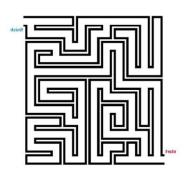


Machine Problem No. 1 "MAZE \$EARCH HOORAY"





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

Th	ne	Ma	aze	2:		
용	90	8	90	90	8	90
용					P	e
용		e	용	of		e
용			용			e
용	ofo				e	e
용			ofo	ofo	olo	ofo
olo	90	90	olo	olo	olo	olo

Manhattan Distance

Straight-line Distance

Paths:

 $1.5\ 2.5\ 3.5\ 3.4\ 4.4\ 4.3\ 4.2\ 5.2\ 5.1$

Paths:

1.5 2.5 3.5 3.4 4.4 4.3 4.2 5.2 5.1

Heuristics: manhattan

Path cost: 8

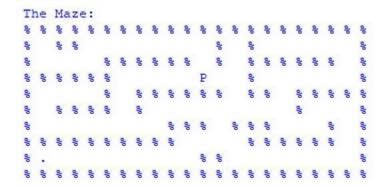
Nodes expanded: 15 Frontier size: 16

Heuristics: straightline

Path cost: 8

Nodes expanded: 14 Frontier size: 16

SMALL MAZE



Manhattan Distance

T	ne	S	011	ıt:	ioi	n:															
olo	olo	8	90	olo	8	olo	%	olo	%	olo	%	olo	90								
ob		8	olo									90		90							8
8					8	90	8	90	8	90		e		90	90	90	90	90	8		8
e	90	8	90	8	용						P			%							8
용					용		용	%	용	%	용	용		%	%		%	%	용	8	용
8		90	90	90	90		90										90				%
ofo									90	90	90		90	90	90				90		90
olo	olo	90	90	90	90	90	90	olo	%					90	90	olo	olo	olo	%		90
olo	1										olo	olo									90
96	96	9	96	96	9	96	96	9	9	9	96	96	96	96	96	96	96	96	96	96	96

Paths:

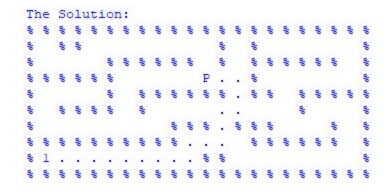
3.11 3.12 3.13 4.13 5.13 5.12 6.12 7.12 7.11 7.10 8.10 8.9 8.8 8.7 8.6 8.5 8.4 8.3 8.2 8.1

Heuristics: manhattan

Path cost: 19

Nodes expanded: 54 Frontier size: 59

Straight-line Distance



Paths:

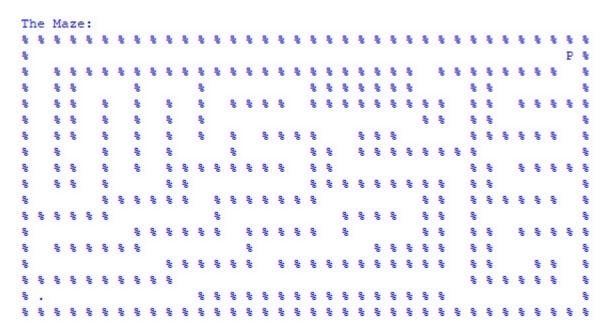
3.11 3.12 3.13 4.13 5.13 5.12 6.12 7.12 7.11 7.10 8.10 8.9 8.8 8.7 8.6 8.5 8.4 8.3 8.2 8.1

Heuristics: straightline

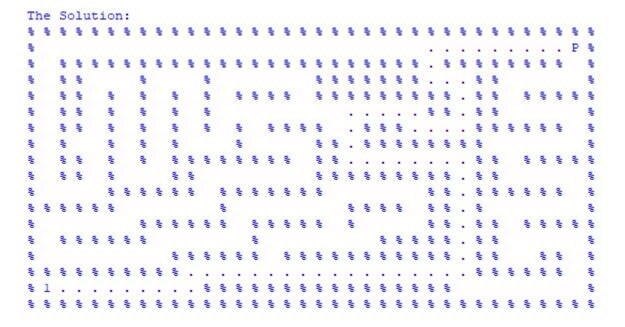
Path cost: 19

Nodes expanded: 57 Frontier size: 61

MEDIUM MAZE



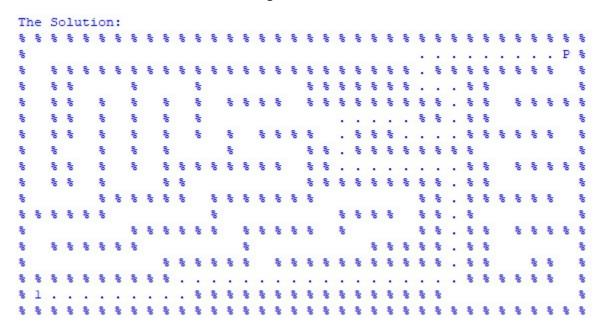
Manhattan Distance



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



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

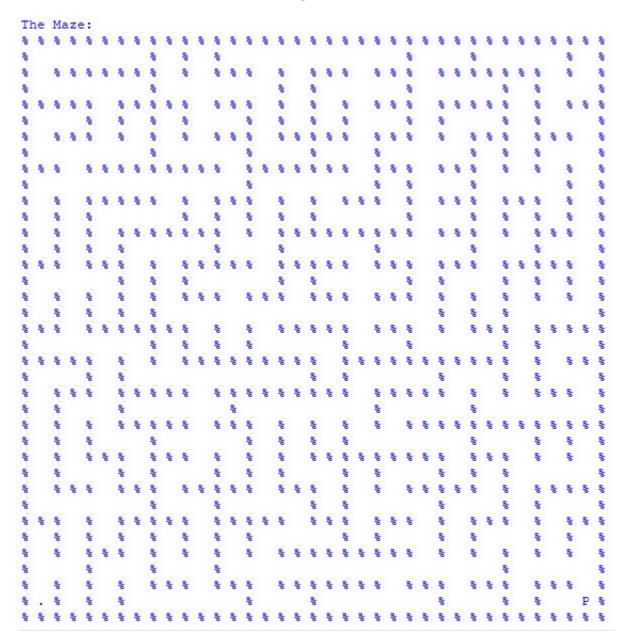
Straight-line:

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

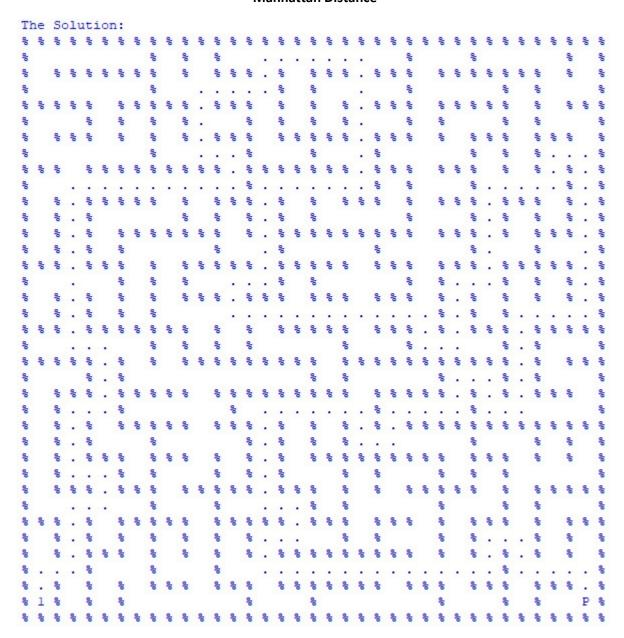
Straight-line:

Heuristics: straightline

Path cost: 210

Nodes expanded: 579 Frontier size: 588

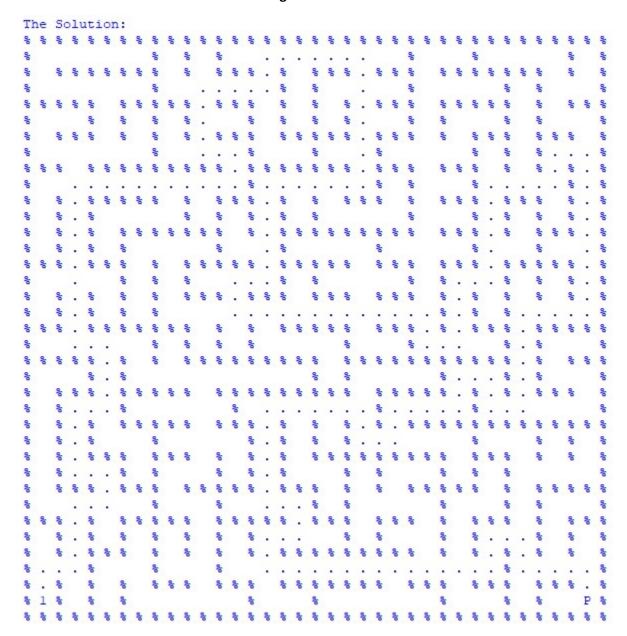
Manhattan Distance



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 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

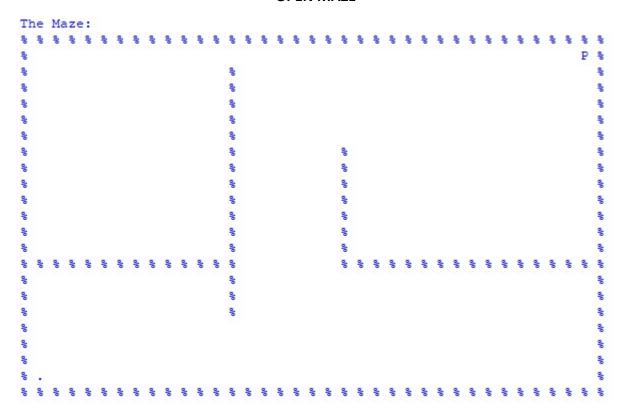
Straight-line Distance



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 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



PERFORMANCE

Manhattan:

Heuristics: manhattan

Path cost: 39

Nodes expanded: 126 Frontier size: 182

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

Straight-line:

Heuristics: straightline

Path cost: 32

Nodes expanded: 255 Frontier size: 300

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

Tì	ie	S	ol	ut:	io	n:																														
ofo	ofo	of	8	용	용	of	of	용	olo	olo	olo	olo	8	90	90	8	olo	olo	olo	olo	8	olo	8	90	90	90	90	90	90	90	8	olo	olo	8	8	90
olo																																			P	olo
olo													olo																							olo
ofo													90																							ofo
ofo													용																							용
of													용																							용
of													용																							용
of													용							8																용
of													용							8																%
of													용							8																%
e													용	/.)	/.)					8																%
ob													용							8																8
ob													8	/.)						8																90
of													%							%																%
ofo	of	8	용	용	용	8	8	용	90	90	90	90	8							90	8	90	8	8	8	8	8	8	8	8	8	90	ofo	8	8	90
ofo													8																							90
ofo													%																							90
ofo													8																							8
olo																																				ofo
ofo																																				ofo
ob																																				ofo
olo	1																																			ofo
90	90	olo	ofo	olo	olo	olo	olo	olo	ofo	ofo	90	ofo	00	90	90	00	8	ofo	ofo	ofo	8	olo	00	00	00	00	00	8	00	00	90	90	8	olo	90	8

Straight-line Distance

Th	ne	S	oli	ut:	io	n:																														
of	용	용	8	8	용	8	8	8	용	8	8	8	8	8	8	8	용	8	8	8	8	8	8	8	8	용	용	8	8	8	용	용	용	8	8	8
olo																																			P	olo
olo													8																							ofo
olo													8																							olo
of													용																							of
ob													용																							ob
e													용																							ob
ob													용							8																8
ob													용							용																of
ob													용							8																8
ob													용							8																8
å													용							%																o
å													용							용																8
e													용							90																ob
ob	8	8	8	8	8	ob	8	8	8	8	ob	8	용							90	90	8	90	90	90	용	8	90	ob	90	용	용	8	용	용	8
e													용																							90
ob													용																							90
ob													용																							8
ofo																																				8
ofo																																				8
ofo																																				80
olo	1		٠	٠																																80
o	8	ob	8	8	8	8	ob	8	8	8	8	8	8	ob	8	ob	8	of	8	8	8	8	8	8	8	ob	o	8	8	8	ob	ob	o	of	of	8

PART TWO: SEARCH WITH MULTIPLE GOALS

TRICKY SEARCH

T	ne	Ma	aze	€:																
olo	olo	90	90	90	olo	olo	olo	olo	olo	olo	90	olo	olo	olo	olo	90	olo	olo	olo	
olo															8				8	
olo		olo	90		olo		olo													
olo									P								90		90	
olo	olo	90	olo	olo	olo	olo	90	olo	90	olo	olo		8							
olo																			8	
90	90	8	90	8	8	%	8	8	8	8	ofo	8	8	8	8	90	8	8	용	

Manhattan Distance

Th	e S	olu	tio	n:																
90	8	용	용	용	olo	용	8	8	용	8	8	8	8	8	8	8	8	8	8	
%	7												2	3	8				용	
8	8	용	용	6	90	용	5	용	용	1	8	8	4	8	8		8		용	
8									P								8		용	
8	용	용	용	용	90	용	8	용	용	용	8	8	8	8	8	8	8		용	
8	13	12	11	10	9														8	
8	8	8	8	8	9	8	8	8	8	8	8	8	8	8	9	8	8	8	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

Th	e S	olu	tio	n:															
%	용	용	용	용	olo	%	8	8	8	8	olo	%	8	8	8	8	8	8	90
%	7												2	3	8				90
%	8	용	용	6	90	8	5	용	8	1	8	8	4	용	용		용		%
e e									P								용		%
e e	용	용	용	용	90	8	8	용	8	8	용	8	8	8	8	8	용		8
olo O	13	12	11	10	9														8
9	2	9	9	2	9	9.	9.	9.	9.	2	9.	9.	9.	9.	9.	9.	9.	9.	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: ...P. % 8.88.88.88.88.88.88 8 8

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

Th	e S	olu	tio	n:															
8	8	90	8	8	olo	8	8	90	8	8	8	8	8	8	8	8	8	90	90
8	13												3	2	1	P		15	90
8	14	olo	8	12	olo	8	10	90	8	5	8	8	4	8	8		8	16	90
8		90	8		ofo	11	9	8	7	6							용	17	90
9	2	9	2	2	2	2	2	9	2	2	2	2	2	2	2	2	2	2	9

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

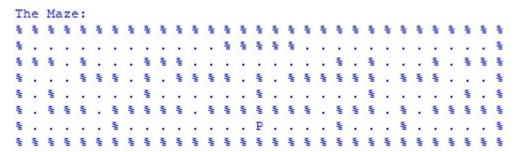
Straight-line:

Heuristics: straightline

Path cost: 48

Nodes expanded: 72 Frontier size: 103

MEDIUM SEARCH



Manhattan Distance

The	Sol	utio	n:																											
용	8	8	8	8	8	8	8	8	8	90	8	8	8	8	8	8	8	8	8	8	8	90	8	8	8	8	90	8	%	90
용	27	26	25	24	23	22	21	20	19	18	17	49	8	8	8	8	8	55	56	57	58	59	60	61	62	63	64	65	66	8
용	8	8	28	8	48	47	46	8	8	용	50	16	15	14	51	52	53	54	82	8	81	용	78	79	80	8	67	8	8	용
용	31	30	29	8	8	8	45	8	9	8	8	8	8	13	8	83	8	8	8	8	8	8	77	8	8	8	68	69	70	8
8	32	8	42	41	40	43	44	8	8	7	6	10	11	12	8	84	85	86	87	88	89	90	76	75	74	73	72	8	71	8
8	33	8	8	8	39	용	8	8	8	8	5	8	8	8	8	8	8	8	90	8	8	8	99	8	103	8	8	8	8	8
8	34	35	36	37	38	8	98	97	96	95	4	3	2	1	P	94	93	92	91	8	102	101	100	8	104	105	106	107	108	8
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	8	2	2	2	2	2

Straight-line Distance

The	e Sol	utic	on:																											
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	90	8	8	90	90	8	8	8
90	27	26	25	24	23	22	21	20	19	18	17	49	8	8	8	8	8	55	56	57	58	59	60	61	62	63	64	65	66	8
90	%	8	28	8	48	47	46	8	8	8	50	16	15	14	51	52	53	54	82	8	81	8	78	79	80	90	67	8	8	90
8	31	30	29	8	8	8	45	8	9	8	용	8	8	13	용	83	8	용	8	8	8	8	77	8	8	8	68	69	70	8
8	32	8	42	41	40	43	44	8	8	7	6	10	11	12	8	84	85	86	87	88	89	8	76	75	74	73	72	8	71	8
8	33	8	8	8	39	8	8	8	8	8	5	8	8	8	8	8	8	8	90	8	8	8	99	8	103	8	8	8	8	8
90	34	35	36	37	38	8	98	97	96	95	4	3	2	1	P	94	93	92	91	8	102	101	100	8	104	105	106	107	108	8
_	-	-	_	_	_	-	_	_	_	_	_	_	_	_	_	_	_	-	_	_	_	_	_	_	_	_	_	_	_	_

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

	Mannattan
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

3.23 2.23

2.23 2.242.24 2.25

6.4 6.5

6.5 5.5

5.5 4.5

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

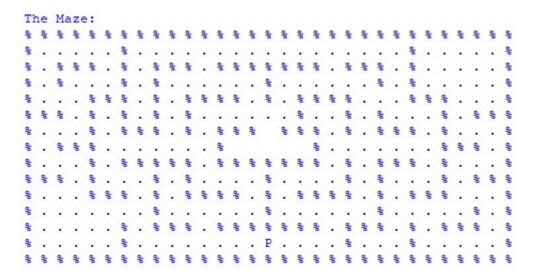
Straight-line

D:	٦t	h	٠.
Г	J L		э.

6.15 6.14	1.6 1.5
6.14 6.13	1.5 1.4
6.13 6.12	1.4 1.3
6.12 6.11	1.3 1.2
6.11 5.11	1.2 1.1
5.11 4.11	1.1 1.2 1.3 2.3
4.11 4.10	2.3 3.3
4.10 4.9	3.3 3.2
4.9 3.9	3.2 3.1
3.9 4.9 4.10 4.11 4.12	3.1 4.1
4.12 4.13	4.1 5.1
4.13 4.14	5.1 6.1
4.14 3.14	6.1 6.2
3.14 2.14	6.2 6.3
2.14 2.13	6.3 6.4
2.13 2.12	6.4 6.5
2.12 2.11 1.11	6.5 5.5
1.11 1.10	5.5 4.5
1.10 1.9	4.5 4.4
1.9 1.8	4.4 4.3
1.8 1.7	4.3 4.4 4.5 4.6
1.7 1.6	4.6 4.7

4.7 3.7	2.23 2.24
3.7 2.7	2.24 2.25
2.7 2.6	2 25 4 25 4 24 4 22 4 22 4 24 2 24
2.6 2.5	2.25 1.25 1.24 1.23 1.22 1.21 2.21
2.5 1.5 1.6 1.7 1.8 1.9 1.10 1.11 1.12	2.21 1.21 1.20 1.19 2.19
1.12 1.11 2.11	2.19 2.18 2.17 2.16 3.16
2.11 2.12 2.13 2.14 2.15	3.16 4.16
2.15 2.16	4.16 4.17
2.16 2.17	4.17 4.18
2.17 2.18	4.18 4.19
2.18 1.18	4.19 4.20
1.18 1.19	4.20 4.21
1.19 1.20	4.21 4.20 4.19 5.19
1.20 1.21	5.19 6.19
1.21 1.22	6.19 6.18
1.22 1.23	6.18 6.17
1.23 1.24	6.17 6.16
1.24 1.25	6.16 6.15 6.14 6.13 6.12 6.11 6.10
1.25 1.26	6.10 6.9
1.26 1.27	6.9 6.8
1.27 1.28	6.8 6.7
1.28 1.29	6.7 6.8 6.9 6.10 6.11 5.11 4.11 4.12 4.13 4.14
1.29 1.28 1.27 2.27	3.14 2.14 2.15 2.16 2.17 2.18 1.18 1.19 1.20
2.27 3.27	1.21 1.22 1.23 2.23 3.23 4.23 5.23
3.27 3.28	5.23 6.23
3.28 3.29	6.23 6.22
3.29 4.29	6.22 6.21
4.29 3.29 3.28 3.27 4.27	6.21 6.22 6.23 5.23 4.23 4.24 4.25 5.25
4.27 4.26	5.25 6.25
4.26 4.25	6.25 6.26
4.25 4.24	6.26 6.27
4.24 4.23	6.27 6.28
4.23 3.23	6.28 6.29
3.23 2.23	

BIG SEARCH



Manhattan Distance

The	Solu	ition	n:																											
용	용	8	용	용	8	8	8	8	8	8	용	8	8	8	8	8	8	8	용	용	용	8	8	8	용	8	8	8	8	8
8	113	112	111	110	109	용	36	35	34	33	32	41	42	43	44	45	46	47	48	49	50	51	52	8	187	188	189	190	191	olo
ક	114	8	8	8	108	8	37	8	%	8	31	8	8	8	8	8	8	8	61	8	8	8	53	8	195	186	193	192	198	olo
용	115	8	105	106	107	용	38	8	69	68	30	29	28	27	8	64	63	62	60	59	58	8	54	8	196	194	185	197	199	%
ક	116	117	104	8	8	8	39	8	70	8	8	용	8	26	8	65	8	%	8	8	57	56	55	8	8	8	184	200	201	olo
용	8	8	103	8	79	용	40	8	71	8	22	23	24	25	67	66	8	151	150	8	155	8	163	162	161	8	183	8	8	90
e e	100	101	102	8	78	8	8	8	72	8	21	8	8	8		8	8	90	149	8	154	8	8	8	160	8	182	181	180	9
용	99	8	8	8	77	76	75	74	73	221	20	8						8	148	152	153	156	157	158	159	용	8	8	179	용
ક	98	97	96	8	80	8	8	8	90	%	19	8	8	8	8	%	8	%	147	8	216	8	8	%	164	8	176	177	178	olo
용	용	8	95	용	81	82	83	8	10	8	18	17	16	15	8	143	144	145	146	용	217	용	167	166	165	8	175	8	용	용
용	91	90	94	8	8	8	84	8	9	%	8	8	8	14	8	142	8	8	8	용	218	8	168	90	8	8	174	202	203	용
용	92	93	89	88	87	86	85	8	8	7	6	11	12	13	8	141	140	139	138	220	219	8	169	170	171	172	173	8	204	용
용	118	119	120	121	122	8	128	8	8	90	5	8	8	90	8	8	8	용	137	용	용	용	212	90	211	8	8	8	205	용
ક	126	125	124	123	127	8	129	130	131	132	4	3	2	1	P	133	134	135	136	8	215	214	213	8	210	209	208	207	206	olo
용	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Straight-line Distance

The	Sol	utio	n:																											
8	8	8	8	90	8	8	8	8	8	90	8	8	8	8	8	8	8	8	8	90	90	8	8	8	8	8	8	90	8	8
8	113	112	111	110	109	8	36	35	34	33	32	41	42	43	44	45	46	47	48	49	50	51	52	8	187	188	189	190	191	8
90	114	8	8	8	108	8	37	8	8	8	31	8	8	8	8	8	8	8	61	8	8	8	53	8	195	186	193	192	197	8
8	115	8	105	106	107	8	38	8	69	68	30	29	28	27	8	64	63	62	60	59	58	8	54	8	196	194	185	198	199	8
8	116	117	104	8	8	용	39	8	70	96	8	8	8	26	8	65	8	8	8	8	57	56	55	90	%	8	184	200	201	%
90	8	8	103	90	79	8	40	8	71	8	22	23	24	25	67	66	8	151	150	90	155	8	163	162	161	8	183	90	8	8
8	100	101	102	96	78	8	%	8	72	96	21	8	8	%		%	%	96	149	90	154	%	%	%	160	%	182	181	180	8
8	99	8	%	8	77	76	75	74	73	221	20	8						8	148	152	153	156	157	158	159	8	8	8	179	8
90	98	97	96	96	80	8	%	8	8	8	19	8	8	%	90	8	%	96	147	90	216	%	8	8	164	8	176	177	178	용
8	90	90	95	96	81	82	83	8	10	8	18	17	16	15	8	143	144	145	146	90	217	8	167	166	165	8	175	90	8	8
90	91	90	94	90	8	8	84	8	9	8	8	8	8	14	8	142	8	8	8	8	218	8	168	8	8	8	174	202	203	8
8	92	93	89	88	87	86	85	8	8	7	6	11	12	13	8	141	140	139	138	220	219	8	169	170	171	172	173	90	204	8
8	118	119	120	121	122	8	128	8	8	8	5	8	8	8	8	8	8	8	137	8	8	8	212	8	211	8	8	90	205	8
90	126	125	124	123	127	8	129	130	131	132	4	3	2	1	P	133	134	135	136	90	215	214	213	8	210	209	208	207	206	8
8	8	8	96	8	8	8	96	8	용	용	90	8	용	96	8	8	96	8	8	8	8	8	8	8	%	8	용	90	8	8

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

6.5 5.5

8.5 9.5

9.5 9.6

9.6 9.7

5.5 6.5 7.5 8.5

1.7 2.7

2.7 3.7

3.7 4.7

4.7 5.7

5.7 4.7 3.7 2.7 1.7 1.8 1.9 1.10 1.11 1.12

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	2.29 3.29
11.25 11.26	3.29 3.28 4.28
11.26 11.27	4.28 4.29
11.27 10.27	4.29 4.28 4.27 5.27 6.27 6.28 6.29 7.29 8.29
10.27 9.27	8.28 8.27 9.27 10.27 10.28
9.27 8.27	10.28 10.29
8.27 8.28	10.29 11.29
8.28 8.29	11.29 12.29
8.29 7.29	12.29 13.29
7.29 6.29	13.29 13.28
6.29 6.28	13.28 13.27
6.28 6.27	13.27 13.26
6.27 5.27	13.26 13.25
5.27 4.27	13.25 12.25
4.27 3.27	12.25 11.25 11.24 11.23 12.23
3.27 3.26 2.26	12.23 13.23
2.26 2.25 1.25	13.23 13.22
1.25 1.26	13.22 13.21
1.26 1.27	13.21 13.22 13.23 12.23 11.23 10.23 9.23 9.24
1.27 1.28	9.25 8.25 7.25 7.24 7.23 7.22 7.21 8.21
1.28 1.29	8.21 9.21
1.29 1.28 2.28	9.21 10.21
2.28 2.27	10.21 11.21
2.27 2.26 3.26	11.21 11.20
3.26 3.25 2.25	11.20 11.19 12.19 13.19 13.18 13.17 13.16
2.25 3.25	13.15 13.14 13.13 13.12 13.11 12.11 11.11
3.25 3.26 3.27 3.28	11.12 11.13 11.14 10.14 9.14 9.13 9.12 9.11
3.28 3.29 2.29	8.11 7.11 7.10

Straight-line

Paths:

13.15 13.14	9.9 10.9 11.9 11.10 11.11 11.12
13.14 13.13	11.12 11.13
13.13 13.12	11.13 11.14
13.12 13.11	11.14 10.14
13.11 12.11	10.14 9.14
12.11 11.11	9.14 9.13
11.11 11.10	9.13 9.12
11.10 11.9	9.12 9.11
11.9 10.9	9.11 8.11
10.9 9.9	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.