COMP7702 ASSIGNMENT1

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1. **What is the formal definition of the navigation agent in this assignment?**

Defining an agent formally can be divided into two steps. The first step is to determine 6 components of the navigation agent.

1. Action space (A). This navigation agent can move towards junctions through the road. Therefore, the action space is moving towards the first junction and moving towards the second junction of one road.
2. Percept space (P). For this case, it includes the start, the destination, the junctions which the agent has passed, the relations between junctions and road, and the distance from the start to the current location.
3. State space (S). All available locations of the environment map and the distance from the start to the specific location.
4. World dynamics (T: S X A -> S). The state of the agent updates after the action, which means the navigation agent goes from old location to a new location after the movement.
5. Percept function (Z: S -> O). When the state of the agent updates, the perception of the agent also updates according to the current state.
6. Utility function (U: S -> real number). The destination state is 1 and the other states are 0.

The second step is to determine what problem the navigation agent solves in this assignment. The purpose of this agent is to find the shortest way from the start to the destination. If the shortest path exists, the agent returns the shortest path and its length, otherwise, it returns “No path”.

2. **What type of agent is the navigation agent as described in question-1 (i.e., discrete / continuous, fully / partially observable, deterministic / non-**

deterministic, static / dynamic)? Please explain your selection.

The navigation agent is a discrete, fully, deterministic and static agent.

1. Discrete. In this case, the agent can move from one junction to another junction through the road. That means the state of the environment, the percepts and actions of the agent are all discrete. Therefore, the agent is discrete.
2. Fully. The environment is fully because the navigation agent always knows where it is. That means the agent knows the details about the current location, like the road name, the junctions of the road and lot numbers. Moreover, the agent knows where it comes from and which junctions and roads it has already passed. Thus, the environment of this agent is fully.
3. Deterministic. The environment of this agent is deterministic because the next state is determined by the current state and the action executed by the agent (Russell, Stuart J, 2016).
4. Static. On the one hand, when the navigation agent is deliberating, the environment (including the properties of roads and junctions) does not change. On the other hand, the environment itself does not change with the passage of time.

3. Please describe the method that your agent uses to find the solution.

The search method of this assignment is uniform-cost search. Uniform-cost search means it is optimal with each step-cost function. At the beginning of the search process, the program checks whether the start and the end are in the same road. If so, the shortest distance will be calculated directly, otherwise, two junctions of the start road will be put into the prior queue. A priority queue is an abstract data structure where data with the highest priority is retrieved first, ensuring that the node with the shortest distance from the start always pops first. Considering a node N1 pops from the queue, for each of its child node N2, the algorithm compares L2 (distance from the start to N2) and L1(the sum of distance from the start to N2 and the length of road R between N1 and N2). If L1 is greater than or equal to L2, it means N2 has been traversed in a previous shorter path, thus N2 should not be pushed into the queue again. If L1 is less than L2, N2 should be pushed into the queue and the value of L2 should be replaced by the value of L1.

The extension of the nodes is repeatedly executed until the end road is found, and then the current node and L (the distance from the start) will be stored. However, the search does not complete if the prior queue still contains other nodes. When traversing and extending all remained nodes, the distance from the start should be compared to the stored value of the node. If the distance between the start and this node N is greater than L, it is unnecessary to extend node N. Eventually, the shortest path is available after all nodes been traversed. The uniform-cost search algorithm does not care about the number of steps, it concentrates on the total cost. If using “b” as the branching factor, C* as the cost of the optimal solution and ε as the min cost of a step, space and time complexity of uniform-cost search are both $O(b^{1+floor(C^*/\varepsilon)})$.

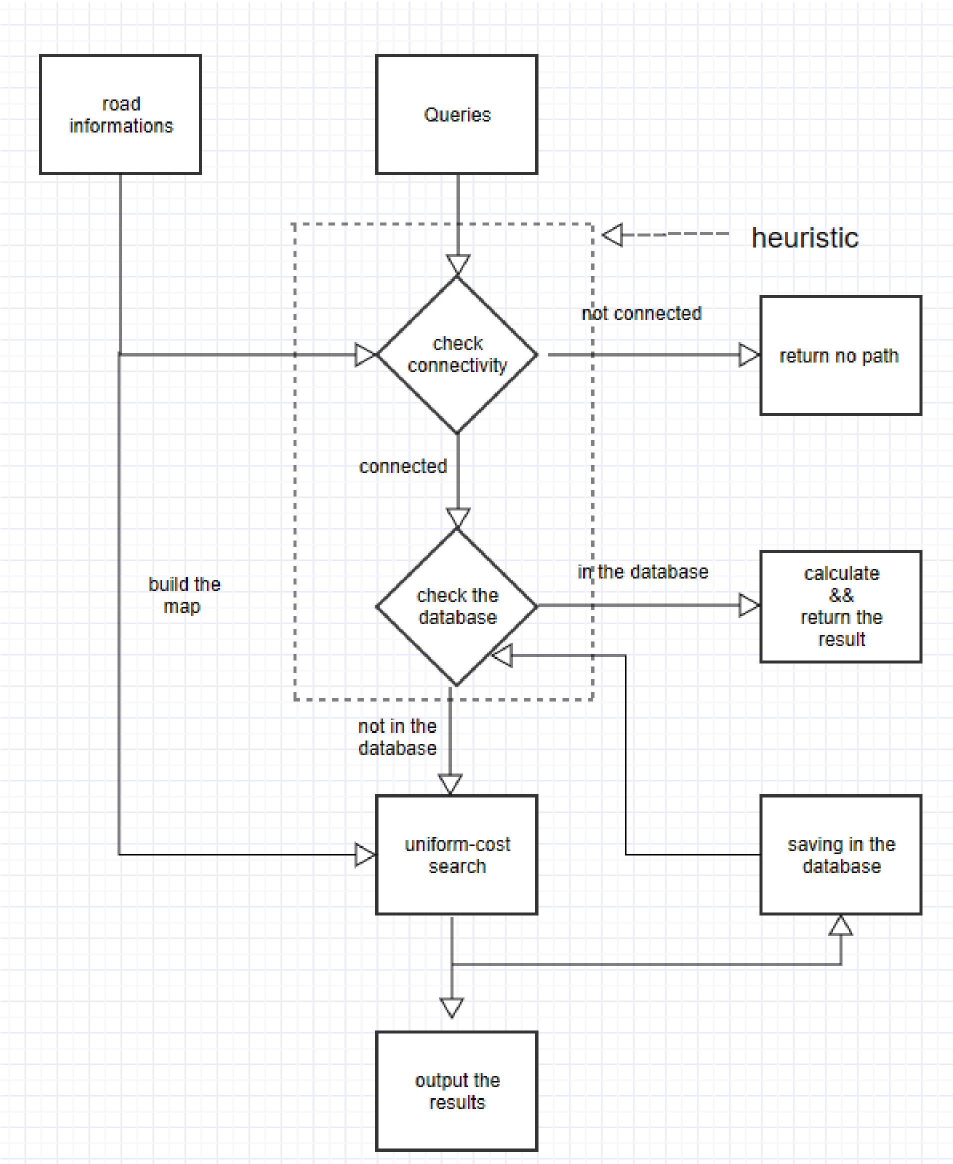
4. Does your method (described in 3) use heuristics? If it is, please explain your heuristic and a reason why you think this is a good heuristic. If you do not use any heuristic, please explain why you think it is not necessary.

The search method does not use any heuristics. Heuristics is often known as a tradeoff between time and accuracy. When the agent’s aim is to find “good” solutions rather than a perfect solution, heuristics may help to save searching time. However, the requirement of this assignment is to find the shortest path, which means heuristics is not necessary as it cannot assure the best solution. In addition, the complicated and irregular map environment of the agent makes it more difficult to implement a heuristics algorithm, as not enough data can be used to determine appropriate h(n).

Additionally, two approaches may also help to simplify the search process.

One is to check if the path exists before search. When constructing the map environment, using Weighted Quick-Union algorithm to connect all roads. After that, the agent can check the connectivity between two given roads. If they are not in the same connected graph, the agent will return “no path”. This approach can save time to deal with some unsolvable queries.

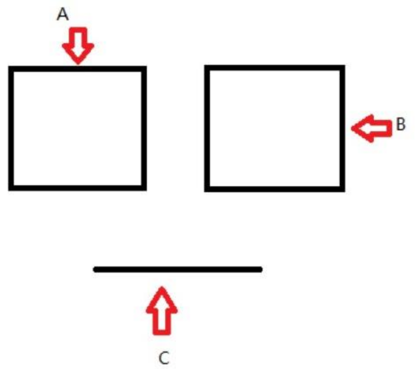
Another approach is to reuse the results of previous queries. If one query is successful, this path can be recorded. When performs a new query, if the start road and end road are both in one recorded path, the agent can directly get the solution of the query. For example, supposing one recorded path is RoadA-RoadB-RoadC-RoadD-RoadE-RoadF. Then if there is another query from RoadB to RoadE, the shortest path should be RoadB_RoadC_RoadD_RoadE and then the agent can directly get the solution rather than performing another search. This process saves time when the map contains considerable quantity of junctions and roads.



However, extra space and time is needed for these two approaches under most situations. Since the advantages of them highly depend on the map environment and queries, they are not implemented in this assignment.

5. **Suppose a query is unsolvable. Is your method able to identify the query is unsolvable? If it is, please explain the computational complexity for this identification. If it is not, please explain if your method can be modified to identify unsolvable queries.**

A path between two roads is not available if they are in separated graphs. For example, the path between any two of the roads among RoadA, RoadB, RoadC is unavailable. Thus, if the destination is not found after all descendant nodes of the start being traversed, the query can be regarded as unsolvable. Then, the computational complexity is the worst case of the uniform-cost search (as mentioned in question3), which is $O(b^{1+floor(C^*/\varepsilon)})$. (Russell, Stuart J, 2016).



In addition, if the query includes invalid road and lot number, the program will write "Invalid road name" or "Invalid lot number" into output file.

Reference

Russell, S., & Norvig, P. (2016). *Artificial intelligence: A modern approach* (3rd edition. Global ed.). Upper Saddle River: Pearson.

Appendix

Work partition:

Program:

Read/Write Files	Yaohui Dong
Search algorithm	Yu Miao

Report:

Question 1245	Yaohui Dong
Question 3 and revising	Yu Miao