Problem Set
Informed Search
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1. Write the algorithm/psuedocode/steps of A* search. You may use the following functions:
    - goalTest(n): returns true if n is goal node
    - g(n) returns pathcost to n from the initial node.
    - h(n) returns the heuristic cost to the goal node from n.
    - f(n) returns g(n)+f(n)

2. What is the importance of having a goalTest(n) function in search algorithms? Explain using two different problem scenarios. Here, n is an arbitrary node given as the input of function goalTest(n). [4pt]

3. For the given map of Romania and the list of straight distance between a city and Bucharest, using the A* algorithm you wrote in 1, find the shortest path from Arad to Bucharest. Show the full simulation.

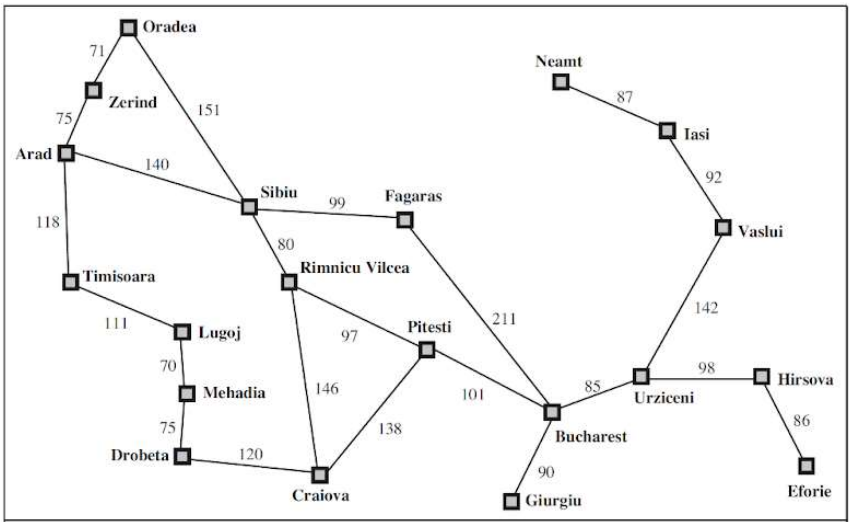

Figure 3.2 A simplified road map of part of Romania.

Arad	366	**Mehadia**	241
Bucharest	0	**Neamt**	234
Craiova	160	**Oradea**	380
Drobeta	242	**Pitesti**	100
Eforie	161	**Rimnicu Vilcea**	193
Fagaras	176	**Sibiu**	253
Giurgiu	77	**Timisoara**	329
Hirsova	151	**Urziceni**	80
Iasi	226	**Vaslui**	199
Lugoj	244	**Zerind**	374

Figure 3.22 Values of h_{SLD}—straight-line distances to Bucharest.

4. In A* algorithm, the solution is returned when *goalTest(n)* is true for node, *n* which is popped from the frontier. If *n* is not the goal, all of its child nodes are pushed to the frontier. Will we get an optimal solution if we do the goalTest on the child nodes before pushing them to the frontier and return the solution if the child is the goal? Verify your answer by simulation on the given map and heuristics.

5. For A* algorithm to produce optimal solutions the heuristic should be consistent for the graph-search version. A heuristic *h(n)* is consistent if, for every node *n* and every successor *ch* of *n* generated by any action *a*, the estimated cost of reaching the goal from *n* is no greater than the step cost of getting to *ch* plus the estimated cost of reaching the goal from *ch*: $h(n) \leq c(n, a, ch) + h(ch)$.
    - Show that the given heuristics in 3.22 are consistent.

6. When we have multiple types of heuristics for a problem, we choose the heuristic which is more dominant. Explain why?
7. Now consider Vaslui to be the goal. Will the heuristics from question 3 be useful? Justify your answer.
8. Write the consistency conditions for the graph in question 3, let Arad be the initial city and Vaslui the goal. Set admissible and consistent heuristics for all nodes.
9. For the heuristics you defined, simulate Greedy best first algorithm and A* search to reach Vaslui from Arad.
10. Explain why GBFS is incomplete and how it can be solved?
11. Explain why GBFS is suboptimal?
12. The edges and edge costs for a bidirectional graph is given below. Let. Start node be A and Goal Node be G. The heuristics are also given. Check admissibility and consistency of the following graph. Update values if necessary. Simulate A* and Greedy Best First Algorithm on the following graphs (use updated heuristics, if you have made changes).

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Graph Structure				**Heuristic**	
Vertex	Vertex	Edge Cost		Node	h(Node)
A	B	3		A	10
A	C	6		B	8
A	D	7		C	7
B	E	5		D	9
C	E	4		E	5
4	F	3		F	3
E	F	2		G	0
E	G	6			
F	G	4			
C	F	8			

13. Consider a 5x5 grid where the top-left corner is the start node (0,0) and the bottom-right corner (4,4) is the goal node. Obstacles are placed at nodes (1,2), (2,2), and (3,2). Assuming equal cost for all valid moves (up, down, left, right), run the A* algorithm and find the path from the start to the goal. Use Manhattan distance as the heuristic function.
14. If diagonal moves were allowed in 13, would you make any changes in the Manhattan distance? Justify your answer.