ensia The National School of Artificial Intelligence المدرسة الوطنية العليا للذكاء الاصطناعي

Introduction to Artificial Intelligence

Lab 7 (Week 7) -Search Algorithms: Part 3 - Informed Search

2023 - 2024

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Objectives

- Implementation of the Best First Search, A* and Iterative Deepening A* (best first) algorithms for the Travel Planning problem.

Overview:

`LAB 7` is about using heuristics in the Travel Planning problem from `LAB 6`. you will exploit extra details like distances and coordinates, along with a given heuristic function, to create informed search algorithms.

Your mission

Your mission in this lab is to perform the following tasks leveraging the Graph Search Algorithm:

Task 1

In this task, you have the following heuristic function that computes the crow's flight distance (straight line) between two cities based on their coordinates.

```python
from math import radians, sin, cos, sqrt, atan2
# get the cowl flew distance from the current node to the goal node
def get_cowl_flew_distance(self, coordinates, goal_coordinates):
    # Get latitude and longitude coordinates for each city
    lat1, lon1 = coordinates
    lat2, lon2 = goal_coordinates
    # Convert latitude and longitude from degrees to radians
    lat1, lon1, lat2, lon2 = map(radians, [lat1, lon1, lat2, lon2])
    # Calculate the straight-line distance using Haversine formula
    dlat = lat2 - lat1
    dlon = lon2 - lon1
    a = sin(dlat / 2)**2 + cos(lat1) * cos(lat2) * sin(dlon / 2)**2
    c = 2 * atan2(sqrt(a), sqrt(1 - a))
    h = 6371 * c  # Radius of the Earth in kilometers
    return h
```

Your task is to:

- Integrate the provided heuristic function into the travel planning problem.
- Ensure that the heuristic is taken into account when determining the node's cost.

Task 2

For the second task, you are provided with definitions of the A* and Best First Search algorithms:

- **A***: This strategy distinguishes itself from uninformed strategies by selecting the node with the minimal cost for expansion at each iteration. It computes the cost by considering both actual (g) and estimated (h) costs.
- **Best First Search**: In contrast, this strategy only takes the estimated (heuristic) cost into account when deciding which node to expand next.

Considering the given definitions:

- Update the Graph Search General Algorithm from LAB 5 and the Travel Planning problem from LAB 6 to accommodate both A* and Best First Search strategies.
- Solve the Travel Planning problem using both strategies.
- Display the following metrics:
  - Cost of the solution node.
  - Number of steps (explored nodes) leading to the solution node.
  - Depth of the solution node.
- Evaluate the quality of the heuristic function.

Task 3

For the third task, you are given pseudo algorithms for Iterative Deepening A* Search in Algorithms 1 and 2.

Algorithm 1: Cost Limited Depth First Search algorithm

Input: $Problem, Cost\_limit$;
Output: $Solution|Cost\_limit$;
Call DFS algorithm with $Cost\_limit$;
Expand a node only if its cost is less than $Cost\_limit$, otherwise continue;
if *solution is reached* **then**
  return solution ;
else
  return the minimum cost among non expanded nodes;
end

Algorithm 2: Iterative Deepening A* Search algorithm

```
Input: Problem, Cost_limit ;
Output: Solution;
Initialize solution to None ;
Initialize Cost_limit;
while solution == None do
    response = Cost Limited Depth First Search(Problem, Cost_limit);
    if response is a node then
        solution = response;
    else
        Update Cost_limit with response ;
    end
end
```

In essence, it's an IDS with a cost limit parameter (g + h for A* and h for Best First). It executes Depth First Search at each iteration and increases the cost limit each time until reaching the goal node. At each iteration, the new cost limit is set to the minimum cost of the failed nodes of the previous iteration.

Your goal is to :

- Implement the corresponding functions (or methods) utilizing the Graph Search General Algorithm established in LAB 5.
- Solve the Travel Planning Using both Strategies.
- Display the following: the cost of the solution node, the number of steps (explored nodes) leading to the solution node, and the depth of the solution node.

Discussion

- Which strategy do you find better based on the given metrics, and why?