

Project 1 Part 1

Joshua Westbrook & Arifur Rahman

1 The maps

The map files are available at <https://github.com/Joshua-Westbrook/AIproject1maps>

They are also in the folder that opens after unzipping the .zip file attached and importing it into Eclipse as an existing project.

2 The algorithm

The algorithms can be found in the searches package. The UCS algorithm is fully implemented in SearchAlgo.java but uses UCS.java so it has a specific name. A* and Weighted A* overwrite the h(n) being zero in UCS with them using either the heuristic from DistanceHeuristic.java or the heuristic times the weight. Unfortunately the algorithms do not seem to be working fully properly. There is no error where Weighted A* sometimes returning a cheaper path than A*. We have not been able to figure out the cause yet.

3 Optimizations

No optimizations have been done beyond that of following the UCS/A*/Weighted A* rules.

4 Heuristics

The Heuristic we finally used was a modified Euclidean distance . We then multiply the Euclidean distance between the currNode and goal by .25 and the start node and the goal by 0.25 since in a best case scenario the entire path to the goal is an highway/river with no hard to travel in which case all movements is the distance divided by 4 which is the same thing as times 0.25 The formula for the heuristic is
$$\frac{0.25 * \sqrt{(currNode.x - end.x)^2 + (currNode.y - end.y)^2}}{0.25 * \sqrt{(start.x - end.x)^2 + (start.y - end.y)^2}}.$$

Other attempted heuristics included just the Euclidean distance which was not admissible. We also tried using numbers like 0.50 or 0.75 instead of 0.25 when modifying the Euclidean Distance but those failed. Our first attempt was to use just the Euclidean distance from the currNode to the goal which also failed to be admissible.

5 benchmarks

The Nodes found by each search is above the cost of the path it found.

5.1 Map 1

5.1.1 start and goal a

15663 nodes were looked at before goal was found

The cost of found UCS path is: 191.99991

15591 nodes were looked at before goal was found

The cost of found A* path is: 198.37859

15649 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 196.42148

5.1.2 start and goal b

15710 nodes were looked at before goal was found

The cost of found UCS path is: 195.51031

15714 nodes were looked at before goal was found

The cost of found A* path is: 196.68619

15712 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 195.91412

5.1.3 start and goal c

15618 nodes were looked at before goal was found

The cost of found UCS path is: 181.55751

15660 nodes were looked at before goal was found

The cost of found A* path is: 189.40065

15654 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 184.6151

5.1.4 start and goal d

15666 nodes were looked at before goal was found

The cost of found UCS path is: 198.35652

15580 nodes were looked at before goal was found

The cost of found A* path is: 196.72476

15625 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 197.61816

5.1.5 start and goal e

7926 nodes were looked at before goal was found

The cost of found UCS path is: 112.21073

2380 nodes were looked at before goal was found

The cost of found A* path is: 130.01709

341 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 137.83081

5.1.6 start and goal f

13740 nodes were looked at before goal was found

The cost of found UCS path is: 172.30873

9419 nodes were looked at before goal was found

The cost of found A* path is: 532.98535

9419 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 532.98535

5.1.7 start and goal g

15261 nodes were looked at before goal was found

The cost of found UCS path is: 185.96866

14823 nodes were looked at before goal was found

The cost of found A* path is: 186.87982

14607 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 179.0085

5.1.8 start and goal h

14772 nodes were looked at before goal was found

The cost of found UCS path is: 168.033

14371 nodes were looked at before goal was found

The cost of found A* path is: 168.45457

14369 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 168.43312

5.1.9 start and goal i

15719 nodes were looked at before goal was found

The cost of found UCS path is: 223.68861

15719 nodes were looked at before goal was found

The cost of found A* path is: 223.88162
15720 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 226.38469

5.1.10 start and goal j

14957 nodes were looked at before goal was found
The cost of found UCS path is: 160.32957
15151 nodes were looked at before goal was found
The cost of found A* path is: 169.53668
14863 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 164.70825

5.2 map2

5.2.1 start and goal a

15724 nodes were looked at before goal was found
The cost of found UCS path is: 210.2107
15689 nodes were looked at before goal was found
The cost of found A* path is: 212.22784
15676 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 210.8749

5.2.2 start and goal b

14239 nodes were looked at before goal was found
The cost of found UCS path is: 185.32346
14100 nodes were looked at before goal was found
The cost of found A* path is: 188.05139
13572 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 183.6666

5.2.3 start and goal c

7739 nodes were looked at before goal was found
The cost of found UCS path is: 105.460724
7748 nodes were looked at before goal was found
The cost of found A* path is: 116.12862
6441 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 105.510345

5.2.4 start and goal d

15744 nodes were looked at before goal was found

The cost of found UCS path is: 222.77809

15743 nodes were looked at before goal was found

The cost of found A* path is: 224.51706

15745 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 221.7309

5.2.5 start and goal e

7997 nodes were looked at before goal was found

The cost of found UCS path is: 123.696014

6257 nodes were looked at before goal was found

The cost of found A* path is: 117.19969

5352 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 121.617584

5.2.6 start and goal f

15743 nodes were looked at before goal was found

The cost of found UCS path is: 214.64574

15732 nodes were looked at before goal was found

The cost of found A* path is: 218.1347

15744 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 221.05258

5.2.7 start and goal g

12958 nodes were looked at before goal was found

The cost of found UCS path is: 151.1096

10496 nodes were looked at before goal was found

The cost of found A* path is: 140.55109

10988 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 152.62677

5.2.8 start and goal h

14772 nodes were looked at before goal was found

The cost of found UCS path is: 168.033

14371 nodes were looked at before goal was found

The cost of found A* path is: 168.45457

14369 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 168.43312

5.2.9 start and goal i

7881 nodes were looked at before goal was found

The cost of found UCS path is: 96.0073

15029 nodes were looked at before goal was found

The cost of found A* path is: 214.82095

15029 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 214.82095

5.2.10 start and goal j

7599 nodes were looked at before goal was found

The cost of found UCS path is: 102.753624

14788 nodes were looked at before goal was found

The cost of found A* path is: 252.00476

14788 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 252.00476

5.3 map3

5.3.1 start and goal a

9561 nodes were looked at before goal was found

The cost of found UCS path is: 141.63106

9140 nodes were looked at before goal was found

The cost of found A* path is: 144.08081

8102 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 138.93866

5.3.2 start and goal b

15271 nodes were looked at before goal was found

The cost of found UCS path is: 201.55016

15240 nodes were looked at before goal was found
The cost of found A* path is: 206.22784
15021 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 202.5857

5.3.3 start and goal c

9105 nodes were looked at before goal was found
The cost of found UCS path is: 132.86023
5425 nodes were looked at before goal was found
The cost of found A* path is: 133.17395
3791 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 133.76709

5.3.4 start and goal d

12768 nodes were looked at before goal was found
The cost of found UCS path is: 144.69601
3409 nodes were looked at before goal was found
The cost of found A* path is: 367.2229
3409 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 367.2229

5.3.5 start and goal e

7981 nodes were looked at before goal was found
The cost of found UCS path is: 130.26709
5276 nodes were looked at before goal was found
The cost of found A* path is: 106.38965
3408 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 108.63229

5.3.6 start and goal f

8198 nodes were looked at before goal was found
The cost of found UCS path is: 128.39577
8707 nodes were looked at before goal was found
The cost of found A* path is: 338.9581
8707 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 338.9581

5.3.7 start and goal g

8851 nodes were looked at before goal was found

The cost of found UCS path is: 135.86758

6890 nodes were looked at before goal was found

The cost of found A* path is: 140.59552

5007 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 140.00974

5.3.8 start and goal h

13417 nodes were looked at before goal was found

The cost of found UCS path is: 156.40189

13044 nodes were looked at before goal was found

The cost of found A* path is: 148.94478

12997 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 149.19478

5.3.9 start and goal i

9365 nodes were looked at before goal was found

The cost of found UCS path is: 143.51709

8406 nodes were looked at before goal was found

The cost of found A* path is: 142.85287

7503 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 139.53915

5.3.10 start and goal j

14330 nodes were looked at before goal was found

The cost of found UCS path is: 175.17577

13419 nodes were looked at before goal was found

The cost of found A* path is: 165.7156

13114 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 161.84428

5.4 map4

5.4.1 start and goal a

11864 nodes were looked at before goal was found

The cost of found UCS path is: 149.31673

12066 nodes were looked at before goal was found
The cost of found A* path is: 153.29466
12046 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 151.34859

5.4.2 start and goal b

15743 nodes were looked at before goal was found
The cost of found UCS path is: 222.34915
15740 nodes were looked at before goal was found
The cost of found A* path is: 220.50664
15738 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 218.69228

5.4.3 start and goal c

15743 nodes were looked at before goal was found
The cost of found UCS path is: 218.6347
15743 nodes were looked at before goal was found
The cost of found A* path is: 215.32098
15743 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 219.14941

5.4.4 start and goal d

The cost of found UCS path is: 142.43436
9864 nodes were looked at before goal was found
The cost of found A* path is: 137.52444
10460 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 140.25974

5.4.5 start and goal e

7135 nodes were looked at before goal was found
The cost of found UCS path is: 120.710724
11608 nodes were looked at before goal was found
The cost of found A* path is: 1202.1127
11608 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 1202.1127

5.4.6 start and goal f

15721 nodes were looked at before goal was found

The cost of found UCS path is: 198.14941

15698 nodes were looked at before goal was found

The cost of found A* path is: 195.82834

15685 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 197.14941

5.4.7 start and goal g

15483 nodes were looked at before goal was found

The cost of found UCS path is: 195.94595

15570 nodes were looked at before goal was found

The cost of found A* path is: 199.92145

15524 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 197.27805

5.4.8 start and goal h

The cost of found UCS path is: 168.50912

13614 nodes were looked at before goal was found

The cost of found A* path is: 176.51953

13785 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 176.36942

5.4.9 start and goal i

15632 nodes were looked at before goal was found

The cost of found UCS path is: 215.04892

15693 nodes were looked at before goal was found

The cost of found A* path is: 217.85652

15725 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 219.80257

5.4.10 start and goal j

15743 nodes were looked at before goal was found

The cost of found UCS path is: 201.14941

15737 nodes were looked at before goal was found

The cost of found A* path is: 201.8357

15731 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 200.17148

5.5 map5

5.5.1 start and goal a

15184 nodes were looked at before goal was found
The cost of found UCS path is: 190.5575
15079 nodes were looked at before goal was found
The cost of found A* path is: 186.91411
15226 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 191.58566

5.5.2 start and goal b

15465 nodes were looked at before goal was found
The cost of found UCS path is: 204.75726
15348 nodes were looked at before goal was found
The cost of found A* path is: 190.59673
15409 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 204.02502

5.5.3 start and goal c

14102 nodes were looked at before goal was found
The cost of found UCS path is: 158.40556
14652 nodes were looked at before goal was found
The cost of found A* path is: 166.64085
14077 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 172.20825

5.5.4 start and goal d

9351 nodes were looked at before goal was found
The cost of found UCS path is: 126.2671
6990 nodes were looked at before goal was found
The cost of found A* path is: 123.277504
6103 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 129.10287

5.5.5 start and goal e

13973 nodes were looked at before goal was found

The cost of found UCS path is: 179.25113

13453 nodes were looked at before goal was found

The cost of found A* path is: 171.27258

13974 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 179.70825

5.5.6 start and goal f

15419 nodes were looked at before goal was found

The cost of found UCS path is: 206.52808

15551 nodes were looked at before goal was found

The cost of found A* path is: 209.2499

15521 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 209.85405

5.5.7 start and goal g

15612 nodes were looked at before goal was found

The cost of found UCS path is: 203.48518

15636 nodes were looked at before goal was found

The cost of found A* path is: 204.3565

15699 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 209.77072

5.5.8 start and goal h

8398 nodes were looked at before goal was found

The cost of found UCS path is: 114.77812

3393 nodes were looked at before goal was found

The cost of found A* path is: 596.2852

3393 nodes were looked at before goal was found

The cost of found Weighted A* path with weight of 2.0 is: 596.2852

5.5.9 start and goal i

15662 nodes were looked at before goal was found

The cost of found UCS path is: 191.00357

15617 nodes were looked at before goal was found

The cost of found A* path is: 188.97906
15702 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 196.19356

5.5.10 start and goal j

7831 nodes were looked at before goal was found
The cost of found UCS path is: 105.46073
1937 nodes were looked at before goal was found
The cost of found A* path is: 111.71073
271 nodes were looked at before goal was found
The cost of found Weighted A* path with weight of 2.0 is: 111.29651

6 Final Explanation

Unfortunately as can be seen in some of the benchmarks such as Map1b our heuristic is still not optimal and will sometimes result in A* looking at more nodes than Uniform Cost Search which should not happen. We were unable to find one that was more effective.

Map 2e also shows an issue since it has A* finding a better path than UCS. Again we were unable to figure out what was causing that issue or how we could fix it.

another problem that can be seen on maps like 2j when the start and the goal are close to each other in either the rows or the columns is that A* and Weighted A* end up taking a very windy path while UCS goes straight ahead.

2j also has a problem where even UCS decides to leave the nice path up the highway for no reason we could find.

Whether these issues are caused by the heuristic not being correct even if it seems to be admissible or if they are caused by something wrong with our search Algorithm is not something we have been able to figure out.