ECE 322
SOFTWARE TESTING AND MAINTENANCE
Fall 2015

Assignment #2

Due date: Monday, October 5, 2015 by 3:00 PM
(return to the appropriate box- 2nd floor of ECERF building)

Total: 40 points

Value 10 points

1.Consider a program that solves the following system of linear equations with unknown $\boldsymbol{x}$

$$\mathbf{A}\boldsymbol{x} = \mathbf{b}$$

where $\mathbf{A} = [a_{ij}]$, i=1,2,.., M, j=1, 2,…, N, $\mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ \dots \\ b_M \end{bmatrix}$ and $\boldsymbol{x} = \begin{bmatrix} x_1 \\ x_2 \\ \dots \\ x_N \end{bmatrix}$

(a)Discuss a testing strategy using equivalence classes. Elaborate on the valid and invalid equivalence classes. Consider situations when (i) M=N and (ii) N < M.

Solution
The equivalence classes are associated with the condition expressing whether the above set of equations is solvable. In case M=N, the condition is $\det(\boldsymbol{A}^{-1}) \neq 0$. For N < M, there is an approximate solution only.
Assuming that N=M, we have two valid equivalence classes in the M x M space of values of **A**, namely $\{ a_{11}, a_{12},\dots, a_{MM}\}$

(i) $\{ a_{11}, a_{12},\dots, a_{MM} | \det(A) = 0\}$, and
(ii) $\{ a_{11}, a_{12},\dots, a_{MM} | \det(A) \neq 0\}$

Invalid equivalence classes might be related with non-numeric entries of **A**.

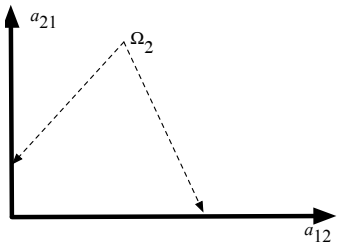
(b) using a method of equivalence classes, construct detailed test cases for N = M = 2 and

$\mathbf{A} = \begin{bmatrix} 0 & a_{12} \\ a_{21} & 0 \end{bmatrix}$ Plot the boundaries of the equivalence classes.

Solution
Given the condition under which the equations are solvable, $\det(A^{-1}) \neq 0$, we have the following two equivalence classes in the space of parameters

$$\Omega_1 = \{(a_{12}, a_{21}) \mid a_{12}a_{21} \neq 0\}$$
$$\Omega_2 = \{(a_{12}, a_{21}) \mid a_{12}a_{21} = 0\}$$

The plots of these equivalence classes are shown below



Value 10 points

2. As a part of requirements, a software system to be developed has to check the validity of a 2017 date presented as a triple in the form "month-day-weekday". Identify equivalence classes. Suggest test cases. Show them explicitly, viz. list the corresponding triples in the form "month-day-weekday". Include valid and invalid equivalence classes. In total, how many test cases are required?

Solution
To build the equivalence classes, we look at the components of the data: month, day, and weekday

month

valid equivalence classes
- 30 day long,
- 31 day long,
- February

invalid equivalence classes
- ≥ 13
- ≤ 0
- any non integer
- empty
- ≥ 3 integers

day
valid equivalence classes
- 1-30,
- 1-31,
- 1-28

invalid equivalence classes

≥ 32
≤ 0
any non integer
empty
≥ 3 integers

weekday {Mon, Tue,…, Sun} or 1…7 (alternatively 0…6)
valid equivalence classes
{1…7}
invalid equivalence classes
≥ 8
≤ 0
any non integer
empty
≥ 2 integers

Value 10 points

3. Consider a 4-dimensional input domain described as

$$W = [0, 10] \times [-5, 20] \times [0, 1] \times [-10, 35]$$

(viz. there are 4 input variables taking values from the corresponding intervals). In this domain there are 3 equivalence classes

$W1 = \{(x, y, z, w) \mid (x-1)^2 + (y-1)^2 + (z-0.7)^2 + (w-0.2)^2 \le r^2\}$
$W2 = \{(x, y, z, w) \mid (x-8)^2 + (y-17)^2 + (z-0.1)^2 + (w+6)^2 \le r^2\}$
$W3 = W-W1-W2$

where r is a certain positive number.

What is the maximal value of "r" (r_{max}) for which the domains (equivalence classes) W1 and W2 are disjoint?

The intention of this exercise is to assess effectiveness of random testing. Write a short program generating "N" random numbers (test cases) coming from a uniform distribution defined over the corresponding variables. Check if a suite of tests built in this way "covers" all equivalence classes. Record your results for several values of "N" and "r", say N = 5, 10, 20, 50, 100, 400 and selected 4-5 values of "r" coming from the admissible range of their values (0, r_{max}). Comment on the obtained results.

Solution

The equivalence classes W1 and W2 are spheres in the 3-dim space. To make them disjoint (they cannot overlap), we require that the distance between these spheres L is greater or equal to $2r_{max}$. The distance is computed as follows

$L^2 = (1-8)^2+(1-17)^2+(07-0.1)^2+ (0.2+6)^2 = 343.8$ and $L= 18.54$ so $r \le L/2$ and

$r_{max} \leq 9.27$.

Having the three equivalence classes, an idea of random testing is to randomly draw 4-tuples of numbers (test cases) coming from the uniform distribution expressed over the entire input domain. Say, we have generated N 4-tuples (x_1, y_1, z_1, w_1), and check in which subdomains these numbers are located. For low values of N, it might occur that some subdomains are not "covered" (there is no tuple located in this particular domain), especially if some subdomains are quite small (so the likelihood of drawing the number located there is quite low). This conclusion could be arrived at through experimentation.

Value 10 points

4. Consider the following specifications:

> Write a program to reformat a text in the following way. Given a text terminated by an `ENDOFTEXT` character and consisting of words separated by `BLANK` and `NEWLINE` characters, reformat it to a line-by-line form in accordance with the following rules:
>
> - Line breaks are made only where the given text has `BLANK` and `NEWLINE`,
> - Each line is filled as far as possible as long as
> - No line will contain more than `MAXPOS` characters.
>
> The resulting text should contain no blank lines. Generate an alarm and terminate the program if the text contains an oversized word.

Use error guessing to develop a collection of test cases.

Solution
A collection of possible test cases:

`MAXPOS` set to a number greater than the system default line length
A text contain nonprintable characters
A text contains digits or special characters
A line with `BLANK` as the first or last character
Words separated by two or more consecutive `BLANK`s or `NEWLINE`s
A text with an empty line
A text containing nothing but `BLANK`s and `NEWLINE`s
A text containing a very long word (of length greater than `MAXPOS`)
A text containing a word of length `MAXPOS`
A text containing no `ENDOFTEXT` character
An input text of length zero