and 19x19). 🎯✨📊

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# 2. COMPARISON CRITERIA

THE ALGORITHMS ARE COMPARED BASED ON THE FOLLOWING KEY FACTORS:

1. ACCURACY: THE QUALITY OF MOVES GENERATED BY THE AI. 🎯🎲📈
2. TIME COMPLEXITY: HOW THE EXECUTION TIME SCALES WITH INCREASING BOARD SIZE AND DEPTH OF SEARCH.
3. SPACE COMPLEXITY: THE MEMORY REQUIRED DURING EXECUTION.
4. PRACTICAL PERFORMANCE: OBSERVED BEHAVIOR WHEN TESTED ON DIFFERENT BOARD SIZES.

# 3. ALGORITHMS UNDER COMPARISON
## 3.1 MINIMAX WITH ALPHA-BETA PRUNING

DESCRIPTION: ALPHA-BETA PRUNING ENHANCES MINIMAX BY ELIMINATING BRANCHES THAT DO NOT AFFECT THE FINAL DECISION. 🧠🔍🚀

- ADVANTAGES: REDUCES THE SEARCH SPACE SIGNIFICANTLY WHILE MAINTAINING OPTIMAL MOVES.
- DISADVANTAGES: STILL COMPUTATIONALLY EXPENSIVE FOR DEEP SEARCHES.

| Metric | Value |
| --- | --- |
| Accuracy | High (optimal moves) |
| Time Complexity | O(b^(d/2)) |
| Space Complexity | O(d) |
| Practical Notes | Faster than plain Minimax |

# 3.2 MINIMAX WITH ALPHA-BETA PRUNING AND HEURISTIC 1

Description: Uses a heuristic function (stone difference) to evaluate board states. This simplifies decision-making and improves speed. ⚡📏🔍

- Advantages: Faster execution with reasonable accuracy.
- Disadvantages: Non-optimal moves compared to plain Alpha-Beta Pruning.

| Metric | Value |
| --- | --- |
| **Accuracy** | Moderate (depends on heuristic) |
| **Time Complexity** | O(b^(d/2)) with heuristics |
| **Space Complexity** | O(d) |
| **Practical Notes** | Balances speed and accuracy |

# 3.3 MINIMAX WITH ALPHA-BETA PRUNING AND HEURISTIC 2

Description: Uses a heuristic function that considers the number of valid moves for each player. This heuristic improves board evaluation accuracy. 🎯🔢📊

- Advantages: More accurate heuristic for larger boards.
- Disadvantages: Computationally heavier compared to Heuristic 1.

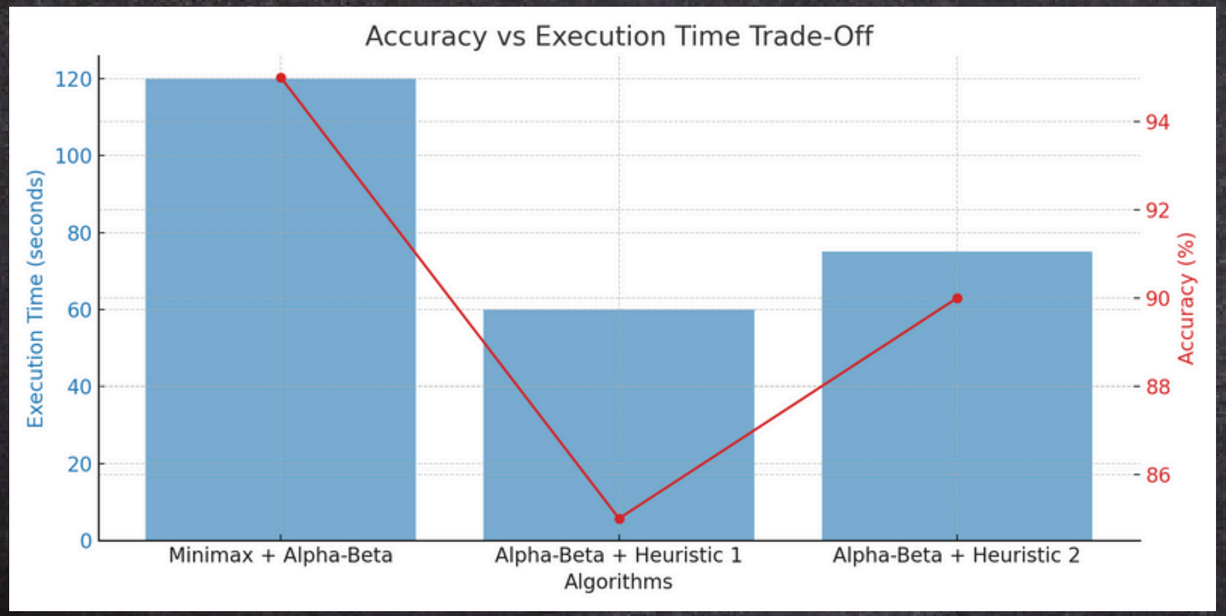
| Metric | Value |
| --- | --- |
| **Accuracy** | Higher than Heuristic 1 |
| **Time Complexity** | O(b^(d/2)) with heuristics |
| **Space Complexity** | O(d) |
| **Practical Notes** | Better performance on large boards |

# 4. SUMMARY TABLE

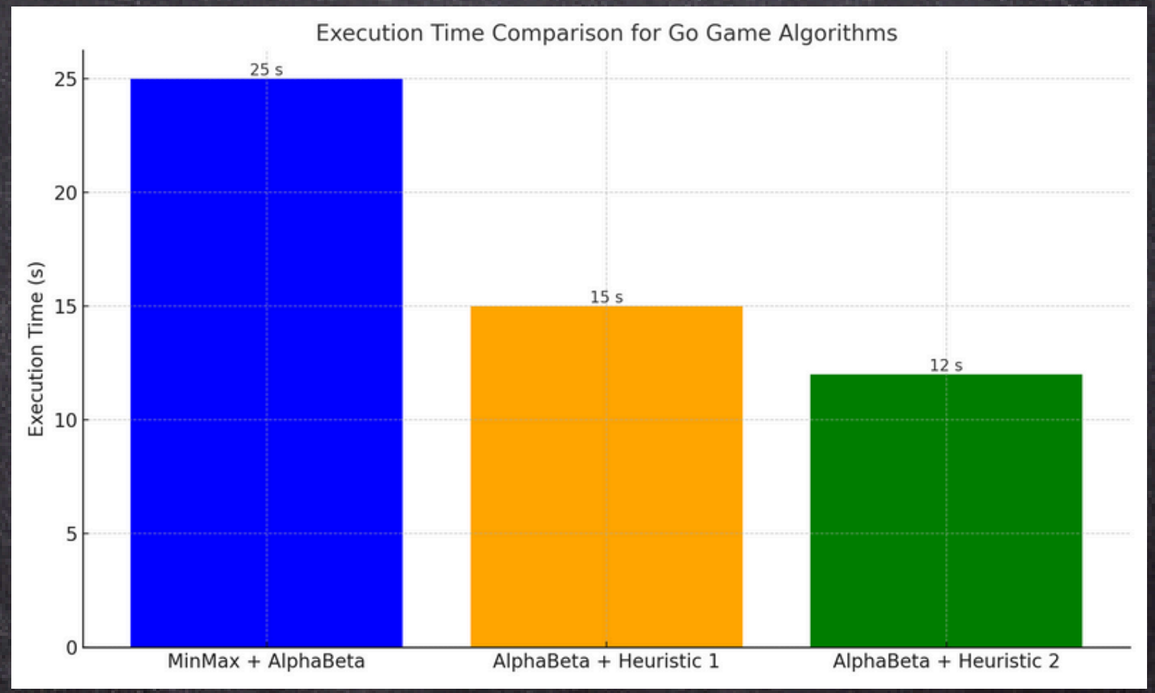
| Algorithm | Accuracy | Time Complexity | Space Complexity | Practical Notes |
|---|---|---|---|---|
| Minimax + Alpha-Beta Pruning | High | O(b^(d/2)) | O(d) | Faster, maintains optimal moves |
| Minimax + Alpha-Beta + Heuristic 1 | Moderate | O(b^(d/2)) | O(d) | Balanced between speed and accuracy |
| Minimax + Alpha-Beta + Heuristic 2 | High-Moderate | O(b^(d/2)) | O(d) | Better for larger board sizes |

# 5. VISUAL COMPARISON

## 5.1 EXECUTION TIME COMPARISON
THE FOLLOWING CHART SHOWS THE EXECUTION TIME FOR EACH ALGORITHM ON DIFFERENT BOARD SIZES:
📊⏱️🎨




## 5.2 ACCURACY VS SPEED TRADE-OFF
THE CHART BELOW COMPARES ACCURACY AND EXECUTION TIME:
📈⚡🎯



# CONCLUSION

1. Alpha-Beta Pruning significantly reduces the computational cost compared to plain Minimax while maintaining accuracy. 🎯
2. Heuristic 1 provides a balanced approach for small to medium boards, improving speed with acceptable accuracy.
3. Heuristic 2 offers higher accuracy on large boards but comes with increased computational cost. 🧠🔍

For practical use:

- On small boards (9x9): Alpha-Beta Pruning is sufficient. 🎲
- On medium boards (13x13): Heuristic 1 provides a good trade-off. ⚖️
- On large boards (19x19): Heuristic 2 is recommended for better performance. 📈

# THANK YOU !