CIS 421 Artificial Intelligence

Fall 2016 **Dr. Laura Grabowski**

Program 3: A* Search – Traveling in Middle-earth

DUE DATE: Wednesday, October 19, 2016, 11:00 PM (through submit on CS lab server)

SCENARIO: You are a dwarf merchant preparing to make your annual trip from your home in the Blue Mountains to the Iron Hills to sell your wares. You will travel with a small group of 3-4 other dwarves and a dozen or so ponies to ride and carry goods and supplies. This journey is long and possibly quite dangerous. You need to plan a route that will be both fast and as safe as possible.

PROBLEM: Use the A* algorithm to find the lowest cost path from the Blue Mountains to the Iron Hills. **You will do your program in two steps. BE SURE THAT YOU TURN IN A PROGRAM THAT HANDLES BOTH STEPS**.

Step 1: Use a simple heuristic that uses ONLY the distances:

g = (distance from the parent node to the current node) + (distance from start to parent node) (Table 2 "Distance" column)

h = estimated distance from current node to the goal node (Table 1)

This heuristic is just like the one used in the "traveling in Romania" example that we did in class.

Step 2: Modify your program by designing your own heuristic that uses the ALL of the following information:

1. Estimated distance from each location on the map to the goal location (the Iron Hills), shown in Table 1. This value will still be at least part of the *h* value in your heuristic.
2. Information about point-to-point travel. This information will be used to find the *g* value in your heuristic.
   a. Distances between the two points (in miles).
   b. The quality of the road between the two points (0 is complete wilderness, 100 is a Middle-earth interstate).
   c. The risk level of traveling between each pair of locations, shown in Table 2. The risk level goes from 0 (no risk) to 100 (certain death, dun-dun-dun).
3. Connections between locations, shown in Figure 1.

You must use all of the information provided in order to get your final estimated cost to the goal (the *f* value), but the exact heuristic calculation is up to you. **You will design and test 2 different heuristics that use all of the information given above. The designs of the heuristics are up to you, but you must modify how you use at least one of the pieces of information given.**

Program Output: Program output for both steps will be a list of the locations in the path that your implementation selects.

Bonus Step (5 points): Modify your program so that the search can start from any location on the map. The goal will remain the same (Iron Hills).

Please be sure to submit your input data file(s) with your code for testing.

Discussion: After you have run Steps 1 and 2, you will briefly analyze how the various versions of the heuristic worked.

In a separate word-processed file, provide the following:
1. Clear descriptions for each of the 3 heuristics used (Step 1 heuristic, 2 versions of Step 2 heuristic).
2. The solutions found using each of the 3 heuristics you tested and show the associated heuristic costs and (3) a brief (1 paragraph) explanation of why the different heuristics performed differently (or not, depending on what you find). Note that, depending on your heuristics, the heuristic costs for your different version may be wildly different.

WHAT YOU WILL TURN IN:
1. Source code (remember that it MUST compile on the CS lab server/machines).
2. Your input files.
3. Your word-processed discussion (.pdf, .doc, .docx formats acceptable).

GRADING CRITERIA:
Step 1: 45 points
- Result produced: 30 points
  - Poor/incorrect result -10
  - No result or Step 1 not included – 30
  - No output of result -20
- Heuristic: 15 points
  - Incorrect heuristic used -15
  - Calculation errors -10

Step 2: 30 points
- Heuristic: 20 points
  - Did not use all information for heuristic -15
  - Did not explain heuristics in comments -10
  - Did not use 2 different versions of Step 2 heuristic -10
- Result produced: 10 points
  - Unreasonable result -5
  - No output of result -15

Discussion: 10 points
- Discussion not submitted -10
- Did not explain/describe all 3 heuristics used in the program -5
- Results for all 3 heuristics not included -5
- No discussion of differences/similarities in results -5

Code structure, format, and style: 15 points
- Poor use of data structures -7
- Poor code structure/design -7
- Inadequate commenting -7
- Poor code formatting -7

Extra credit: 5 points

Table 1. Estimated distance in miles to the goal location (Iron Hills).

Location	Distance to Iron Hills	Location	Distance to Iron Hills
Blue Mountains	1250	Caradhras	550
Grey Havens	1200	North Pass	500
White Towers	1150	Carrock	450
Michel Delving	1075	Gladden Fields	500
Lake Evendim	1025	Lothlorien	660
Fornost	925	Isengard	890
Hobbiton	1050	Moria	620
Brandy Hall	1000	Dol Guldur	500
Bree	900	Wood Elves	275
Sarn Ford	975	Esgaroth	175
Weathertop	825	Erebor	200
Rivendell	580	Dale	180

Table 2. Point-to-point Information. NOTE: All connections are bidirectional, but point-to-point information is listed only once for the sake of brevity.

From	To	Distance (miles)	Road Quality	Risk Level
Blue Mountains	Lake Evendim	250	0	41
	Michel Delving	270	65	15
	White Towers	225	75	21
	Grey Havens	240	75	21
Lake Evendim	Fornost	85	11	64
	Michel Delving	110	2	55
Grey Havens	White Towers	100	95	8
	Sarn Ford	270	30	12
White Towers	Michel Delving	40	54	7
	Hobbiton	70	62	6
Michel Delving	Hobbiton	35	87	1
	Brandy Hall	80	79	6
Hobbiton	Brandy Hall	50	73	7
	Bree	100	65	9
	Sarn Ford	130	47	27
Brandy Hall	Bree	50	68	6
Bree	Fornost	115	41	38
	Weathertop	100	36	67
	Sarn Ford	105	40	35
Fornost	Weathertop	160	23	65
	Rivendell	375	14	58
Sarn Ford	Weathertop	180	13	61
	Rivendell	400	15	55
	Isengard	500	0	72

From	To	Distance	Road Quality	Risk Level
Weathertop	Rivendell	230	50	4.5
Rivendell	North Pass	100	2	6.5
	Caradhras	60	25	6.5
	Moria	180	15	9
	Isengard	500	12	8.5
North Pass	Carrock	80	0	7
Caradhras	Carrock	70	0	7
	Gladden Fields	150	12	6
	Lothorien	300	32	5.5
Moria	Gladden Fields	140	16	9.5
	Lothlorien	20	21	9.5
Gladden Fields	Esgaroth	400	0	6
	Dol Guldur	175	2	8
	Lothlorien	190	18	7
Lothlorien	Dol Guldur	180	0	8.5
	Isengard	240	28	8
Carrock	Wood Elves	175	12	8
	Erebor	250	18	8
	Esgaroth	240	24	8
	Dol Guldur	300	0	8.5
Dol Guldur	Isengard	390	0	8.5
Wood Elves	Dale	90	84	3
	Erebor	100	90	3
Esgaroth	Dale	40	95	1.5
	Erebor	50	98	1.5
	Iron Hills	175	82	3
Dale	Erebor	10	99	1
	Iron Hills	180	87	3
Erebor	Iron Hills	200	91	3

Figure 1. Map of Middle-earth.

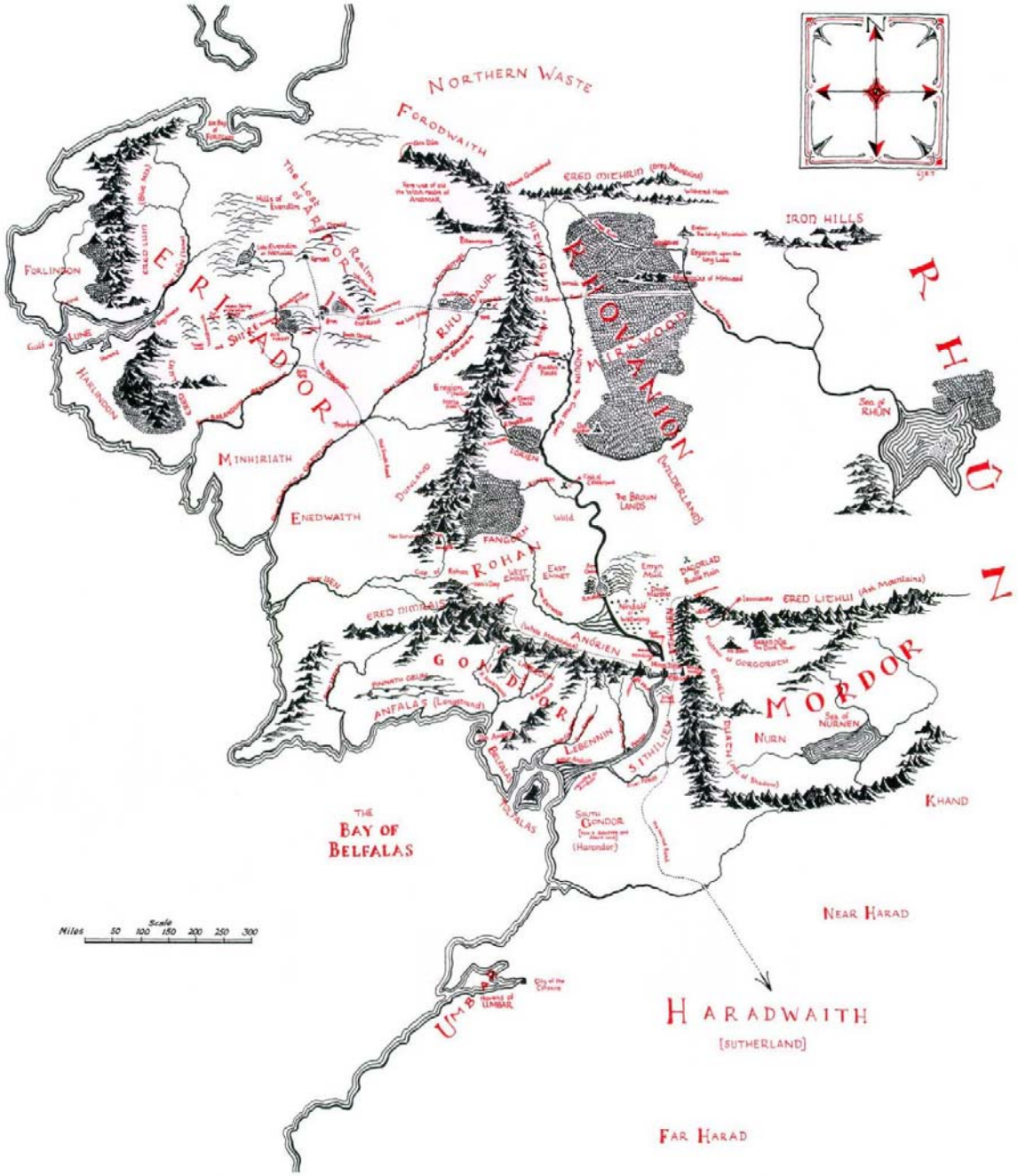

Figure 2. Connections between locations. NOTE: NOT DRAWN TO SCALE! SEE TABLES 1 AND 2 FOR INFORMATION. THIS GRAPH IS FOR CONNECTIVITY INFORMATION ONLY!