

Project Proposal

Project Title: AI-Powered Quoridor with Modified Rules and Advanced Search Algorithms

Submitted By: Muhammad Umer Ahmed Abbasi (22K-4599 > Group Leader), Jawwad Ahmed (22K-4648), Talha Asim (22K-4589)

Course: AI

Instructor: Abdullah Yaqoob

Submission Date: 10-March-2025

1. Project Overview

Project Topic:

The project focuses on implementing Artificial Intelligence (AI) for the board game **Quoridor**. This project will modify the traditional game by increasing the number of players, changing board dimensions, and introducing special moves to enhance strategic depth. AI will be implemented using search algorithms to suggest optimal moves, making the gameplay more challenging.

Objective:

The primary goal is to develop an AI that can efficiently play Quoridor by evaluating the best possible moves using heuristic-based and search-based approaches. The AI will use multiple algorithms, including **Minimax**, **Alpha Beta Pruning**, and BFS to find optimal paths and predict opponent strategies. This project aims to explore the effectiveness of different search techniques in a real-time strategic game setting.

2. Game Description

Original Game Background:

Quoridor is a strategy-based board game where players aim to reach the opposite side of the board while placing walls to obstruct their opponents. The game requires players to find the shortest path while anticipating their opponents' moves.

Innovations Introduced:

- **Increased Players:** The game will be modified to allow **4 players** instead of just 2, making the AI's decision-making more complex.

- **Expanded Board Size:** The standard **9x9 board** will be modified to **13x13**, increasing the number of possible paths and requiring more strategic planning.
- **Special Moves:** Players will have the ability to place or remove walls under specific conditions, introducing dynamic obstacles that will test the AI's adaptability.

These modifications will significantly impact game complexity, requiring AI to evaluate a larger decision space and adapt to dynamic game conditions.

3. AI Approach and Methodology

AI Techniques to be Used:

We try to implement two to three algorithms from the below mentioned algorithms

- **Minimax Algorithm** (with Alpha-Beta Pruning) for decision-making in a competitive environment.
- **A* Search Algorithm**** for optimal pathfinding towards the goal.
- **Breadth-First Search (BFS)** for shortest path calculations.

Heuristic Design:

- Path length to the goal will be a primary heuristic for decision-making.
- The number of remaining walls and their impact on opponents will influence move selection.
- Opponent movement prediction will be incorporated to counter strategic blocking.

Complexity Analysis:

- **Minimax with Alpha-Beta Pruning:** $O(b^d)$ in the worst case, but pruning significantly reduces computation.

4. Game Rules and Mechanics

Modified Rules:

- The number of players is increased from 2 to **4**.
- The board size is expanded from **9x9 or 13x13**.

Winning Conditions:

- A player wins by reaching the opposite side of the board first.
- If all players are blocked with no valid moves, the game ends, and the player closest to their goal wins.

Turn Sequence:

- Each player moves one step per turn or places a wall.
- Walls cannot completely block all paths, ensuring fair gameplay.
- AI evaluates multiple possible moves before selecting the best option.

5. Implementation Plan

Programming Language:

Python

Libraries and Tools:

- **tkinter** (for GUI development and game rendering)

Milestones and Timeline:

- **Week 9:** Game design, rule finalization, and initial board setup.
- **Week 10-11:** Development of AI strategy (Minimax, BFS, etc.).
- **Week 12:** Coding and testing the game mechanics.
- **Week 13:** AI integration and performance evaluation.
- **Week 14:** Final testing, debugging, and report preparation.

6. References

- Quoridor Official Rules: <https://boardgamegeek.com/boardgame/624/quoridor>
- AI in Games – Russell & Norvig, “Artificial Intelligence: A Modern Approach”
- BFS/Minimax Tutorials: GeeksForGeeks, Stack Overflow
- Python Tkinter Documentation
- Original Quoridor Python Implementations and GitHub Projects