Problem 1

States:

Eat:

Problem 2

1. in step 1, a path from A to B using an admissible heuristic function
2. in step 2, a path from A to B using a non-admissible heuristic function
3. in step 3, a path from A to B using an admissible heuristic function
4. in step 4, a path from A to B using a non- admissible heuristic function

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | . | **C** | . | X | X | X | X | X | X |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | . | . | . | . | . | . | . | . | . |
| X | . | . | . | . | . | . | . | . | . | . | . | . | . | X | X | . | X | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| X | X | X | . | X | . | . | . | X | . | . | . | X | X | . | . | . | . | X | . | X | X | X | . | X | . | . | . | . | X | X | X |
| X | . | . | . | . | . | . | . | . | . | . | . | X | . | X | X | X | . | X | X | . | X | X | . | X | . | . | . | . | . | . | . |
| X | . | X | . | . | . | X | X | X | . | X | X | X | . | . | . | X | X | . | . | X | X | . | . | . | . | . | . | X | X | . | . |
| . | . | X | X | . | . | . | . | . | X | X | X | X | . | . | . | . | . | X | X | . | . | X | X | X | . | . | X | . | . | . | X |
| X | X | X | X | . | . | . | . | . | . | . | . | . | . | X | X | X | . | . | . | . | . | . | . | . | . | . | . | . | . | X | X |
| . | . | . | . | . | . | . | . | . | X | X | X | . | . | X | . | . | . | . | . | . | X | . | . | . | X | . | . | X | X | . | X |
| . | X | X | X | . | . | . | . | . | . | . | . | . | . | X | X | . | . | . | . | . | . | . | X | . | . | X | . | . | . | . | . |
| . | X | . | X | X | X | X | X | . | . | . | . | . | . | . | . | X | . | . | . | . | X | X | . | . | . | X | X | . | . | . | . |
| . | . | . | . | . | . | . | X | X | X | . | . | . | . | . | . | . | . | X | X | X | X | X | X | . | . | . | . | . | X | . | . |
| X | X | X | X | X | . | X | X | X |  | X | X | X | X | . | . | . | X | X | X | X | X | X | X | . | . | . | X | X | . | . | . |
| X | X | X | X | X | . | . | . | . | X | X | X | X | . | . | . | . | X | X | X | X | X | X | X | . | . | . | X | X | X | X | X |
| X | X | X | X | X | X | . | . | . | . | . | X | . | . | . | . | . | X | X | X | X | X | X | X | . | . | . | . | X | X | . | . |
| X | X | X | X | X | X | . | X | . | . | . | . | . | . | . | X | X | X | X | X | X | X | X | X | . | . | . | . | . | . | . | . |
| . | **A** | . | . | X | . | X | X | X | X | . | . | . | . | X | X | X | X | X | X | X | X | . | . | X | X | . | . | X | X | X | **B** |
| X | X | X | X | . | . | . | . | . | . | . | . | . | . | . | . | X | X | X | X | . | . | . | X | X | X | . | . | X | X | X | . |

This figure indicates the matrix that a robot can pass. “X” indicates obstacle that robot cannot pass, on the other hand “.” Indicates the cell is clear to pass.

Let 10 be the moving cost of moving horizontally and vertically, 14 be the moving cost of movie diagonally.

Step 1. Admissible heuristic function

Heuristic(A) = 30

dx = abs(A.x - B.x) = 30

dy = abs(A.y - B.y) = 0

h(A)= sqrt((dx\*dx + dy\*dy)/2) = 21

original grid map

XXXXXXXXXXXXXXXXXXXXXXX.C.XXXXXX

XXXXXXXXXXXXXXXXXXXXXXX.........

X.............XX.X..............

XXX.X...X...XX....X.XXX.X....XXX

X...........X.XXX.XX.XX.X.......

X.X...XXX.XXX...XX..XX......XX..

..XX.....XXXX.....XX..XXX..X...X

XXXX..........XXX.............XX

.........XXX..X......X...X..XX.X

.XXX..........XX.......X..X.....

.X.XXXXX........X....XX...XX....

.......XXX........XXXXXX.....X..

XXXXX.XXXXXXX...XXXXXXX...XX....

XXXXX....XXXX....XXXXXXX...XXXXX

XXXXXX.....X.....XXXXXXX....XX..

XXXXXX.X.......XXXXXXXXX........

.A..X.XXXX....XXXXXXXX..XX..XXXB

XXXX............XXXX...XXX..XXX.

grid occupancy map with A as start and B as goal with “@” as the path:

XXXXXXXXXXXXXXXXXXXXXXX.C.XXXXXX

XXXXXXXXXXXXXXXXXXXXXXX.........

X.............XX.X..............

XXX.X...X...XX....X.XXX.X....XXX

X...........X.XXX.XX.XX.X.......

X.X...XXX.XXX...XX..XX......XX..

..XX.....XXXX.....XX..XXX..X...X

XXXX..........XXX.............XX

.........XXX..X......X...X..XX.X

.XXX..........XX.....@@X..X.....

.X.XXXXX........X.@@@XX@..XX....

.......XXX......@@XXXXXX@....X..

XXXXX.XXXXXXX..@XXXXXXX..@XX....

XXXXX....XXXX.@..XXXXXXX..@XXXXX

XXXXXX.....X.@...XXXXXXX...@XX..

XXXXXX.X....@..XXXXXXXXX....@@@.

.A@@X.XXXX@@..XXXXXXXX..XX..XXXB

XXXX@@@@@@......XXXX...XXX..XXX.

[16, 1]->[16, 2]->[16, 3]->[17, 4]->[17, 5]->[17, 6]->[17, 7]->[17, 8]->[17, 9]->[16, 10]->[16, 11]->[15, 12]->[14, 13]->[13, 14]->[12, 15]->[11, 16]->[11, 17]->[10, 18]->[10, 19]->[10, 20]->[9, 21]->[9, 22]->[10, 23]->[11, 24]->[12, 25]->[13, 26]->[14, 27]->[15, 28]->[15, 29]->[15, 30]->[16, 31]

length of the path A-B: 30

The result of path from cell A to cell B

Step 2.non-admissible heuristic function

Heuristic(A) = 30

Dx = abs(A.x – B.x) = 30

Dy = abs(A.y – B.y) = 0

h(A)= (Dx + Dy) = 30

grid with path:

XXXXXXXXXXXXXXXXXXXXXXX.C.XXXXXX

XXXXXXXXXXXXXXXXXXXXXXX.........

X.............XX.X..............

XXX.X...X...XX....X.XXX.X....XXX

X...........X.XXX.XX.XX.X.......

X.X...XXX.XXX...XX..XX......XX..

..XX.....XXXX.....XX..XXX..X...X

XXXX..........XXX.............XX

.........XXX..X......X...X..XX.X

.XXX..........XX....@@@X..X.....

.X.XXXXX........X.@@@XX@@.XX....

.......XXX.....@@@XXXXXX@....X..

XXXXX.XXXXXXX.@@XXXXXXX.@.XX....

XXXXX....XXXX.@..XXXXXXX@..XXXXX

XXXXXX.....X..@..XXXXXXX@@@@XX..

XXXXXX.X.....@@XXXXXXXXX....@@@@

.A@@X.XXXX@@@@XXXXXXXX..XX..XXXB

XXXX@@@@@@@.....XXXX...XXX..XXX.

[16, 1]->[16, 2]->[16, 3]->[17, 4]->[17, 5]->[17, 6]->[17, 7]->[17, 8]->[17, 9]->[17, 10]->[16, 10]->[16, 11]->[16, 12]->[16, 13]->[15, 13]->[15, 14]->[14, 14]->[13, 14]->[12, 14]->[12, 15]->[11, 15]->[11, 16]->[11, 17]->[10, 18]->[10, 19]->[10, 20]->[9, 20]->[9, 21]->[9, 22]->[10, 23]->[10, 24]->[11, 24]->[12, 24]->[13, 24]->[14, 24]->[14, 25]->[14, 26]->[14, 27]->[15, 28]->[15, 29]->[15, 30]->[15, 31]->[16, 31]

length of the path A-B: 42

Step 3. Admissible heuristic function

Heuristic(A) = 20

dx = abs(A.x - C.x) = 23

dy = abs(A.y - C.y) = 16

h(A) = sqrt((dx\*dx + dy\*dy)/2) = 20

grid occupancy map with A as start and C as goal with “@” as the path:

XXXXXXXXXXXXXXXXXXXXXXX.C.XXXXXX

XXXXXXXXXXXXXXXXXXXXXXX.@.......

X.............XX.X......@.......

XXX.X...X...XX....X.XXX@X....XXX

X...........X.XXX.XX.XX@X.......

X.X...XXX.XXX...XX..XX@.....XX..

..XX.....XXXX.....XX.@XXX..X...X

XXXX..........XXX...@.........XX

.........XXX..X....@.X...X..XX.X

.XXX..........XX..@....X..X.....

.X.XXXXX........X@...XX...XX....

.......XXX.....@@.XXXXXX.....X..

XXXXX.XXXXXXX.@.XXXXXXX...XX....

XXXXX....XXXX@...XXXXXXX...XXXXX

XXXXXX.@@@@X@....XXXXXXX....XX..

XXXXXX@X...@...XXXXXXXXX........

.A@@X@XXXX....XXXXXXXX..XX..XXXB

XXXX@...........XXXX...XXX..XXX.

[16, 1]->[16, 2]->[16, 3]->[17, 4]->[16, 5]->[15, 6]->[14, 7]->[14, 8]->[14, 9]->[14, 10]->[15, 11]->[14, 12]->[13, 13]->[12, 14]->[11, 15]->[11, 16]->[10, 17]->[9, 18]->[8, 19]->[7, 20]->[6, 21]->[5, 22]->[4, 23]->[3, 23]->[2, 24]->[1, 24]->[0, 24]

length of the path A-C: 26

Step 4. Non- admissible heuristic function

Heuristic(C) = 39

Dx = abs(A.x – C.x) = 23

Dy = abs(A.y – C.y) = 16

h(A)= (Dx + Dy) = 39

Path:

XXXXXXXXXXXXXXXXXXXXXXX.C@XXXXXX

XXXXXXXXXXXXXXXXXXXXXXX..@......

X.............XX.X.......@......

XXX.X...X...XX....X.XXX.X@...XXX

X...........X.XXX.XX.XX.X@......

X.X...XXX.XXX...XX..XX...@..XX..

..XX.....XXXX.....XX..XXX@.X...X

XXXX..........XXX.......@@....XX

.........XXX..X......X@@.X..XX.X

.XXX..........XX@@@@@@@X..X.....

.X.XXXXX.......@X....XX...XX....

.......XXX.....@..XXXXXX.....X..

XXXXX.XXXXXXX..@XXXXXXX...XX....

XXXXX....XXXX..@.XXXXXXX...XXXXX

XXXXXX.....X@@@@.XXXXXXX....XX..

XXXXXX.X...@...XXXXXXXXX........

.A@@X.XXXX@@..XXXXXXXX..XX..XXXB

XXXX@@@@@@@.....XXXX...XXX..XXX.

[16, 1]->[16, 2]->[16, 3]->[17, 4]->[17, 5]->[17, 6]->[17, 7]->[17, 8]->[17, 9]->[17, 10]->[16, 10]->[16, 11]->[15, 11]->[14, 12]->[14, 13]->[14, 14]->[14, 15]->[13, 15]->[12, 15]->[11, 15]->[10, 15]->[9, 16]->[9, 17]->[9, 18]->[9, 19]->[9, 20]->[9, 21]->[9, 22]->[8, 22]->[8, 23]->[7, 24]->[7, 25]->[6, 25]->[5, 25]->[4, 25]->[3, 25]->[2, 25]->[1, 25]->[0, 25]->[0, 24]

length of the path A-C: 39

Based on the result I’ve run the program, the length of each path is smaller than the admissible heuristic function, which never overestimate the cost of reaching the target location.