Artificial Intelligence Assignment 2 Report

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1 Problem Statement

In this assignment, We have to implement n-queens problem and tic-tac-toe 4x4 game. In n-queens problem, we have place n-queens on nxn size board in such a way that they are not attacking each other i.e. in non-attacking positions.

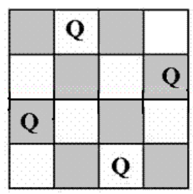

Figure 1: Solution of 4 queens problem

Tic-tac-toe is a two player game in which each player have its own symbol from 'X' and 'O'. If any player puts his/her symbol n-times on nxn board in straight line then he/she will the game otherwise game will draw.

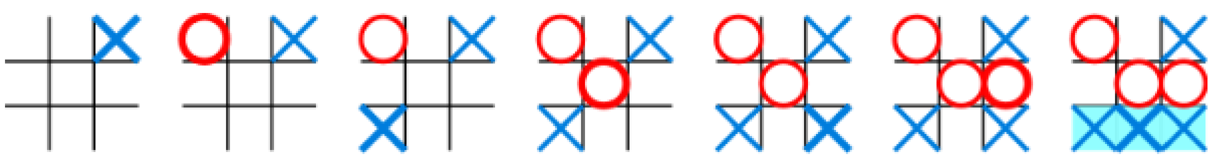

Figure 2: Example of tic-tac-toe Game

In above example, game is won by the player X.

2 Basic Concepts and Implemented Algorithms

In n-queens problem, I am using three different algorithms:

- Hill climbing
- Simulated Annealing
- Genetic Algorithm

and in tic-tac-toe game, I am using minimax algorithm with three different approach:

- Minimax algorithm
- Minimax algorithm with $\alpha - \beta$ pruning
- Minimax algorithm with heuristic

3 Results of each algorithm for N-queens problem

For results, I am taking 8x8 size board and running same algorithm for 5 times.

3.1 N-queens using Hill Climbing

In hill climbing algorithm, we are always choosing best available option from current state. If there is no best option from available options then hill climbing algorithm will stop searching.

- Iteration = 1
  Initial position = (4, 5, 2, 1, 6, 6, 0, 5) with value = -8
  Max. state = (3, 7, 2, 2, 6, 6, 0, 5) with value = -2
  GOAL IS NOT FOUND

- Iteration = 2
  Initial position = (4, 7, 2, 1, 7, 7, 7, 4) with value = -11
  Max. state = (5, 7, 2, 6, 3, 7, 0, 4) with value = -1
  GOAL IS NOT FOUND

- Iteration = 3
  Initial position = (1, 4, 1, 5, 2, 0, 0, 7) with value = -4
  Max. state = (4, 6, 1, 5, 2, 0, 3, 7) with value = 0
  GOAL IS FOUND

- Iteration = 4
  Initial position = (1, 4, 6, 3, 7, 7, 4, 1) with value = -5
  Max. state = (1, 4, 6, 3, 0, 7, 5, 2) with value = 0
  GOAL IS FOUND

- Iteration = 5
  Initial position = (7, 4, 7, 4, 3, 4, 2, 4) with value = -12
  Max. state = (6, 4, 7, 1, 3, 5, 2, 4) with value = -1
  GOAL IS NOT FOUND

3.2 N-queens using Simulated Annealing

In hill climbing, we are always choosing upward moves from available options so it can get stuck at local maximum but in simulated annealing, we are scheduling some temperature. Whenever temperature is high, we are allowing downward moves with some probability and we are allowing upward moves with probability 1.

Initial position = (4, 4, 1, 1, 7, 0, 1, 7) with value = -9

- Iteration = 1
  Temperature = 1048576
  Max state = (3, 6, 4, 1, 5, 0, 2, 7) with value = 0
  GOAL IS FOUND

- Iteration = 2
  Temperature = 500000
  Max state = (5, 2, 4, 6, 0, 3, 1, 7) with value = 0
  GOAL IS FOUND

- Iteration = 3
  Temperature = 100000
  Max state = (0, 2, 3, 5, 0, 4, 3, 5) with value = -5
  Goal IS NOT FOUND

- Iteration = 4
  Temperature = 300000
  Max state = (4, 1, 7, 0, 3, 6, 2, 5) with value = 0
  GOAL IS FOUND
- Iteration = 5
  Temperature = 200000
  Max state = (4, 1, 5, 0, 6, 3, 7, 2) with value = 0
  GOAL IS FOUND

3.3 N-queens using Genetic Algorithm

In genetic algorithm, There are three hyper-parameters viz. 1. Population size, 2. Crossover probability, 3. Mutation probability.

Iteration - 1

```
Enter population size: 100

Enter crossover probability: 0.8

Enter mutation probability: 0.5
GOAL IS FOUND
. Q . . . . . .
. . . . . . Q .
. . Q . . . . .
. . . . . Q . .
. . . . . . . Q
. . . . Q . . .
Q . . . . . . .
. . . Q . . . .
```

Iteration - 2

```
Enter population size: 100

Enter crossover probability: 0.8

Enter mutation probability: 0.02
GOAL IS FOUND
. Q . . . . . .
. . . . . Q . .
Q . . . . . . .
. . . . . . Q .
. . . Q . . . .
. . . . . . . Q
. . Q . . . . .
. . . . Q . . .
```

Iteration - 3

```
Enter population size: 20

Enter crossover probability: 0.8

Enter mutation probability: 0.2
GOAL IS NOT FOUND
. . . . . . Q .
Q . . . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . . . Q
. . . . . Q . .
. . . Q . . . .
```

Iteration - 4

```
Enter population size: 20

Enter crossover probability: 0.8

Enter mutation probability: 0.01
GOAL IS NOT FOUND
. . Q . . . . .
. . . . . Q . .
. . . . . . . Q
Q . . . . . . .
Q . . . . . . .
. . . Q . . . .
. Q . . . . . .
. . . . . . Q .
```

Iteration - 5

```
Enter population size: 50

Enter crossover probability: 0.3

Enter mutation probability: 0.7
GOAL IS FOUND
. . Q . . . . .
. . . . Q . . .
. . . . . . . Q
. . . Q . . . .
Q . . . . . . .
. . . . . . Q .
. Q . . . . . .
. . . . . Q . .
```

Iteration - 6

```
Enter population size: 20

Enter crossover probability: 0.5

Enter mutation probability: 0.5
GOAL IS FOUND
. . Q . . . . .
. . . . . . Q .
. Q . . . . . .
. . . . . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . . . .
. . . . Q . . .
```

Figure 3: Results of Genetic Algorithm for 6 iterations

4 Comparison between Hill climbing, Simulated annealing and Genetic Algorithm

Sometimes, Hill climbing can stuck in local maximum. So hill climbing will not always find the optimal solution (Global solution).In simulated annealing, if temperature is low then it can stuck in local maximum but if temperature is high then there is more chances that it can achieve optimal solution. In genetic algorithm, if population size is low then it's not always find optimal solution. If population is enough and other parameters are low then it may be find optimal solution.

5 Results of Tic-Tac-Toe Game

5.1 Heuristic

My heuristic is numbers of winning chances. In 4x4 tic-tac-toe game, There are total 10 winning chances for each player i.e. 4 rows, 4 columns and 2 diagonals.

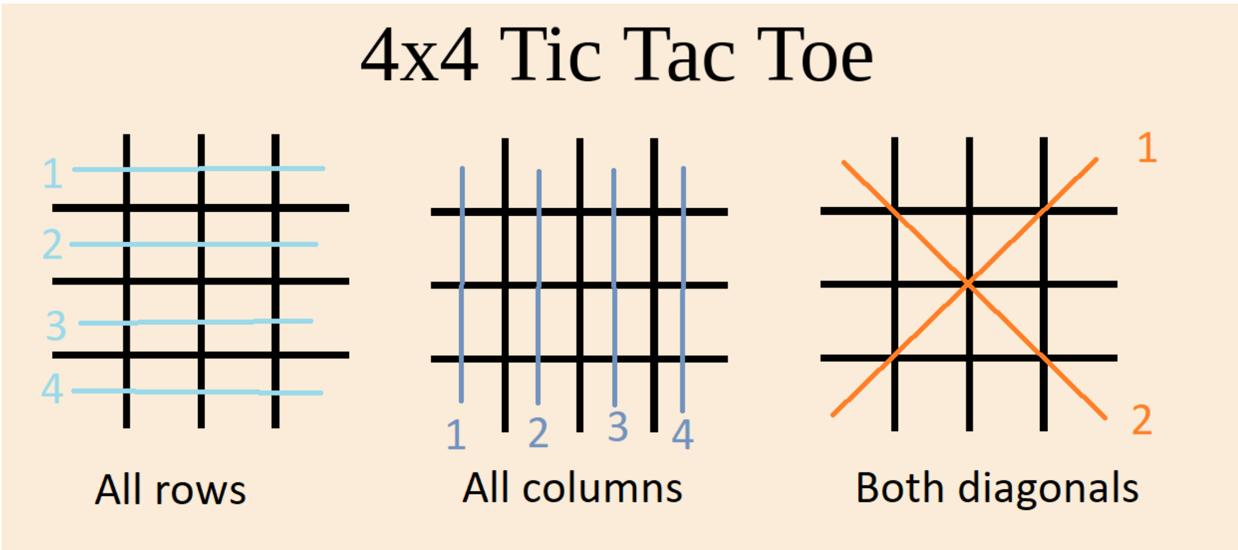

Figure 4: All possible chance of winning for any player

5.2 Questions and answers

- How about pitching your game agent against that of your friends in the class?
  My game agent is optimal even when search of depth is 3.
- How about pitching between two game agent?
  Most of games are draw.
- Can your game agent beat a human player?
  Yes, my game agent can beat human player.
- Pitch your game agent for a tournament of 5 games against a human player?
  Most of time, game will draw or game agent will win. In the report folder, I am including recorded game between my friend and game agent.