Knight-and-Queens Problem Using Local Search

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***Abstract*—The document depicts the implementation of various local search algorithms to achieve the desired outcome. Our current goal is to place queens and knights on a board with zero conflicts. Initially we tackle the problem using Hill Climbing (HC) approach followed by Simulated Annealing (SA) approach to determine the solution.**

***Index Terms*—Local Search, Hill Climbing, Simulated Annealing, N-Queens**

I. Introduction

Implementation of local search algorithms for Knights-and-Queens problem.

II. Problem Scenario

Given an N × M board, 'Q' queens, and 'K' knights, the objective is to place all the queens and the knights on the board so as to reduce the overall number of conflicts. We count as a conflict only the following:

- A Knight (K_i) attacks another Knight (K_j)
- A Knight (K_i) attacks a Queen (Q_i)
- A Queen (Q_i) attacks another Queen (Q_j)

III. Hill Climbing

The initial board is setup by placing 'Q' queens, and 'K' knights randomly on an N × M board. The initial board is evaluated (cost) to check if the desired goal is achieved. If the goal is not achieved, we compare all the neighbours of a given state and select the best neighbour.In our case, a piece is selected (a queen or knight) is selected at random and we compare it will all the neighbours of a given state. We select the best neighbour (next state) based on the cost (no of conflicts). The process is repeated for the next state (new state) till the goal is achieved i.e cost = 0.

A. Different regions in the State Space Diagram:

- Local maximum : It is a state which is better than its neighboring state however there exists a state which is better than it(global maximum).
- Global maximum : It is the best possible state in the state space diagram.(i.e preferably goal state)
- Flat local maximum : It is a flat region of state space where neighboring states have the same value.
- Shoulder : It is a plateau that has an uphill edge.

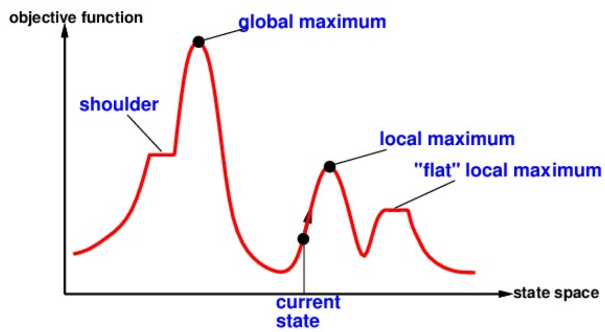

Fig. 1. State Space Diagram : Hill Climbing.

B. Drawbacks of Hill climbing:

- Hill climbing is neither complete nor provides optimal solution, No special data structure is implemented as previous nodes are discarded.
- The solution may get hung up at local maximum.

To tackle this situation, we have implemented random restart hill climbing, a variant of simple hill climbing to restart the algorithm at a new initial state.In our scenario, implementing the placement of both queens and knights has resulted in an swift solution since a queen can hide behind a knight to avoid conflicts

IV. Simulated Annealing

The initial board is setup by placing 'Q' queens, and 'K' knights randomly on an N × M board. The initial board is evaluated (cost) to check if the desired goal is achieved. If the goal is not achieved, a new state(neighbour) is picked at random. If the cost(conflicts) is better than the current state, we move on to the next state. If we do not obtain a better neighbour, we only select the next state using a probabilistic function. This randomness is useful to escape the drawback of optimization heuristics — getting trapped in local maxima. In our scenario, we pick a piece at random(either a queen or knight) and select a random neighbour to attain a new state by either comparison or probabilistic function. The process is repeated until the goal is attained (i.e cost =0)

$$\Delta = cost(next) - cost(current)$$

If P is the probability T is the temperature function then.

$$P = e^{-\Delta/T}$$

Rows	Columns	Queens	Knights	HC-RR (sec)
4	4	4	0	0.1
5	5	5	0	2.1
6	6	6	0	4.8
7	7	7	0	5.4
8	8	8	0	6.8
9	9	9	0	9.6
10	10	10	0	12.3
11	11	11	0	13.2
12	12	12	0	13.6
13	13	13	0	15.9
14	14	14	0	17.2
15	15	15	0	19.1

Fig. 2. Hill Climbing Statistics

Rows	Columns	Queens	Knights	SA(sec)
4	4	4	0	0.08
5	5	5	0	0.1
6	6	6	0	1.7
7	7	7	0	2.1
8	8	8	0	6.2
9	9	9	0	9.7
10	10	10	0	23.7
11	11	11	0	40.7
12	12	12	0	74.3
13	13	13	0	91.6
14	14	14	0	109.8
15	15	15	0	120

Fig. 3. SA Statistics

REFERENCES

[1] S. Russel, B. Noble, and P.Norvig, ‘Artificial Intelligence A Modern Approach - Fourth Edition’