Problem 4.1 Heuristic Searches

Answer:

According to the problem description,

$c(m,n) = cost\ of\ going\ from\ m\ to\ n$

$g(n) = cheapest\ path\ cost\ to\ n$

$h(n) = heuristic\ function\ which\ states\ the\ straight\ line\ distance\ between\ n\ to\ Bucharest$

1. In Greedy and A* search, both expand the node n that minimizes an evaluation function $f(n)$. Their evaluation function is as follows,

   A. Greedy search, $f(n) = h(n)$

   B. A* search, $f(n) = g(n) + h(n)$

2. $h^*(n)$ is the optimal cost of the shortest path from n to goal state (*Bucharest*). Since $c(m,n)$ is always bigger than the straight-line distance from m to n, $h(n) \leq h^*(n)$. Therefore $h(n)$ is admissible.

3. For each search, the order in which nodes are expanded are as follows,

Greedy Search:

I. Expanded Nodes: *empty*

   Fringe: $Lugoj\ (244)$

II. Expanded Nodes: $Lugoj(244)$

   Fringe: $Timisoara\ (329), Mehadia\ (241)$

III. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (241)$

   Fringe: $Timisoara\ (329), Drobeta\ (242)$

IV. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (241) \rightarrow Drobeta\ (242)$

   Fringe: $Timisoara\ (329), Craiova\ (160)$

V. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (241) \rightarrow Drobeta\ (242) \rightarrow Craiova\ (160)$

   Fringe: $Timisoara\ (329), Rimnicu\ Vilcea\ (193), Pitesti\ (100)$

VI. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (241) \rightarrow Drobeta\ (242) \rightarrow Craiova\ (160) \rightarrow Pitesti\ (100)$

   Fringe: $Timisoara\ (329), Rimnicu\ Vilcea\ (193), Bucharest\ (0)$

VII. Expanded Nodes: $\boldsymbol{Lugoj(244) \rightarrow Mehadia\ (241) \rightarrow Drobeta\ (242) \rightarrow Craiova\ (160) \rightarrow Pitesti\ (100) \rightarrow Bucharest\ (0)}$

A* Search:

I. Expanded Nodes: *empty*

   Fringe: $Lugoj\ (0 + 244 = 244)$

II. Expanded Nodes: $Lugoj(244)$

   Fringe: $Timisoara\ (111 + 329 = 440), Mehadia\ (70 + 241 = 311)$

III. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (311)$

Fringe: $Timisoara\ (440), Drobeta\ ((70+75)+242=387)$

IV. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (311) \rightarrow Drobeta\ (387)$

Fringe: $Timisoara\ (440), Craiova\ ((70+75+120)+160=425)$

V. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (311) \rightarrow Drobeta\ (387) \rightarrow Craiova\ (425)$

Fringe: $Timisoara\ (440), Rimnicu\ Vilcea\ \big((70+75+120+146)+193=604\big), Pitesti\ ((70+75+120+138)+100=503)$

VI. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (311) \rightarrow Drobeta\ (387) \rightarrow Craiova\ (425) \rightarrow Timisoara\ (440)$

Fringe: $Rimnicu\ Vilcea\ (604), Pitesti\ (503), Arad\ \big((111+118)+366=595\big)$

VII. Expanded Nodes: $Lugoj(244) \rightarrow Mehadia\ (311) \rightarrow Drobeta\ (387) \rightarrow Craiova\ (425) \rightarrow Timisoara\ (440) \rightarrow Pitesti\ (503)$

Fringe: $Rimnicu\ Vilcea\ (604), Arad\ (595), Bucharest\ ((70+75+120+138+101)+0=504)$

VIII. Expanded Nodes: $\boldsymbol{Lugoj(244) \rightarrow Mehadia\ (311) \rightarrow Drobeta\ (387) \rightarrow Craiova\ (425) \rightarrow Timisoara\ (440) \rightarrow Pitesti\ (503) \rightarrow Bucharest\ (504)}$

Problem 4.2 Heuristics

Answer:

1. **Similarity:** Greedy search and A* search both use an evaluation function $f(n)$ for expanding the node n that minimizes the evaluation function $f(n)$.

   Difference: Though Greedy search and A* search both expand the node n that minimizes the evaluation function $f(n)$, but their evaluation function is different from each other which are as follows, Greedy search, $f(n)=h(n)$, and A* search, $f(n)=g(n)+h(n)$. Here, $h(n)$ is the heuristic function and $g(n)$ is the cheapest path cost.

2. $h(n)$ is admissible, if $h(n) \leq h^*(n)$, where $h^*(n)$ is the optimal cost of the shortest path from n to goal state. For a constant function $h(n)=0$, the evaluation function of A* search, $f(n)=g(n)+h(n)=g(n)+0=g(n)$. So, the constant function $h(n)=0$ is always less than the cost of the shortest path for A* search, thus it is admissible. But it is a useless heuristic function since it doesn't help to decide which nodes should be expanded next.