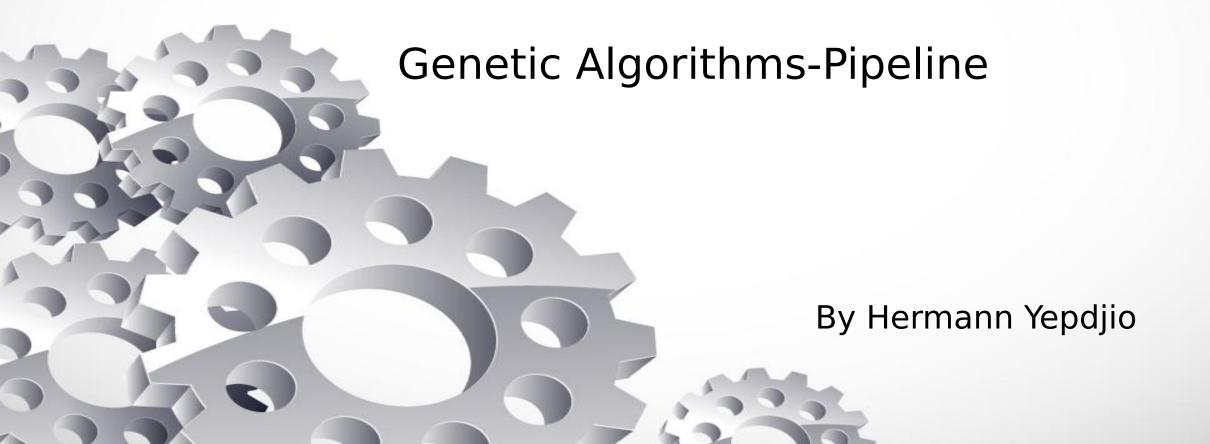
CS465-Midterm



Introduction

The project was about optimizing the operations of a crude oil extraction plant. As requirements the program should be able to find a solution that would

- maintain each one of the 16 tanks of the pipeline to about 45% of their capacity,
- maintain a constant delivery flow of about 160 gallons per hour for the whole plant,
- maximize the lifespan of the plant,
- minimize the electricity consumption.

Tools we used



To solve this problem, we considered implementing a genetic algoritm from scratch following some examples seen in class and some others found on the internet

Steps

- 1. Create a station class
- 2. Create an initial population of 16 stations
- 3. Initialize the population with random values
- 4. Simulate the functioning of the plant for 48 hours
- 5. Use the Roulette-Wheel to pick 2 parents
- 6. Apply Cross-Over to obtain new children
- 7. Replace old individuals with new children

Steps

- 8. Simulate again
- 9. Repeat the last 4 steps until the solution does not improve anymore
- 10. Apply mutation and go back to step 4

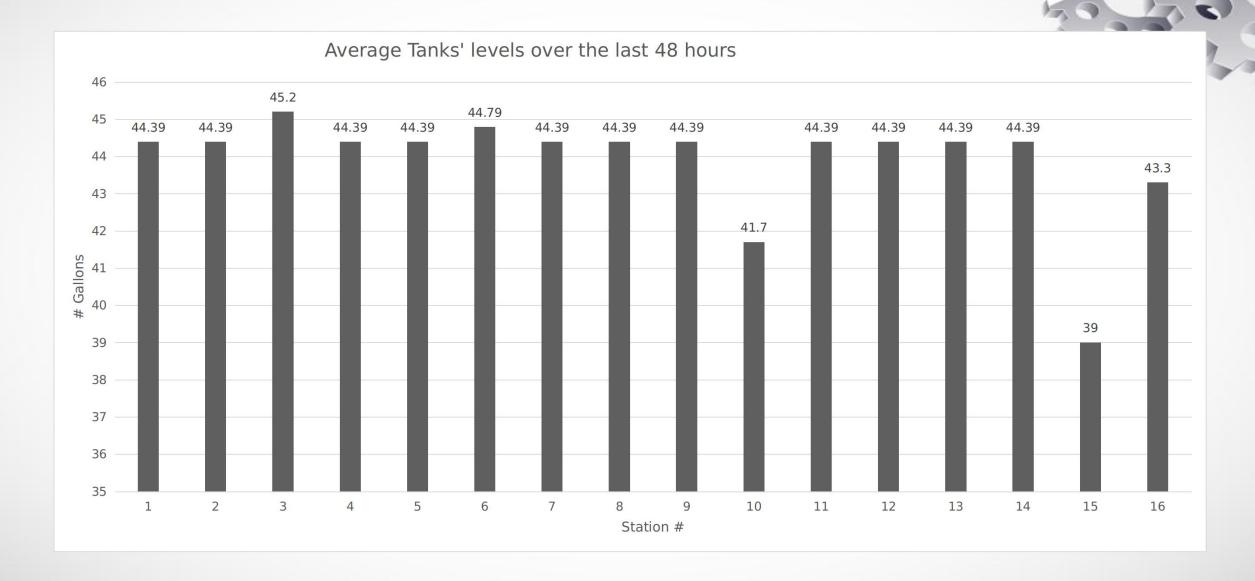
	1 ess: 0.877 dispatch: 179.	1 75812734491865 gal		4.39	11.17	11.17	1	60R	0.986
new chi	ild will replace	n station #3 and s station #6 which	has the lo					from_center	fitnos
		h pump_out swit =========							
1]	1	[1		4.39	11.17	11.17	ACCUSE OF THE PERSON NAMED IN COLUMN 1	0L []	0.986
2	!! <u>1</u>	ļļ <u>1</u>		4.39	11.17	11.17		0R	0.986
3	1	!! 1		5.20	11.09	11.09		0L	0.996
4]	1	!! 1		4.39	11.17	11.17		0R	0.986
5	1	1		4.39	11.17	11.17	- C - C - C - C - C - C - C - C - C - C	0L	0.986
6	1	1		4.79	11.13	11.13		0R	0.995
7		ļļ <u>1</u>	The second secon	4.39 4.39	11.17 11.17	11.17		0L 0R	0.986
9	1 1			4.39 4.39		11.17		.00L	0.986
10	1			1.70	11.17 10.59	10.59		.00R	0.986
11	1			4.39	11.17	11.17		20L	0.986
12	1	ii i	100	4.39	11.17	11.17		20R	0.986
13		11 1		4.39	11.17	11.17		40L	0.986
14	1	ii i	20.00	4.39	11.17	11.17	- C - C - C - C - C - C - C - C - C - C	40R	0.986
15		ii i	200	9.00	10.00	10.00		60L	0.867
16	1 1	1 1	1000	4.39		11.17	1604	60R	0.986
tion #	pump_in switc	88841274000453 gal h pump_out swit =========	$ch \mid \mid tank$					from_center	
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2		1	11 4	4.39	11.17	11.17	[] 2	.0R []	0.986
	1	1	The second secon	5.20	11.09	11.09		0L	0.996
4	1	1		4.39	11.17	11.17		0R []	0.986
	1	[] 1		4.39	11.17	11.17	ACCUSATION OF THE PROPERTY OF	0L	0.986
5 j	1	[] 1		4.79	11.13	11.13		0R	0.995
6 j		!! 1		4.39	11.17	11.17		0L	0.986
6 j	V 100	1 1	4	4.39	11.17	11.17		0R	0.986
6 7 8	1							00L	0.986
6 7 8 9	j 1	jj <u>1</u>		4.39	11.17	11.17	- C - C - C - C - C - C - C - C - C - C	-0.0	
6 7 8 9 10	1 1		jj 4:	1.70	10.59	10.59	jj 1	00R	0.927
6 7 8 9 10 11			4: 4:	1.70 4.39	10.59 11.17	10.59		00R 20L	0.986
6 7 8 9 10 11 12	1 1 1 1			1.70 4.39 4.39	10.59 11.17 11.17	10.59 11.17 11.17	1 1 1	00R 20L 20R	0.986 0.986
6 7 8 9 10 11 12 13	1 1 1 1 1		4: 4: 4:	1.70 4.39 4.39 4.39	10.59 11.17 11.17 11.17	10.59 11.17 11.17 11.17	1 1 1 1	00R	0.986 0.986 0.986
6 7 8 9 10 11 12 13 14 1	1 1 1 1 1		4: 4: 4: 4:	1.70 4.39 4.39 4.39 4.39	10.59 11.17 11.17 11.17 11.17	10.59 11.17 11.17 11.17 11.17		00R 20L 20R 40L 40R	0.986 0.986 0.986 0.986
6 7 8 9 10 11 12 13 14 15 15	1 1 1 1 1 1		4: 4: 4: 4: 4: 3:	1.70 4.39 4.39 4.39 4.39 9.00	10.59 11.17 11.17 11.17 11.17 10.00	10.59 11.17 11.17 11.17 11.17 10.00		00R	0.986 0.986 0.986 0.986 0.867
6 7 8 9 10 11 12 13 14 15 16 16	1 1 1 1 1		4: 4: 4: 4: 4: 3:	1.70 4.39 4.39 4.39 4.39	10.59 11.17 11.17 11.17 11.17 10.00	10.59 11.17 11.17 11.17 11.17		00R 20L 20R 40L 40R	0.986 0.986 0.986 0.986

ur: 1							
mental and the second		pump_out switch				Position_from_center	
1	1	1	44.39	11.17	11.17	20L	0.986
	1	1	44.39		11.17	20R	0.986
3	1	1	45.20	11.09	11.09	40L	0.996
4	1	1	44.39	11.17	11.17	40R	0.986
5	ļ 1	ļļ 1	44.39	11.17	11.17	60L	0.986
6	1]] 1	44.79	11.13	11.13	60R	0.995
7	1	[] 1	44.39	11.17	11.17	80L	0.986
8] 1]] 1	44.39	11.17	11.17	80R	0.986
9	1	ļļ 1	44.39	11.17	11.17	100L	0.986
10	! !]] 1	41.70	10.59	10.59	100R	0.927
11	! 1	!! 1	44.39	11.17	11.17	120L	0.986
12	1	[] 1	44.39	11.17	11.17	120R	0.986
13	1 1]] 1	44.39	11.17	11.17	140L	0.986
14	! !]] 1	44.39	11.17	11.17	140R	0.986
15	1	!! 1	39.00	10.00	10.00	160L	0.867
16	1 ess: 0.894	1	44.39	11.17	11.17	160R	0.986
			11 44 20				========
2	1 1	1	44.39	11.17			11 0 000
		11 1	11 44 30	AND THE PERSON NAMED IN	11.17	20L	0.986
2	In the second se	1 1	11 44.39	11.17	11.17		0.986
3	j 1	jj 1	45.20	11.17 11.09	11.17 11.09	20R 40L	0.986 0.996
4 j	j 1 1		45.20 44.39	11.17 11.09 11.17	11.17 11.09 11.17		0.986 0.996 0.986
4 i	i 1 1 1		45.20 44.39 44.39	11.17 11.09 11.17 11.17	11.17 11.09 11.17 11.17		0.986 0.996 0.986 0.986
4 5 6	1 1 1 1		45.20 44.39 44.39 44.79	11.17 11.09 11.17 11.17 11.13	11.17 11.09 11.17 11.17 11.13		0.986 0.996 0.986 0.986 0.995
4 i	i 1 1 1		45.20 44.39 44.39 44.79 44.39	11.17 11.09 11.17 11.17 11.13 11.17			0.986 0.996 0.986 0.986 0.995 0.986
4 5 6 7	1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17			0.986 0.996 0.986 0.986 0.995 0.986
4 5 6 7 8 9	1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17			0.986 0.996 0.986 0.986 0.995 0.986 0.986
4 5 6 7 8	1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17			0.986 0.996 0.986 0.986 0.995 0.986
4	1 1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L	0.986 0.996 0.986 0.986 0.986 0.986 0.986 0.986
4 1 5 1 6 7 8 9 1 1 1 1	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L 100R	0.986 0.996 0.986 0.986 0.986 0.986 0.986 0.927 0.986
4 1 5 6 7 8 9 10 11 12 12	1 1 1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 41.70 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 10.59 11.17		20R 40L 40R 60L 60R 80L 80R 100L 100R 120L	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.927 0.986 0.986
4 1 5 6 7 8 9 10 11 12 13 13	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 10.59 11.17 11.17		20R 40L 40R 60L 60R 80L 100L 100R 120L 120R	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.927 0.986 0.986
4 1 5 6 7 8 9 10 11 12 13 14 14	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 10.59 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L 100R 120L 120R 140L	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.927 0.986 0.986 0.986
4	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 41.70 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L 120R 120R 120R 140L 140R	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.986 0.986 0.986 0.986
4	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 41.70 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L 120R 120R 120R 140L 140R	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.986 0.986 0.986 0.986
4	1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 41.70 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17		20R 40L 40R 60L 60R 80L 80R 100L 120R 120R 120R 140L 140R	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.986 0.986 0.986 0.986
4	1 1 1 1 1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17			0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.927 0.986 0.986 0.986 0.986
4	1 1 1 1 1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 10.59 11.17 11.17 11.17 11.17 11.17	20R 40L 40R 60L 60R 80L 80R 100L 120R 120R 120R 140L 140R	0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.986 0.986 0.986 0.986 0.986
4	1 1 1 1 1 1 1 1 1 1		45.20 44.39 44.39 44.79 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39 44.39	11.17 11.09 11.17 11.13 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17 11.17	11.17 11.09 11.17 11.17 11.13 11.17 11.17 11.17 10.59 11.17 11.17 11.17 11.17 11.17		0.986 0.996 0.986 0.986 0.995 0.986 0.986 0.986 0.986 0.986 0.986 0.986

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File Edit View Search Terminal Help
Plant fitness: 0.964
Plant total dispatch: 165.75812734491868 gallons
Hour: 29
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
                                                   44.39
                                                               11.17
                                                                                                             0.986
                                                                           11.17
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              20R
   2
                                                                                                             0.986
                                                   45.20
                                                               11.09
                                                                           11.09
                                                                                              40L
                                                                                                             0.996
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              40R
                                                                                                             0.986
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              60L
                                                                                                             0.986
                                                   11.00
                                                               8.00
                                                                           14.00
                                                                                              60R
                                                                                                             0.244
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              80L
                                                                                                             0.986
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              80R
                                                                                                             0.986
                                                   44.39
                                                               11.17
                                                                           11.17
   9
                                                                                              100L
                                                                                                             0.986
                                                   41.70
                                                               10.59
                                                                           10.59
   10
                                                                                              100R
                                                                                                             0.927
                                                   44.39
                                                               11.17
                                                                           11.17
   11
                                                                                              120L
                                                                                                             0.986
   12
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              120R
                                                                                                             0.986
                                                   44.39
   13
                                                               11.17
                                                                           11.17
                                                                                              140L
                                                                                                             0.986
   14
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                                             0.986
                                                                                              140R
   15
                                     1
                                                   39.00
                                                               10.00
                                                                           10.00
                                                                                              160L
                                                                                                             0.867
                                                   44.39
   16
                                                               11.17
                                                                           11.17
                                                                                              160R
                                                                                                            0.986
Plant fitness: 0.877
Plant total dispatch: 179.75812734491865 gallons
Hour: 30
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
44.39
                                                               11.17
                                                                           11.17
                                                                                              20L
                                                                                                             0.986
   2
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              20R
                                                                                                             0.986
                                                               11.09
                                                   45.20
                                                                           11.09
                                                                                              40L
                                                                                                             0.996
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              40R
                                                                                                             0.986
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              60L
                                                                                                             0.986
                                                                           14.00
                                                               8.00
                                                                                              60R
                                                   5.00
                                                                                                             0.111
                                                               11.17
                                                                           11.17
                                                   44.39
                                                                                              80L
                                                                                                             0.986
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              80R
                                                                                                             0.986
   9
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              100L
                                                                                                             0.986
                                                               10.59
   10
                                                   41.70
                                                                           10.59
                                                                                              100R
                                                                                                             0.927
                                                   44.39
                                                                           11.17
   11
                                                               11.17
                                                                                              120L
                                                                                                             0.986
   12
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              120R
                                                                                                             0.986
   13
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              140L
                                                                                                             0.986
   14
                                     1
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              140R
                                                                                                             0.986
   15
                                     1
                                                   39.00
                                                               10.00
                                                                           10.00
                                                                                              160L
                                                                                                            0.867
   16
                                                   44.39
                                                               11.17
                                                                           11.17
                                                                                              160R
                                                                                                           0.986
Plant fitness: 0.964
Plant total dispatch: 165.75812734491868 gallons
Hour: 31
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
```

🙆 🖱 in hermann@hrm-GL72M-7RDX: /media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution File Edit View Search Terminal Help 16 1 44.39 || 11.17 || 11.17 160R | 0.986 Plant fitness: 0.894 Plant total dispatch: 176.88841274000453 gallons Hour: 48 Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness 0.986 44.39 11.17 11.17 20L 2 44.39 11.17 11.17 20R 0.986 3 45.20 11.09 11.09 40L 0.996 44.39 11.17 40R 4 11.17 0.986 5 44.39 11.17 11.17 60L 0.986 44.79 11.13 60R 0.995 6 11.13 7 44.39 11.17 11.17 80L 0.986 8 44.39 11.17 11.17 80R 0.986 9 44.39 11.17 11.17 100L 0.986 10 41.70 10.59 10.59 100R 0.927 11 44.39 11.17 11.17 120L 0.986 12 11.17 44.39 11.17 120R 0.986 13 44.39 11.17 11.17 140L 0.986 14 44.39 11.17 11.17 140R 0.986 15 39.00 10.00 10.00 160L 0.867 16 44.39 11.17 11.17 160R 0.986 Plant fitness: 0.894 Plant total dispatch: 176.88841274000453 gallons Mutation was just applied on station #16 Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness 11.17 11.1720L 0.986 2 44.39 11.17 11.17 20R 0.986 3 11.09 40L 45.20 11.09 0.996 4 44.39 11.17 11.17 40R 0.986 5 44.39 11.17 11.17 60L 0.986 6 44.79 11.13 11.13 60R 0.995 7 44.39 11.17 11.17 80L 0.986 8 44.39 11.17 11.17 80R 0.986 9 44.39 11.17 11.17 1 100L 0.986 10 41.70 10.59 10.59 0.927 100R 11 44.39 11.17 11.17 120L 0.986 12 44.39 11.17 11.17 120R 0.986 13 11.17 44.39 11.17 140L 0.986 14 44.39 140R 0.986 11.17 11.17 15 39.00 10.00 10.00 160L 0.867 16 26.00 15.00 10.00 160R | | 0.578 Plant fitness: 0.902 Plant total dispatch: 175.71476346772897 gallons

hermann@hrm-GL72M-7RDX:/media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution\$



Conclusion



To prevent the program to run for ever trying to find the perfect solution, I set it to stop whenever it finds a solution that has a plant fitness of 0.9 and above and an average station fitness of 0.95 and above