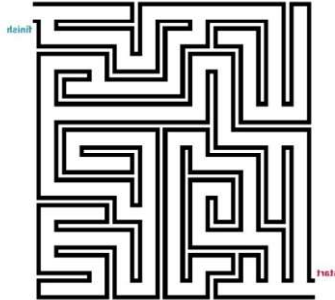




Machine Problem No. 1
"MAZE SEARCH HOORAY"



Introduction to Artificial Intelligence
CMSC 170

October 23, 2017
(Monday)

Submitted to:
Miss Avrie German

Submitted by:
Bonganay, Arvin
Pama, Jose Arniel

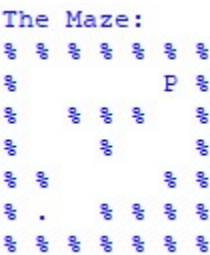
<https://github.com/pama-arniel/Maze-Search-Hooray>

PYTHON IMPLEMENTATION

PART ONE: BASIC PATHFINDING

TINY MAZE

The Maze:

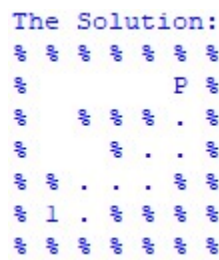


Manhattan Distance

Paths:

1.5 2.5 3.5 3.4 4.4 4.3 4.2 5.2 5.1

The Solution:



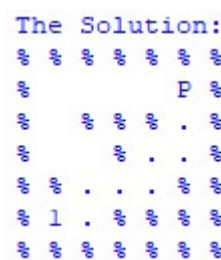
Heuristics: manhattan
Path cost: 8
Nodes expanded: 15
Frontier size: 16

Straight-line Distance

Paths:

1.5 2.5 3.5 3.4 4.4 4.3 4.2 5.2 5.1

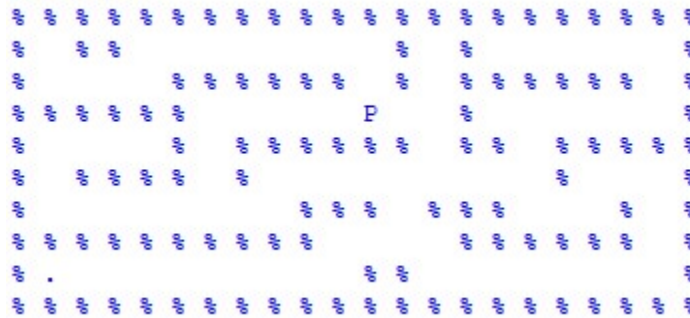
The Solution:



Heuristics: straightline
Path cost: 8
Nodes expanded: 14
Frontier size: 16

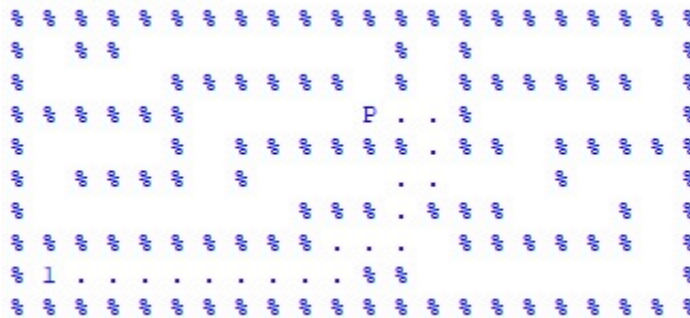
SMALL MAZE

The Maze:



Manhattan Distance

The Solution:



Paths:

3.11 3.12 3.13 4.13 5.13 5.12 6.12
7.12 7.11 7.10 8.10 8.9 8.8 8.7 8.6
8.5 8.4 8.3 8.2 8.1

Heuristics: manhattan

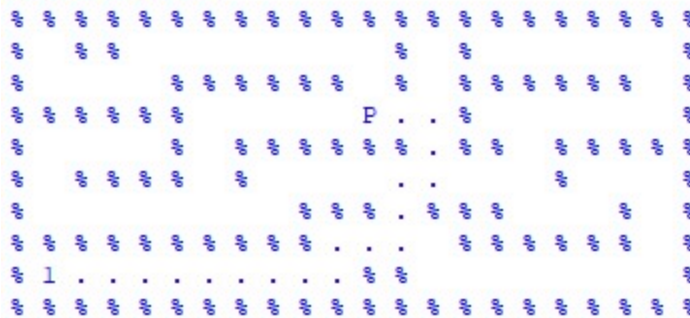
Path cost: 19

Nodes expanded: 54

Frontier size: 59

Straight-line Distance

The Solution:



Paths:

3.11 3.12 3.13 4.13 5.13 5.12 6.12
7.12 7.11 7.10 8.10 8.9 8.8 8.7 8.6
8.5 8.4 8.3 8.2 8.1

Heuristics: straightline

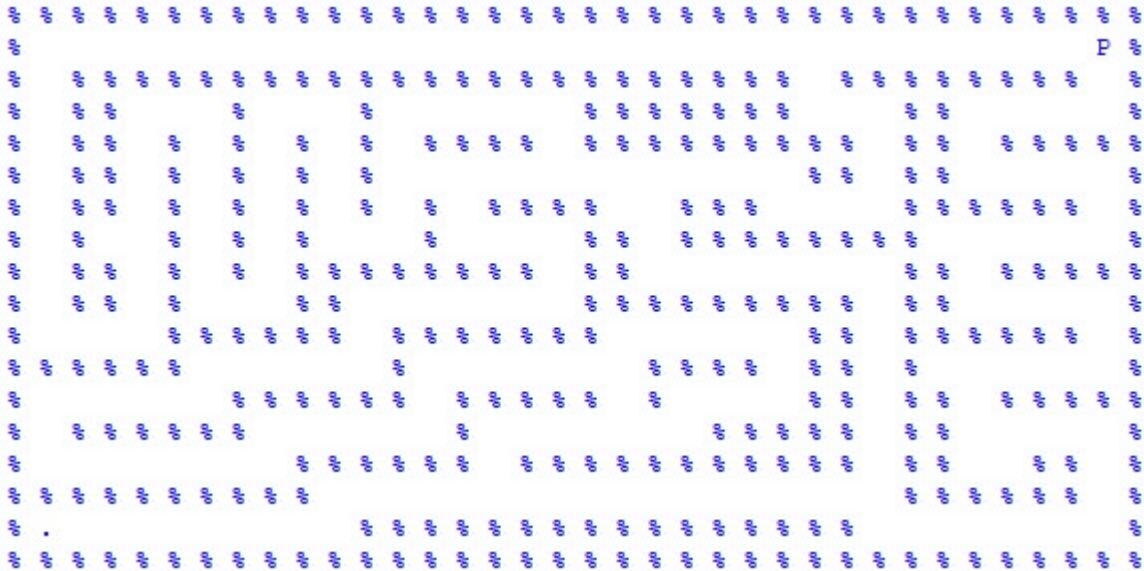
Path cost: 19

Nodes expanded: 57

Frontier size: 61

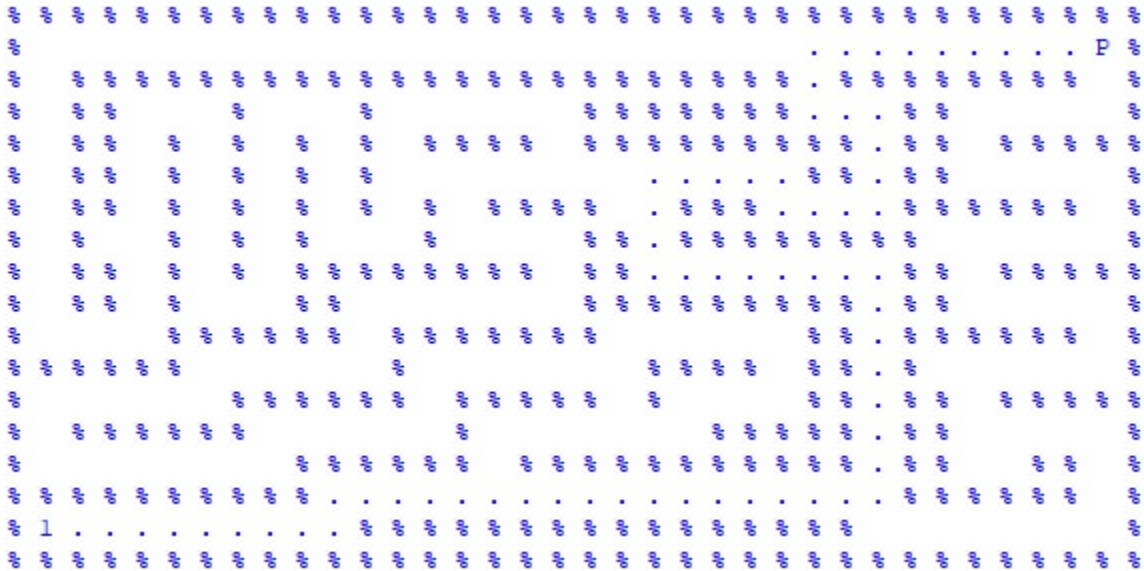
MEDIUM MAZE

The Maze:



Manhattan Distance

The Solution:

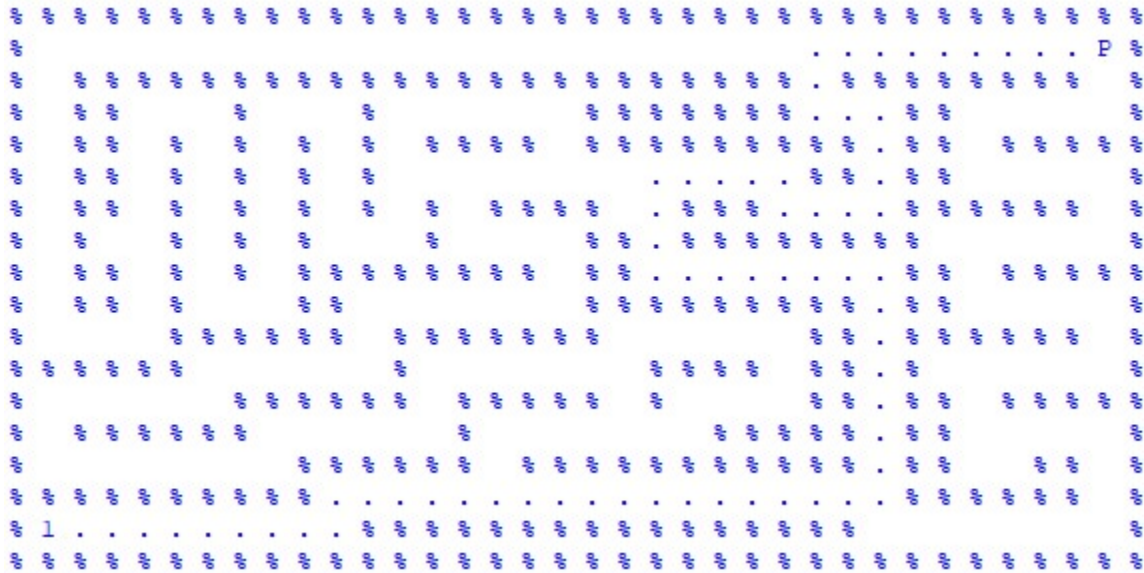


Paths:

1.34 1.33 1.32 1.31 1.30 1.29 1.28 1.27 1.26 1.25 2.25 3.25 3.26 3.27 4.27 5.27 6.27 6.26 6.25 6.24 5.24 5.23
 5.22 5.21 5.20 6.20 7.20 8.20 8.21 8.22 8.23 8.24 8.25 8.26 8.27 9.27 10.27 11.27 12.27 13.27 14.27 15.27
 15.26 15.25 15.24 15.23 15.22 15.21 15.20 15.19 15.18 15.17 15.16 15.15 15.14 15.13 15.12 15.11 15.10
 16.10 16.9 16.8 16.7 16.6 16.5 16.4 16.3 16.2 16.1

Straight-line Distance

The Solution:



Paths:

1.34 1.33 1.32 1.31 1.30 1.29 1.28 1.27 1.26 1.25 2.25 3.25 3.26 3.27 4.27 5.27 6.27 6.26 6.25 6.24 5.24 5.23
5.22 5.21 5.20 6.20 7.20 8.20 8.21 8.22 8.23 8.24 8.25 8.26 8.27 9.27 10.27 11.27 12.27 13.27 14.27 15.27
15.26 15.25 15.24 15.23 15.22 15.21 15.20 15.19 15.18 15.17 15.16 15.15 15.14 15.13 15.12 15.11 15.10
16.10 16.9 16.8 16.7 16.6 16.5 16.4 16.3 16.2 16.1

PERFORMANCE

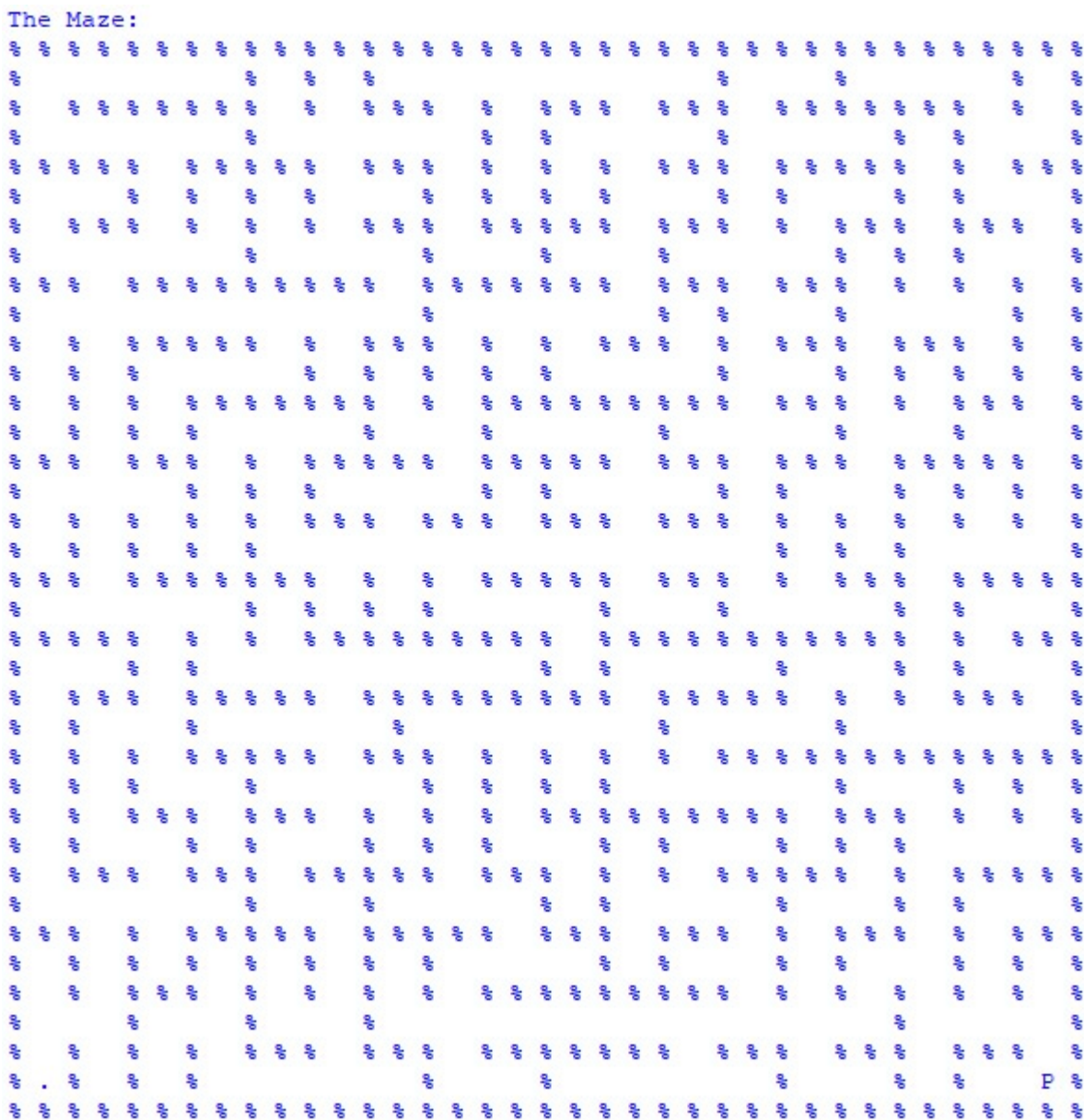
Manhattan:

Heuristics: manhattan
Pathcost: 68
Nodes expanded: 222
Frontier size: 228

Straight-line:

Heuristics: straightline
Pathcost: 68
Nodes expanded: 229
Frontier size: 233

BIG MAZE



PERFORMANCE

Manhattan:

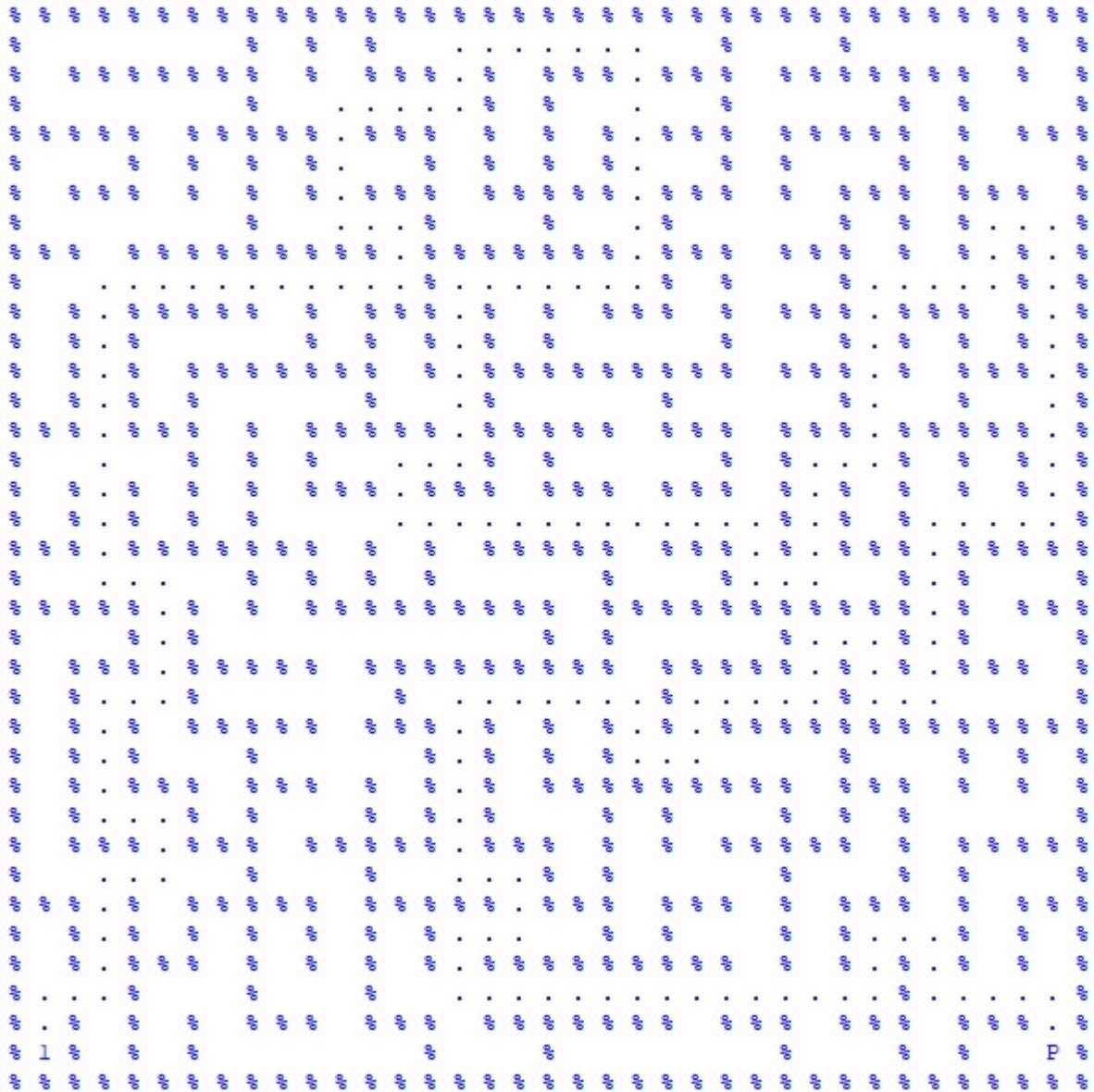
Heuristics: manhattan
Path cost: 210
Nodes expanded: 550
Frontier size: 557

Straight-line:

Heuristics: straightline
Path cost: 210
Nodes expanded: 579
Frontier size: 588

Manhattan Distance

The Solution:



Paths:

35.35 34.35 33.35 33.34 33.33 33.32 33.31 32.31 31.31 31.30 31.29 32.29 33.29 33.28 33.27 33.26 33.25 33.24 33.23
33.22 33.21 33.20 33.19 33.18 33.17 33.16 33.15 32.15 31.15 31.16 31.17 30.17 29.17 29.16 29.15 28.15 27.15 26.15
25.15 24.15 23.15 23.16 23.17 23.18 23.19 23.20 23.21 24.21 25.21 25.22 25.23 24.23 23.23 23.24 23.25 23.26 23.27
22.27 21.27 21.28 21.29 22.29 23.29 23.30 23.31 22.31 21.31 20.31 19.31 18.31 17.31 17.32 17.33 17.34 17.35 16.35
15.35 14.35 13.35 12.35 11.35 10.35 9.35 8.35 7.35 7.34 7.33 8.33 9.33 9.32 9.31 9.30 9.29 10.29 11.29 12.29 13.29
14.29 15.29 15.28 15.27 16.27 17.27 18.27 19.27 19.26 19.25 18.25 17.25 17.24 17.23 17.22 17.21 17.20 17.19 17.18
17.17 17.16 17.15 17.14 17.13 16.13 15.13 15.14 15.15 14.15 13.15 12.15 11.15 10.15 9.15 9.16 9.17 9.18 9.19 9.20
9.21 8.21 7.21 6.21 5.21 4.21 3.21 2.21 1.21 1.20 1.19 1.18 1.17 1.16 1.15 2.15 3.15 3.14 3.13 3.12 3.11 4.11 5.11 6.11
7.11 7.12 7.13 8.13 9.13 9.12 9.11 9.10 9.9 9.8 9.7 9.6 9.5 9.4 9.3 10.3 11.3 12.3 13.3 14.3 15.3 16.3 17.3 18.3 19.3 19.4
19.5 20.5 21.5 22.5 23.5 23.4 23.3 24.3 25.3 26.3 27.3 27.4 27.5 28.5 29.5 29.4 29.3 30.3 31.3 32.3 33.3 33.2 33.1 34.1

Straight-line Distance

The Solution:

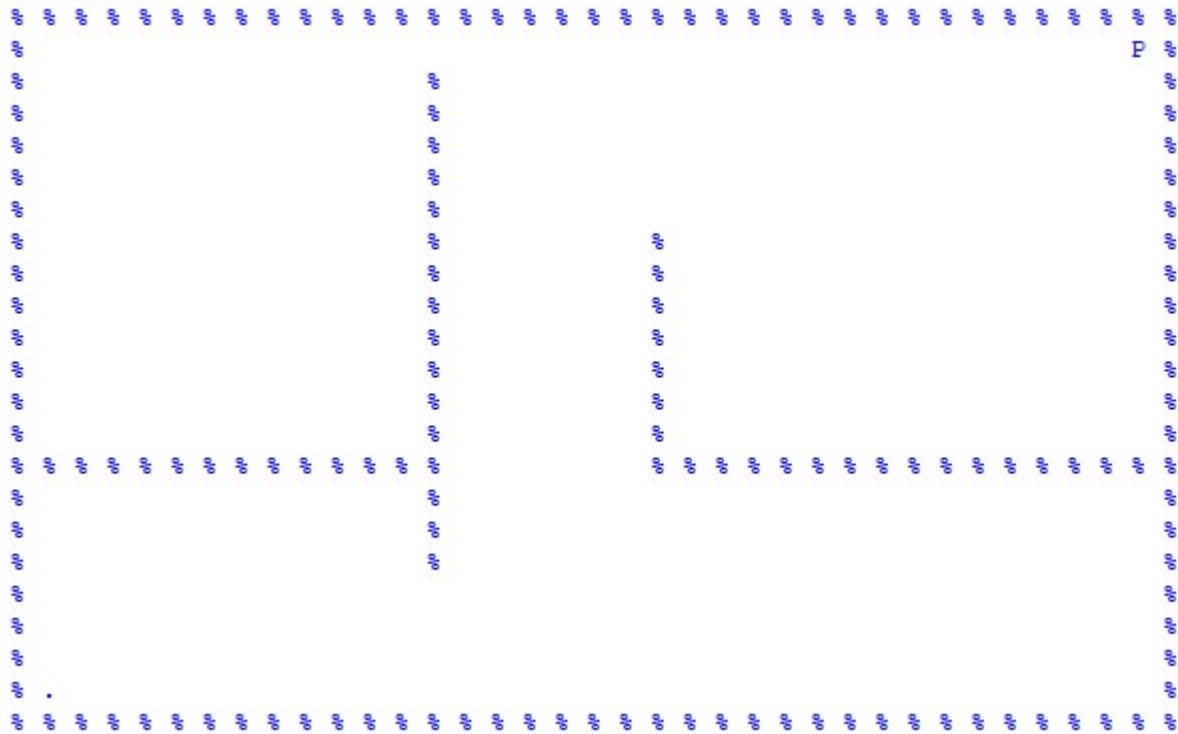
[illegible]

Paths:

35.35 34.35 33.35 33.34 33.33 33.32 33.31 32.31 31.31 31.30 31.29 32.29 33.29 33.28 33.27 33.26 33.25 33.24 33.23
33.22 33.21 33.20 33.19 33.18 33.17 33.16 33.15 32.15 31.15 31.16 31.17 30.17 29.17 29.16 29.15 28.15 27.15 26.15
25.15 24.15 23.15 23.16 23.17 23.18 23.19 23.20 23.21 24.21 25.21 25.22 25.23 24.23 23.23 23.24 23.25 23.26 23.27
22.27 21.27 21.28 21.29 22.29 23.29 23.30 23.31 22.31 21.31 20.31 19.31 18.31 17.31 17.32 17.33 17.34 17.35 16.35
15.35 14.35 13.35 12.35 11.35 10.35 9.35 8.35 7.35 7.34 7.33 8.33 9.33 9.32 9.31 9.30 9.29 10.29 11.29 12.29 13.29
14.29 15.29 15.28 15.27 16.27 17.27 18.27 19.27 19.26 19.25 18.25 17.25 17.24 17.23 17.22 17.21 17.20 17.19 17.18
17.17 17.16 17.15 17.14 17.13 16.13 15.13 15.14 15.15 14.15 13.15 12.15 11.15 10.15 9.15 9.16 9.17 9.18 9.19 9.20
9.21 8.21 7.21 6.21 5.21 4.21 3.21 2.21 1.21 1.20 1.19 1.18 1.17 1.16 1.15 2.15 3.15 3.14 3.13 3.12 3.11 4.11 5.11 6.11
7.11 7.12 7.13 8.13 9.13 9.12 9.11 9.10 9.9 9.8 9.7 9.6 9.5 9.4 9.3 10.3 11.3 12.3 13.3 14.3 15.3 16.3 17.3 18.3 19.3 19.4
19.5 20.5 21.5 22.5 23.5 23.4 23.3 24.3 25.3 26.3 27.3 27.4 27.5 28.5 29.5 29.4 29.3 30.3 31.3 32.3 33.3 33.2 33.1 34.1

OPEN MAZE

The Maze:



PERFORMANCE

Manhattan:

Heuristics: manhattan

Path cost: 39

Nodes expanded: 126

Frontier size: 182

Straight-line:

Heuristics: straightline

Path cost: 32

Nodes expanded: 255

Frontier size: 300

Paths:

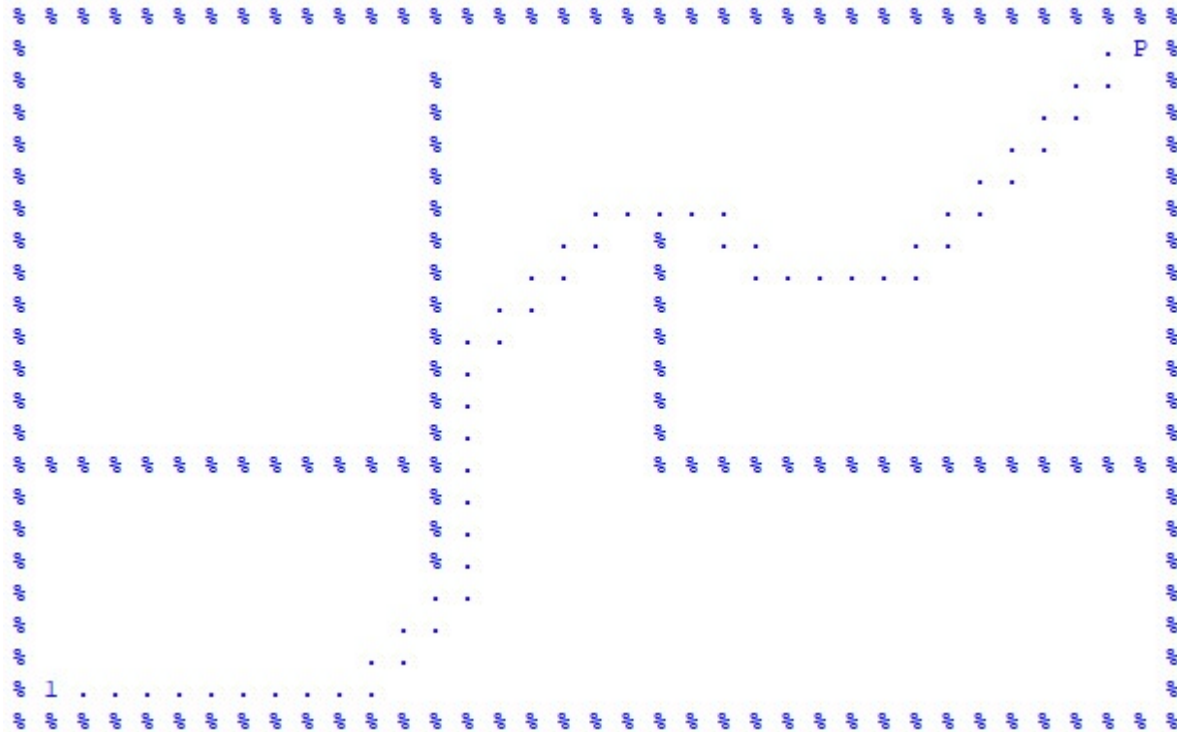
1.35 1.34 2.34 2.33 3.33 3.32 4.32 4.31 5.31
5.30 6.30 6.29 7.29 7.28 8.28 8.27 8.26 8.25
8.24 8.23 7.23 7.22 6.22 6.21 6.20 6.19 6.18
7.18 7.17 8.17 8.16 9.16 9.15 10.15 10.14
11.14 12.14 13.14 14.14 15.14 16.14 17.14
18.14 18.13 19.13 19.12 20.12 20.11 21.11
21.10 21.9 21.8 21.7 21.6 21.5 21.4 21.3
21.2 21.1

Paths:

1.35 2.35 2.34 2.33 2.32 2.31 2.30 2.29
2.28 2.27 2.26 2.25 2.24 2.23 2.22 3.22
3.21 4.21 4.20 5.20 5.19 6.19 6.18 7.18
7.17 8.17 8.16 9.16 9.15 10.15 10.14 11.14
12.14 13.14 14.14 15.14 16.14 17.14
18.14 19.14 19.13 19.12 19.11 19.10 19.9
19.8 19.7 19.6 19.5 20.5 20.4 21.4 21.3
21.2 21.1

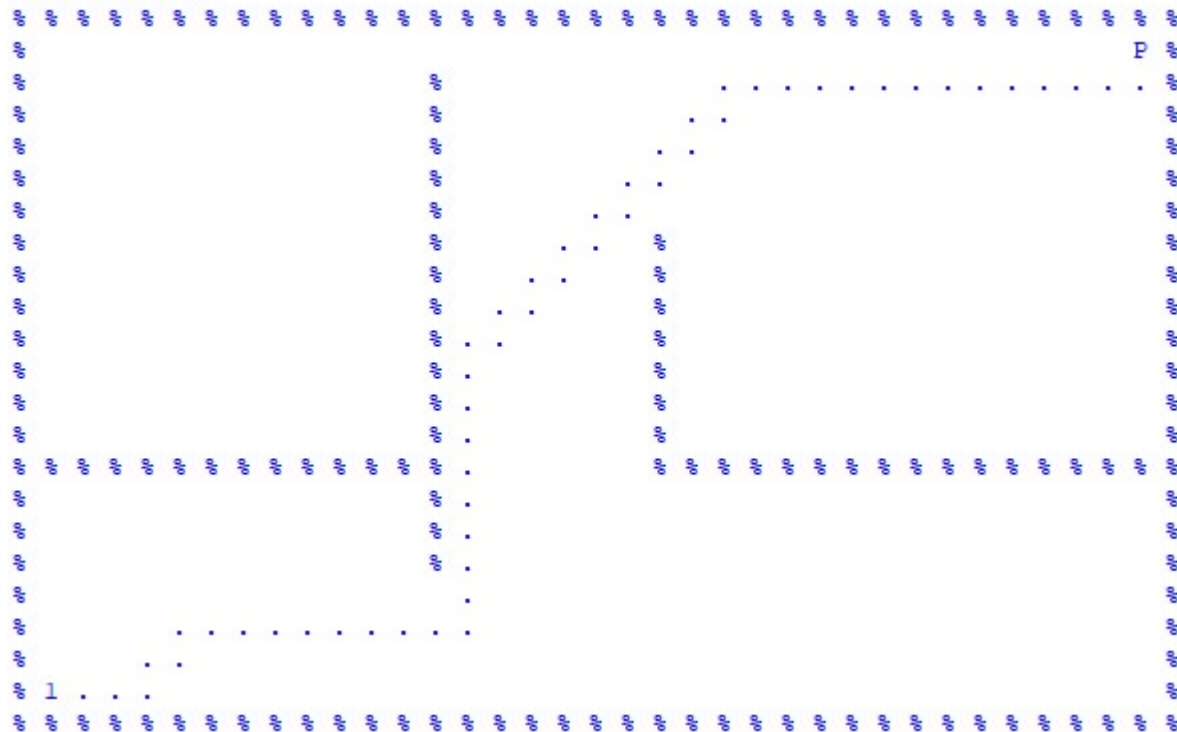
Manhattan Distance

The Solution:



Straight-line Distance

The Solution:



PART TWO: SEARCH WITH MULTIPLE GOALS

TRICKY SEARCH

The Maze:

```

# # # # # # # # # # # # # # # # # # # # # # # # # # # #
# .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
# . # # # . # # # . # # # . # # # . # # # . # # # . # # #
#                                     P
# # # # # # # # # # # # # # # # # # # # # # # # # # # #
# . . . . .   .   .   .   .   .   .   .   .   .   .   .   .
# # # # # # # # # # # # # # # # # # # # # # # # # # # #

```

Manhattan Distance

The Solution:

```

# # # # # # # # # # # # # # # # # # # # # # # # # # # #
# 7 . . .   .   .   .   2 3 # # # . . . # # #
# 8 # # 6 # # 5 # # 1 # # 4 # # . . . # # #
# . . . . .   .   .   P   .   .   .   .   .   .   .   .
# # # # # # # # # # # # # # # # # # # # # # # # # # # #
# 13 12 11 10 9 . . . . .   .   .   .   .   .   .   .   .
# # # # # # # # # # # # # # # # # # # # # # # # # # # #

```

Paths:

3.9 3.10 2.10

2.10 1.10 1.11 1.12 1.13

1.13 1.14

1.14 1.13 2.13

2.13 3.13 3.12 3.11 3.10 3.9 3.8 3.7 2.7

2.7 3.7 3.6 3.5 3.4 2.4

2.4 1.4 1.3 1.2 1.1

1.1 2.1

2.1 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 3.10 3.11 3.12 3.13 3.14 3.15 3.16 2.16 1.16 1.17 1.18 2.18 3.18

4.18 5.18 5.17 5.16 5.15 5.14 5.13 5.12 5.11 5.10 5.9 5.8 5.7 5.6 5.5

5.5 5.4

5.4 5.3

5.3 5.2

5.2 5.1

Straight-line Distance

The Solution:

	7	.	.	.						.	.	.	2	3		.	.	.	
	8			6			5			1			4			.		.	
	.	.	.	.	.	.	.	.	P	.	.	.	.	.	.	.	.	.
																		.	
	13	12	11	10	9	.	.	.	.	.	.	.	.	.	.	.	.	.

Paths:

3.9 3.10 2.10
 2.10 1.10 1.11 1.12 1.13
 1.13 1.14
 1.14 1.13 2.13
 2.13 3.13 3.12 3.11 3.10 3.9 3.8 3.7 2.7
 2.7 3.7 3.6 3.5 3.4 2.4
 2.4 1.4 1.3 1.2 1.1
 1.1 2.1
 2.1 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 3.10 3.11 3.12 3.13 3.14 3.15 3.16 2.16 1.16 1.17 1.18 2.18 3.18
 4.18 5.18 5.17 5.16 5.15 5.14 5.13 5.12 5.11 5.10 5.9 5.8 5.7 5.6 5.5
 5.5 5.4
 5.4 5.3
 5.3 5.2
 5.2 5.1

PERFORMANCE

Manhattan:

Heuristics: manhattan
 Path cost: 68
 Nodes expanded: 111
 Frontier size: 133

Straight-line:

Heuristics: straightline
 Path cost: 68
 Nodes expanded: 115
 Frontier size: 139

SMALL SEARCH

The Maze:

```

# # # # # # # # # # # # # # # # # # # # #
# . . . . . . . . . . . . . . . . . #
# . # # . # # . # # . # # . # # . # # #
#   # # #   # . . . . .   #   # # #
# # # # # # # # # # # # # # # # # # # # #

```

Manhattan Distance

The Solution:

```

# # # # # # # # # # # # # # # # # # # # #
# 13 . . . . . . . . . 3 2 1 P . 15 #
# 14 # # 12 # # 10 # # 5 # # 4 # #   # 16 #
#   # #   # 11 9 8 7 6 . . .   # 17 #
# # # # # # # # # # # # # # # # # # # # #

```

Paths:

1.16 1.15

1.15 1.14

1.14 1.13

1.13 2.13

2.13 3.13 3.12 3.11 3.10 2.10

2.10 3.10

3.10 3.9

3.9 3.8

3.8 3.7

3.7 2.7

2.7 3.7 3.6

3.6 3.7 2.7 1.7 1.6 1.5 1.4 2.4

2.4 1.4 1.3 1.2 1.1

1.1 2.1

2.1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 1.10 1.11 1.12 1.13 1.14 1.15 1.16 1.17 1.18

1.18 2.18

2.18 3.18

Straight-line Distance

The Solution:

```

# # # # # # # # # # # # # # # # # # # #
# 13 . . . . . . . . . . . 3 2 1 P . 15 #
# 14 # # 12 # # 10 # # 5 # # 4 # # # # 16 #
#   # #   # 11 9 8 7 6 . . .   # 17 #
# # # # # # # # # # # # # # # # # # # #

```

Paths:

1.16 1.15
1.15 1.14
1.14 1.13
1.13 2.13
2.13 3.13 3.12 3.11 3.10 2.10
2.10 3.10
3.10 3.9
3.9 3.8
3.8 3.7
3.7 2.7
2.7 3.7 3.6
3.6 3.7 2.7 1.7 1.6 1.5 1.4 2.4
2.4 1.4 1.3 1.2 1.1
1.1 2.1
2.1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 1.10 1.11 1.12 1.13 1.14 1.15 1.16 1.17 1.18
1.18 2.18
2.18 3.18

PERFORMANCE

Manhattan:

Heuristics: manhattan
Path cost: 48
Nodes expanded: 70
Frontier size: 103

Straight-line:

Heuristics: straightline
Path cost: 48
Nodes expanded: 72
Frontier size: 103

MEDIUM SEARCH

The Maze:

[illegible]

Manhattan Distance

The Solution:

[illegible]

Straight-line Distance

The Solution:

[illegible]

PERFORMANCE

Manhattan:

Heuristics: manhattan
Path cost: 175
Nodes expanded: 315
Frontier size: 465

Straight-line:

Heuristics: straightline
Path cost: 175
Nodes expanded: 321
Frontier size: 471

Manhattan

Paths:

6.15 6.14	4.5 4.4
6.14 6.13	4.4 4.3
6.13 6.12	4.3 4.4 4.5 4.6
6.12 6.11	4.6 4.7
6.11 5.11	4.7 3.7
5.11 4.11	3.7 2.7
4.11 4.10	2.7 2.6
4.10 4.9	2.6 2.5
4.9 3.9	2.5 2.6 1.6 1.7 1.8 1.9 1.10 1.11 1.12
3.9 4.9 4.10 4.11 4.12	1.12 1.11 2.11
4.12 4.13	2.11 2.12 2.13 2.14 2.15
4.13 4.14	2.15 2.16
4.14 3.14	2.16 2.17
3.14 2.14	2.17 2.18
2.14 2.13	2.18 1.18
2.13 2.12	1.18 1.19
2.12 2.11 1.11	1.19 1.20
1.11 1.10	1.20 1.21
1.10 1.9	1.21 1.22
1.9 1.8	1.22 1.23
1.8 1.7	1.23 1.24
1.7 1.6	1.24 1.25
1.6 1.5	1.25 1.26
1.5 1.4	1.26 1.27
1.4 1.3	1.27 1.28
1.3 1.2	1.28 1.29
1.2 1.1	1.29 1.28 1.27 2.27
1.1 1.2 1.3 2.3	2.27 3.27
2.3 3.3	3.27 3.28
3.3 3.2	3.28 3.29
3.2 3.1	3.29 4.29
3.1 4.1	4.29 3.29 3.28 3.27 4.27
4.1 5.1	4.27 4.26
5.1 6.1	4.26 4.25
6.1 6.2	4.25 4.24
6.2 6.3	4.24 4.23
6.3 6.4	4.23 3.23
6.4 6.5	3.23 2.23
6.5 5.5	2.23 2.24
5.5 4.5	2.24 2.25

2.25 1.25 1.24 1.23 1.22 1.21 2.21
 2.21 1.21 1.20 1.19 2.19
 2.19 2.18 2.17 2.16 3.16
 3.16 4.16
 4.16 4.17
 4.17 4.18
 4.18 4.19
 4.19 4.20
 4.20 4.21
 4.21 4.20 4.19 5.19
 5.19 6.19
 6.19 6.18
 6.18 6.17
 6.17 6.16
 6.16 6.15 6.14 6.13 6.12 6.11 6.10

6.10 6.9
 6.9 6.8
 6.8 6.7
 6.7 6.8 6.9 6.10 6.11 5.11 4.11 4.12 4.13 4.14
 3.14 2.14 2.15 2.16 2.17 2.18 1.18 1.19 1.20
 1.21 1.22 1.23 2.23 3.23 4.23 5.23
 5.23 6.23
 6.23 6.22
 6.22 6.21
 6.21 6.22 6.23 5.23 4.23 4.24 4.25 5.25
 5.25 6.25
 6.25 6.26
 6.26 6.27
 6.27 6.28
 6.28 6.29

Straight-line

Paths:

6.15 6.14
 6.14 6.13
 6.13 6.12
 6.12 6.11
 6.11 5.11
 5.11 4.11
 4.11 4.10
 4.10 4.9
 4.9 3.9
 3.9 4.9 4.10 4.11 4.12
 4.12 4.13
 4.13 4.14
 4.14 3.14
 3.14 2.14
 2.14 2.13
 2.13 2.12
 2.12 2.11 1.11
 1.11 1.10
 1.10 1.9
 1.9 1.8
 1.8 1.7
 1.7 1.6

1.6 1.5
 1.5 1.4
 1.4 1.3
 1.3 1.2
 1.2 1.1
 1.1 1.2 1.3 2.3
 2.3 3.3
 3.3 3.2
 3.2 3.1
 3.1 4.1
 4.1 5.1
 5.1 6.1
 6.1 6.2
 6.2 6.3
 6.3 6.4
 6.4 6.5
 6.5 5.5
 5.5 4.5
 4.5 4.4
 4.4 4.3
 4.3 4.4 4.5 4.6
 4.6 4.7

4.7 3.7
3.7 2.7
2.7 2.6
2.6 2.5
2.5 1.5 1.6 1.7 1.8 1.9 1.10 1.11 1.12
1.12 1.11 2.11
2.11 2.12 2.13 2.14 2.15
2.15 2.16
2.16 2.17
2.17 2.18
2.18 1.18
1.18 1.19
1.19 1.20
1.20 1.21
1.21 1.22
1.22 1.23
1.23 1.24
1.24 1.25
1.25 1.26
1.26 1.27
1.27 1.28
1.28 1.29
1.29 1.28 1.27 2.27
2.27 3.27
3.27 3.28
3.28 3.29
3.29 4.29
4.29 3.29 3.28 3.27 4.27
4.27 4.26
4.26 4.25
4.25 4.24
4.24 4.23
4.23 3.23
3.23 2.23

2.23 2.24
2.24 2.25
2.25 1.25 1.24 1.23 1.22 1.21 2.21
2.21 1.21 1.20 1.19 2.19
2.19 2.18 2.17 2.16 3.16
3.16 4.16
4.16 4.17
4.17 4.18
4.18 4.19
4.19 4.20
4.20 4.21
4.21 4.20 4.19 5.19
5.19 6.19
6.19 6.18
6.18 6.17
6.17 6.16
6.16 6.15 6.14 6.13 6.12 6.11 6.10
6.10 6.9
6.9 6.8
6.8 6.7
6.7 6.8 6.9 6.10 6.11 5.11 4.11 4.12 4.13 4.14
3.14 2.14 2.15 2.16 2.17 2.18 1.18 1.19 1.20
1.21 1.22 1.23 2.23 3.23 4.23 5.23
5.23 6.23
6.23 6.22
6.22 6.21
6.21 6.22 6.23 5.23 4.23 4.24 4.25 5.25
5.25 6.25
6.25 6.26
6.26 6.27
6.27 6.28
6.28 6.29

BIG SEARCH

The Maze:

[illegible]

Manhattan Distance

The Solution:

[illegible]

Straight-line Distance

The Solution:

[illegible]

Manhattan:

Heuristics: manhattan
Path cost: 329
Nodes expanded: 649
Frontier size: 986

Straight-line:

Heuristics: straightline
Path cost: 329
Nodes expanded: 683
Frontier size: 1023

Manhattan

Paths:

13.15 13.14	1.12 1.13
13.14 13.13	1.13 1.14
13.13 13.12	1.14 1.15
13.12 13.11	1.15 1.16
13.11 12.11	1.16 1.17
12.11 11.11	1.17 1.18
11.11 11.10	1.18 1.19
11.10 11.9	1.19 1.20
11.9 10.9	1.20 1.21
10.9 9.9	1.21 1.22
9.9 10.9 11.9 11.10 11.11 11.12	1.22 1.23
11.12 11.13	1.23 2.23
11.13 11.14	2.23 3.23
11.14 10.14	3.23 4.23
10.14 9.14	4.23 4.22
9.14 9.13	4.22 4.21
9.13 9.12	4.21 3.21
9.12 9.11	3.21 3.20
9.11 8.11	3.20 3.19
8.11 7.11	3.19 2.19
7.11 6.11	2.19 3.19 3.18
6.11 5.11	3.18 3.17
5.11 5.12	3.17 3.16
5.12 5.13	3.16 4.16
5.13 5.14	4.16 5.16
5.14 4.14	5.16 5.15
4.14 3.14	5.15 5.14 4.14 3.14 3.13 3.12 3.11 3.10
3.14 3.13	3.10 3.9
3.13 3.12	3.9 4.9
3.12 3.11	4.9 5.9
3.11 2.11	5.9 6.9
2.11 1.11	6.9 7.9
1.11 1.10	7.9 7.8
1.10 1.9	7.8 7.7
1.9 1.8	7.7 7.6
1.8 1.7	7.6 7.5
1.7 2.7	7.5 6.5
2.7 3.7	6.5 5.5
3.7 4.7	5.5 6.5 7.5 8.5
4.7 5.7	8.5 9.5
5.7 4.7 3.7 2.7 1.7 1.8 1.9 1.10 1.11 1.12	9.5 9.6
	9.6 9.7

9.7 10.7	13.1 13.2 13.3 13.4 13.5
10.7 11.7	13.5 12.5 11.5 11.6 11.7 12.7
11.7 11.6	12.7 13.7
11.6 11.5	13.7 13.8
11.5 11.4	13.8 13.9
11.4 11.3	13.9 13.10
11.3 11.2 10.2	13.10 13.11 13.12 13.13 13.14 13.15 13.16
10.2 10.1	13.16 13.17
10.1 11.1	13.17 13.18
11.1 11.2	13.18 13.19
11.2 11.3 10.3	13.19 12.19
10.3 9.3	12.19 11.19
9.3 8.3	11.19 11.18
8.3 8.2	11.18 11.17
8.2 8.1	11.17 11.16
8.1 7.1	11.16 10.16
7.1 6.1	10.16 9.16
6.1 6.2	9.16 9.17
6.2 6.3	9.17 9.18
6.3 5.3	9.18 9.19
5.3 4.3	9.19 8.19
4.3 3.3	8.19 7.19
3.3 3.4	7.19 6.19
3.4 3.5	6.19 5.19
3.5 2.5	5.19 5.18
2.5 1.5	5.18 5.19 6.19 7.19 7.20
1.5 1.4	7.20 7.21
1.4 1.3	7.21 6.21
1.3 1.2	6.21 5.21
1.2 1.1	5.21 6.21 7.21 7.22
1.1 2.1	7.22 7.23
2.1 3.1	7.23 7.24
3.1 4.1	7.24 7.25
4.1 4.2	7.25 6.25
4.2 4.3 5.3 6.3 6.2 6.1 7.1 8.1 8.2 8.3 9.3 10.3	6.25 5.25
10.2 11.2 11.1 12.1	5.25 5.24
12.1 12.2	5.24 5.23
12.2 12.3	5.23 5.24 5.25 6.25 7.25 8.25
12.3 12.4	8.25 9.25
12.4 12.5	9.25 9.24
12.5 12.4 13.4	9.24 9.23
13.4 13.3	9.23 10.23
13.3 13.2	10.23 11.23
13.2 13.1	11.23 11.24

11.24 11.25
 11.25 11.26
 11.26 11.27
 11.27 10.27
 10.27 9.27
 9.27 8.27
 8.27 8.28
 8.28 8.29
 8.29 7.29
 7.29 6.29
 6.29 6.28
 6.28 6.27
 6.27 5.27
 5.27 4.27
 4.27 3.27
 3.27 3.26 2.26
 2.26 2.25 1.25
 1.25 1.26
 1.26 1.27
 1.27 1.28
 1.28 1.29
 1.29 1.28 2.28
 2.28 2.27
 2.27 2.26 3.26
 3.26 3.25 2.25
 2.25 3.25
 3.25 3.26 3.27 3.28
 3.28 3.29 2.29

2.29 3.29
 3.29 3.28 4.28
 4.28 4.29
 4.29 4.28 4.27 5.27 6.27 6.28 6.29 7.29 8.29
 8.28 8.27 9.27 10.27 10.28
 10.28 10.29
 10.29 11.29
 11.29 12.29
 12.29 13.29
 13.29 13.28
 13.28 13.27
 13.27 13.26
 13.26 13.25
 13.25 12.25
 12.25 11.25 11.24 11.23 12.23
 12.23 13.23
 13.23 13.22
 13.22 13.21
 13.21 13.22 13.23 12.23 11.23 10.23 9.23 9.24
 9.25 8.25 7.25 7.24 7.23 7.22 7.21 8.21
 8.21 9.21
 9.21 10.21
 10.21 11.21
 11.21 11.20
 11.20 11.19 12.19 13.19 13.18 13.17 13.16
 13.15 13.14 13.13 13.12 13.11 12.11 11.11
 11.12 11.13 11.14 10.14 9.14 9.13 9.12 9.11
 8.11 7.11 7.10

Straight-line

Paths:

13.15 13.14
 13.14 13.13
 13.13 13.12
 13.12 13.11
 13.11 12.11
 12.11 11.11
 11.11 11.10
 11.10 11.9
 11.9 10.9
 10.9 9.9

9.9 10.9 11.9 11.10 11.11 11.12
 11.12 11.13
 11.13 11.14
 11.14 10.14
 10.14 9.14
 9.14 9.13
 9.13 9.12
 9.12 9.11
 9.11 8.11
 8.11 7.11

7.11 6.11	3.16 4.16
6.11 5.11	4.16 5.16
5.11 5.12	5.16 5.15
5.12 5.13	5.15 5.14 4.14 3.14 3.13 3.12 3.11 3.10
5.13 5.14	3.10 3.9
5.14 4.14	3.9 4.9
4.14 3.14	4.9 5.9
3.14 3.13	5.9 6.9
3.13 3.12	6.9 7.9
3.12 3.11	7.9 7.8
3.11 2.11	7.8 7.7
2.11 1.11	7.7 7.6
1.11 1.10	7.6 7.5
1.10 1.9	7.5 6.5
1.9 1.8	6.5 5.5
1.8 1.7	5.5 6.5 7.5 8.5
1.7 2.7	8.5 9.5
2.7 3.7	9.5 9.6
3.7 4.7	9.6 9.7
4.7 5.7	9.7 10.7
5.7 4.7 3.7 2.7 1.7 1.8 1.9 1.10 1.11 1.12	10.7 11.7
1.12 1.13	11.7 11.6
1.13 1.14	11.6 11.5
1.14 1.15	11.5 11.4
1.15 1.16	11.4 11.3
1.16 1.17	11.3 11.2 10.2
1.17 1.18	10.2 10.1
1.18 1.19	10.1 11.1
1.19 1.20	11.1 11.2
1.20 1.21	11.2 11.3 10.3
1.21 1.22	10.3 9.3
1.22 1.23	9.3 8.3
1.23 2.23	8.3 8.2
2.23 3.23	8.2 8.1
3.23 4.23	8.1 7.1
4.23 4.22	7.1 6.1
4.22 4.21	6.1 6.2
4.21 3.21	6.2 6.3
3.21 3.20	6.3 5.3
3.20 3.19	5.3 4.3
3.19 2.19	4.3 3.3
2.19 3.19 3.18	3.3 3.4
3.18 3.17	3.4 3.5
3.17 3.16	3.5 2.5

2.5 1.5	5.18 5.19 6.19 7.19 7.20
1.5 1.4	7.20 7.21
1.4 1.3	7.21 6.21
1.3 1.2	6.21 5.21
1.2 1.1	5.21 6.21 7.21 7.22
1.1 2.1	7.22 7.23
2.1 3.1	7.23 7.24
3.1 4.1	7.24 7.25
4.1 4.2	7.25 6.25
4.2 4.3 5.3 6.3 6.2 6.1 7.1 8.1 8.2 8.3 9.3 10.3	6.25 5.25
10.2 11.2 11.1 12.1	5.25 5.24
12.1 12.2	5.24 5.23
12.2 12.3	5.23 5.24 5.25 6.25 7.25 8.25
12.3 12.4	8.25 9.25
12.4 12.5	9.25 9.24
12.5 12.4 13.4	9.24 9.23
13.4 13.3	9.23 10.23
13.3 13.2	10.23 11.23
13.2 13.1	11.23 11.24
13.1 13.2 13.3 13.4 13.5	11.24 11.25
13.5 12.5 11.5 11.6 11.7 12.7	11.25 11.26
12.7 13.7	11.26 11.27
13.7 13.8	11.27 10.27
13.8 13.9	10.27 9.27
13.9 13.10	9.27 8.27
13.10 13.11 13.12 13.13 13.14 13.15 13.16	8.27 8.28
13.16 13.17	8.28 8.29
13.17 13.18	8.29 7.29
13.18 13.19	7.29 6.29
13.19 12.19	6.29 6.28
12.19 11.19	6.28 6.27
11.19 11.18	6.27 5.27
11.18 11.17	5.27 4.27
11.17 11.16	4.27 3.27
11.16 10.16	3.27 3.26 2.26
10.16 9.16	2.26 2.25 1.25
9.16 9.17	1.25 1.26
9.17 9.18	1.26 1.27
9.18 9.19	1.27 1.28
9.19 8.19	1.28 1.29
8.19 7.19	1.29 1.28 2.28
7.19 6.19	2.28 2.27
6.19 5.19	2.27 2.26 3.26
5.19 5.18	3.26 3.25 2.25

2.25 3.25	12.25 11.25 11.24 11.23 12.23
3.25 2.25 2.26 2.27 2.28 2.29	12.23 13.23
2.29 2.28 3.28	13.23 13.22
3.28 3.29	13.22 13.21
3.29 3.28 4.28	13.21 13.22 13.23 12.23 11.23 10.23 9.23 9.24
4.28 4.29	9.25 8.25 7.25 7.24 7.23 7.22 7.21 8.21
4.29 4.28 4.27 5.27 6.27 6.28 6.29 7.29 8.29	8.21 9.21
8.28 8.27 9.27 10.27 10.28	9.21 10.21
10.28 10.29	10.21 11.21
10.29 11.29	11.21 11.20
11.29 12.29	11.20 11.21 10.21 9.21 8.21 7.21 6.21 5.21 4.21
12.29 13.29	3.21 3.20 3.19 3.18 3.17 3.16 4.16 5.16 5.15
13.29 13.28	5.14 5.13 5.12 5.11 6.11 7.11 7.10
13.28 13.27	
13.27 13.26	
13.26 13.25	
13.25 12.25	

CONTRIBUTIONS

Bonganay – implemented the solution in Java; compared the solution with Pama’s; came up with an algorithm for PART TWO; **documentation for Java implementation is yet to be made.**

Pama – implemented the solution in Python; compared the solution with Bonganay’s; came up with a different algorithm for PART TWO (different with Bonganay’s); documented the Python implementation.

FINDINGS

Bonganay’s code and Pama’s code were more or less the same for PART ONE. There were only some point difference between the expanded nodes, maximum frontiers, and path cost.

For PART TWO, although Bonganay’s algorithm was correct, it was inconsistent and did not always guarantee the optimal solution. It utilized the heuristics in finding the next goal to go to. Pama’s implementation, on the other hand, proved better in terms of finding the more optimal solution, since it calculated all the path costs to each goal and chose the goal with the least path cost to go to next in each round. However, it suffered from having a greater time complexity than Bonganay’s.