ECE 322
Lab Report 1

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1 Introduction

The purpose of this lab was to serve as a practical introduction to some more black box testing techniques. In this lab, the testing methods introduced were the Extreme Point Combination (EPC), and the Weak n x 1 strategy methods. We tested two programs written in Java using both of these testing strategies. The first application, named Drone takes in three arguments, and outputs either 'Success!', 'Failure', or an error message based on whether the arguments are integers ≥ 0, and their sum is less than $k = 100$. The second program, named RemoteCar takes in two arguments which represent points on a Cartesian plane, and outputs either 'Ok', 'Out of range', or an error message based on whether the point is on a circle of radius 1 about the origin. The idea for EPC testing is to identify the input domain limits, and produce all possible combinations of inputs with each of the input variables taking on a minimum value, slightly under minimum, a maximum value, and slightly over maximum value. One additional test case is added somewhere within the valid subdomain to generate a total of $4^n + 1$ test cases, where n is the dimension of inputs, or put more simply, the number of input variables. With the weak n x 1 strategy, we attempt to find linear boundaries of the problem using domain analysis. n points are selected on each linear boundary, where n is the number of input variables, and one additional point is chosen outside of each boundary. An additional point within the boundary is chosen if the boundary is open, and if the boundary is instead closed an additional point outside the boundary is chosen. In the end, with the weak n x 1 strategy, $b \times (n + 1)$ test cases are generated, where b is the number of linear boundaries, and n is the dimensionality, or the number of inputs.

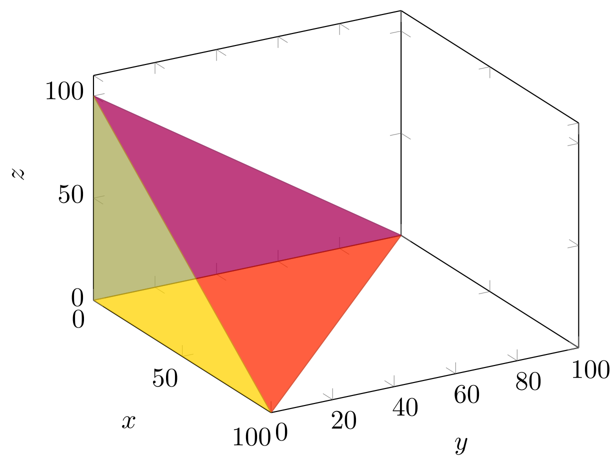
2 Task 1 - Drone

For task one in this lab, the Drone application was tested using both the EPC method and the weak n x 1 strategy. Drone is a command-line program written in java, which takes three inputs, x_1, x_2, and x_3. If $x_1 + x_2 + x_3 \leq k$, where $k = 100$, the program should output 'Success', and if not, it should output 'Failure'. The three inputs must be integers ≥ 0.

2.1 Sudomain plot

The subdomain for this problem is illustrated in the 3-Dimensional graph below:

Subdomain of Valid Inputs for the Drone Program



2.2 EPC Strategy

Using the EPC strategy, since there are 3 input variables, there are $4^3 + 1 = 65$ test cases. The values chosen were:

- max: 100
- min: 0
- slightly under min: -1
- slightly over max: 101

All the permutations of the 3 inputs taking on these values were generated and tested. An additional test case was created within the valid subdomain, which was $(x_1, x_2, x_3) = (10, 20, 30)$. The full table of test cases along with their expected inputs and outputs can be found in Appendix A of this report. The failed test cases are highlighted in red for convenience.

2.3 Weak n x 1 Strategy

Using the weak n x 1 strategy, there are 4 boundary surfaces to take into consideration. Since there are 3 inputs, we pick 3 points on each boundary surface, and one additional point outside of each boundary, for a total of $4 \times (3+1)+1 = 17$ test cases. The additional test case chosen inside the boundary was $(x_1, x_2, x_3) = (30, 20, 10)$. The table of test cases along with their expected inputs and outputs can be found in Appendix B of this report. The failed test cases are highlighted in red for convenience.

2.4 Discussion

Using both the EPC and the weak n x 1 strategy, we see that for all of the failed test cases, the input variable x_2 is a negative. For negative inputs, the program is expected to give an error telling the user that negative inputs are not valid. Instead, the program outputs 'Success!' or 'Failure!' when $x_2 < 0$.

Part 2 - Partition Testing

Task two of this lab involved partition-based testing of a triangle application. The purpose of this application is to take 3 space separated positive integers, each representing sides of a triangle, and the program is expected to tell the user whether the triangle is a scalene, isosceles, or equilateral triangle. The following equivalence classes were decided on for creating the test cases.

Triangle Equivalence Classes

From these equivalence classes, the following test cases were created:

Test cases for valid inputs

- 3 3 3 covers (1, 2, 3, 4, 7, 8)
- 4 4 5 covers (1, 2, 3, 5, 7, 8)
- 6 7 8 covers (1, 2, 3, 6, 7, 8)

Test cases for invalid inputs

- 1 2 covers (9)
- 3 4 5 6 covers (10)
- 7 8   9 covers (11)
- 8_7_6 covers (12)
- 1 −2 3 covers (13)
- 5 0 4 covers (14)
- 3 2 0.1 covers (15)
- 2 2 4 covers (16)

- 3 4 9 covers (17)
- not pressing Enter covers (18)

The results of these test cases, including expected versus actual output can be found in Appendix. Failed test cases are highlighted in red. There was one test case which failed.

- For the input where we have the case $a + b = c$, (2 2 4) in this case, the program tells us that it is a isosceles triangle instead of an invalid one. This is likely because the implementation checks validity by looking for $a + b > c$ instead of $a + b \geq c$. Similarly, with the inputs (1 2 3), the program tells us that it is a scalene triangle instead of showing an error.

Conclusion

In this lab, we were introduced to black-box testing. The techniques learned were dirty testing, error guessing, and partition-based testing. Dirty testing's strength seems to also be its weakness at the same time. That is, the test cases written are only limited by the tester's creativity. One disadvantage, however, is that one can generate a lot of extra test cases that are arguably unnecessary. That is, there is the possibility of having multiple tests which cover the same functionality of the program. This is a problem that using the partition-based testing method addressed. While equivalence testing allowed us to write significantly fewer test cases, it does not catch some unique cases. For example, if dirty testing was done instead, one might have tried the test inputs

$$1111111111\ 1111111111\ 1$$

, which returns ERROR: Invalid triangle instead of saying that it's an isosceles one. This error, and potentially others were not caught using partition-based testing. What is interesting, though is that the one test failure with inputs (2 2 4) for the Triangle program allowed for another error to be found, which is the case where an input like (1 2 3) which should cause an error instead returns 'Scalene'. Overall, it would not be fair to say that one testing method is universally better than the other, however, the tester would need to use their judgement and experience to choose an appropriate testing method for the software that they want to test.

Appendix A: Drone EPC Testing

Testid	description	x1	x2	x3	Expected	Actual
1	EPC permutation	100	100	100	Failure!	Failure!
2	EPC permutation	100	100	0	Failure!	Failure!
3	EPC permutation	100	100	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
4	EPC permutation	100	100	101	Failure!	Failure!
5	EPC permutation	100	0	100	Failure!	Failure!
6	EPC permutation	100	0	0	Success!	Success!
7	EPC permutation	100	0	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
8	EPC permutation	100	0	101	Failure!	Failure!
9	EPC permutation	100	-1	100	ERROR: Invald argument - negative value	Failure!
10	EPC permutation	100	-1	0	ERROR: Invald argument - negative value	Success!
11	EPC permutation	100	-1	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
12	EPC permutation	100	-1	101	ERROR: Invald argument - negative value	Failure!
13	EPC permutation	100	101	100	Failure!	Failure!
14	EPC permutation	100	101	0	Failure!	Failure!
15	EPC permutation	100	101	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
16	EPC permutation	100	101	101	Failure!	Failure!
17	EPC permutation	0	100	100	Failure!	Failure!
18	EPC permutation	0	100	0	Success!	Success!
19	EPC permutation	0	100	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
20	EPC permutation	0	100	101	Failure!	Failure!
21	EPC permutation	0	0	100	Success!	Success!
22	EPC permutation	0	0	0	Success!	Success!
23	EPC permutation	0	0	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
24	EPC permutation	0	0	101	Failure!	Failure!
25	EPC permutation	0	-1	100	ERROR: Invald argument - negative value	Success!
26	EPC permutation	0	-1	0	ERROR: Invald argument - negative value	Success!
27	EPC permutation	0	-1	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
28	EPC permutation	0	-1	101	ERROR: Invald argument - negative value	Success!
29	EPC permutation	0	101	100	Failure!	Failure!
30	EPC permutation	0	101	0	Failure!	Failure!
31	EPC permutation	0	101	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
32	EPC permutation	0	101	101	Failure!	Failure!
33	EPC permutation	-1	100	100	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
34	EPC permutation	-1	100	0	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
35	EPC permutation	-1	100	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
36	EPC permutation	-1	100	101	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
37	EPC permutation	-1	0	100	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
38	EPC permutation	-1	0	0	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
39	EPC permutation	-1	0	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
40	EPC permutation	-1	0	101	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
41	EPC permutation	-1	-1	100	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
42	EPC permutation	-1	-1	0	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
43	EPC permutation	-1	-1	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
44	EPC permutation	-1	-1	101	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
45	EPC permutation	-1	101	100	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
46	EPC permutation	-1	101	0	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value

47	EPC permutation	-1	101	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
48	EPC permutation	-1	101	101	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
49	EPC permutation	101	100	100	Failure!	Failure!
50	EPC permutation	101	100	0	Failure!	Failure!
51	EPC permutation	101	100	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
52	EPC permutation	101	100	101	Failure!	Failure!
53	EPC permutation	101	0	100	Failure!	Failure!
54	EPC permutation	101	0	0	Failure!	Failure!
55	EPC permutation	101	0	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
56	EPC permutation	101	0	101	Failure!	Failure!
57	EPC permutation	101	-1	100	ERROR: Invald argument - negative value	Failure!
58	EPC permutation	101	-1	0	ERROR: Invald argument - negative value	Success!
59	EPC permutation	101	-1	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
60	EPC permutation	101	-1	101	ERROR: Invald argument - negative value	Failure!
61	EPC permutation	101	101	100	Failure!	Failure!
62	EPC permutation	101	101	0	Failure!	Failure!
63	EPC permutation	101	101	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
64	EPC permutation	101	101	101	Failure!	Failure!
65	one valid test case	10	20	30	Success!	Success!

Appendix B: Drone Weak n x 1 Strategy

Testid	description	x1	x2	x3	Expected	Actual
1	x1+x2+x3=100	10	40	50	Success!	Success!
2	x1+x2+x3=100	35	45	20	Success!	Success!
3	x1+x2+x3=100	69	20	11	Success!	Success!
4	just outside of x1+x2+x3 = 100 boundary	33	34	34	Failure!	Failure!
5	x1=0, x2 + x3 < 100	0	20	30	Success!	Success!
6	x1=0, x2 + x3 < 100	0	50	20	Success!	Success!
7	x1=0, x2 + x3 < 100	0	21	36	Success!	Success!
8	just outside of x1=0 boundary	-1	25	62	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
9	x2=0, x2 + x3 < 100	32	0	16	Success!	Success!
10	x2=0, x2 + x3 < 100	48	0	25	Success!	Success!
11	x2=0, x2 + x3 < 100	42	0	14	Success!	Success!
12	just outside of x2=0 boundary	21	-1	42	ERROR: Invald argument - negative value	Success!
13	x3=0, x2 + x3 < 100	6	69	0	Success!	Success!
14	x3=0, x2 + x3 < 100	72	5	0	Success!	Success!
15	x3=0, x2 + x3 < 100	65	12	0	Success!	Success!
16	just outside of x3=0 boundary	45	7	-1	ERROR: Invald argument - negative value	ERROR: Invald argument - negative value
17	additional test case inside the boundary	10	20	30	Success!	Success!

Appendix C: RemoteCar EPC Testing

Testid	description	x	y	Expected	Actual
1	EPC permuation	-0.1	-0.1	Ok.	Ok.
2	EPC permuation	-0.1	0	Ok.	Ok.
3	EPC permuation	-0.1	1	Out of range!	Out of range!
4	EPC permuation	-0.1	1.1	Out of range!	Out of range!
5	EPC permuation	0	-0.1	Ok.	Ok.
6	EPC permuation	0	0	Ok.	Ok.
7	EPC permuation	0	1	Ok.	Ok.
8	EPC permuation	0	1.1	Out of range!	Out of range!
9	EPC permuation	1	-0.1	Out of range!	Out of range!
10	EPC permuation	1	0	Ok.	Ok.
11	EPC permuation	1	1	Out of range!	Out of range!
12	EPC permuation	1	1.1	Out of range!	Out of range!
13	EPC permuation	1.1	-0.1	Out of range!	Out of range!
14	EPC permuation	1.1	0	Out of range!	Out of range!
15	EPC permuation	1.1	1	Out of range!	Out of range!
16	EPC permuation	1.1	1.1	Out of range!	Out of range!
17	one valid test case	0	0	Ok.	Ok.

Appendix D: RemoteCar Weak n x 1 Strategy

Testid	description	x	y	Expected	Actual
1	y=1-x boundary	0.9	0.1	Ok.	Ok.
2	y=1-x boundary	0.1	0.9	Ok.	Ok.
3	just outside of y=1-x boundary	0.5	0.6	Out of range!	Ok.
4	y=1+x boundary	-0.1	0.9	Ok.	Ok.
5	y=1+x boundary	-0.9	0.1	Ok.	Ok.
6	just outside of y=1+x boundary	-0.5	0.6	Out of range!	Ok.
7	y=-(1+x) boundary	-0.9	-0.1	Ok.	Ok.
8	y=-(1+x) boundary	-0.1	-0.9	Ok.	Ok.
9	just outside of y=-(1+x) boundary	-0.5	-0.6	Out of range!	Ok.
10	y=x-1 boundary	0.1	-0.9	Ok.	Ok.
11	y=x-1 boundary	0.9	-0.1	Ok.	Ok.
12	just outside of y=x-1 boundary	0.5	-0.6	Out of range!	Ok.
13	additional test case inside the boundary	0.3	0.7	Ok.	Ok.