CIS 677: Introduction to Artificial Intelligence
Project Proposal

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Domain: Nine Men's Morris Game

How to play:

1. The number of players of the game is 2, each player has 9 pieces (men) of one color. The pieces (men) are placed on the intersection by the player one by one. To choose which player plays first, it is done using coin toss by mutual agreement. Initially, the board is empty. The goal for the player is to make a mill which is 3 pieces in a row.
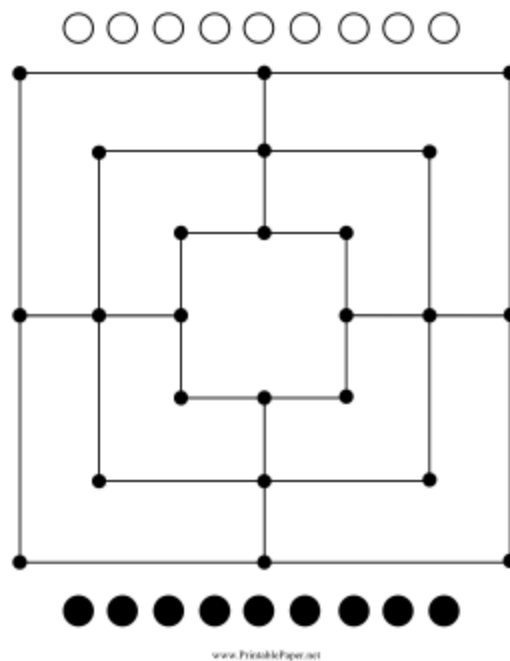
Board of Nine men morris

2. The legal moves of the pieces are horizontally or vertically but not diagonally. Lines must always be connected.
3. Phases of the game,

a. Placing men
   i. Players take turns by placing one man at a time on the empty dots.
   ii. Players try to prevent the opponent from forming a mill. If a player makes a mill, they can remove one man from the opponents not from the mill unless no other men are available. If all the men of the other player form a mill, no men can be removed.
   iii. If a player makes more than one mill with a single move, they can remove as many men of the other player as they want.
b. Moving men
   i. When all the men are placed on the board, the players have to move the men in alternating moves which is one dot at a time to form a mill /mills.
   ii. The men can move to an adjacent dot but cannot jump over each other or skip dots if more than one men are available in the row.
   iii. A player can move the men which were already in a mill before. If the player puts the men back to its position it would be considered a new mill.
c. Flying (Optional)
   i. This phase begins when either one of the players has 3 men left. In this phase, the player can not only move their men only to an adjacent dot. They can move the men to any dot available on the board.
   ii. This phase is optional and considered a variation of the game to give advantage to the losing player.
4. The game ends when one player has two men and can no longer form mills, or when a player has no legal moves left to make.

Tree Search Algorithm: Minimax

Game Modeling:
The agent stores its data in the form of a search tree where each node of the tree contains the following key information:
   1. The Board State
   2. The action taken to reach the board state
   3. The turn count
   4. The first player's current phase of gameplay
   5. The second player's current phase of gameplay
   6. A value which is the utility of the state
   7. A reference to the child state with the highest utility

States & Valid Actions:

Each state can be represented as an array depicting each player's pieces and empty spaces remaining on the board.

Valid Actions:

1.) Place - To place a piece into an empty space in the current state to a new state
2.) Remove - To remove an opponent's piece
3.) Move (Conditional) - When all 18 pieces have been played, a player can move a piece to an adjacent empty space.
4.) FlyMove (Conditional) - When a player has only 3 pieces remaining on the board and all 18 pieces have been played, the player may move a piece to any empty space on the board.

Languages and Libraries: Python, Tensorflow, Numpy, Collections, PyGame

References:

1. https://www.researchgate.net/publication/323059294_Can_Deep_Networks_Learn_to_Play_by_the_Rules_A_Case_Study_on_Nine_Men's_Morris/link/5c8a0ba5a6fdcc381752 7c12/download
2. https://www.ancientgames.org/nine-mens-morris/