
ECE 322
SOFTWARE TESTING AND MAINTENANCE

Mid-term Examination

SOLUTIONS

October 26, 2022
10:00 – 10:50 AM

Total 54 points

GOOD LUCK

Student Name & ID (please print) _____

I certify that during this midterm exam I have not communicated with any other student in the class:

Signature:

1	2	3	4	5	total
/10	/14	/10	/10	/10	/54

1. [10 points] A software module accepts coordinates of 3 points, A , B , and C , in the two-dimensional space of real numbers, where $A = (x_1, y_1)$, $B = (x_2, y_2)$, and $C = (x_3, y_3)$. The module determines whether these points are colinear.

- (i) What is the input domain?
- (ii) Develop a decision table, reduce it, and propose a suite of test cases.

Solution

(i) input domain: 6-dimensional space of real numbers $(x_1, y_1, x_2, \dots, y_3)$.

(ii) There are several options that could be considered here.

1. The points are colinear if the slopes of any two segments (AB, AC or AB, BC or AC, BC) are equal, namely

$$\text{slope AB: } \frac{y_2 - y_1}{x_2 - x_1} \quad \text{slope AC: } \frac{y_3 - y_1}{x_3 - x_1} \quad \text{slope BC: } \frac{y_3 - y_2}{x_3 - x_2}$$

2. The points are colinear if the distance between A and B is equal to the sum of distances between $(A$ and $C)$ and $(C$ and $B)$, namely

$$AB=AC+BC$$

or

$$AC=AB+BC$$

or

$$BC=AB+AC$$

where

$$AB=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$

$$BC=\sqrt{(x_3-x_2)^2+(y_3-y_2)^2}$$

$$AC=\sqrt{(x_3-x_1)^2+(y_3-y_1)^2}$$

$\begin{aligned} &\sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(x_3-x_1)^2+(y_3-y_1)^2} \\ &+ \sqrt{(x_3-x_2)^2+(y_3-y_2)^2} \\ &AB=AC+BC \end{aligned}$	y	n	n	n
$\begin{aligned} &\sqrt{(x_3-x_1)^2+(y_3-y_1)^2} \\ &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &+ \sqrt{(x_3-x_2)^2+(y_3-y_2)^2} \\ &AC=AB+BC \end{aligned}$	n	y	n	n
$\begin{aligned} &\sqrt{(x_3-x_2)^2+(y_3-y_2)^2} \\ &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &+ \sqrt{(x_3-x_1)^2+(y_3-y_1)^2} \\ &BC=AB+AC \end{aligned}$	n	n	y	n
colinear	x	x	x	
Not colinear				x

3. One can also consider an area of the triangle formed by A, B, C : the points are colinear if the area is equal to zero. The area $area(A, B, C)$ can be easily computed using a Heron's formula.

2. [14 points] Answer the following questions, and please be concise.

(a) **[2 points]** Is it possible to have high-quality and low-reliability software? What might be a possible example of such software? Provide an illustrative example.

Solution

Yes, software quality is a multi-faceted concept embracing a number of features; some of them could be of high quality. For instance, a web-based retailer outlet. Note, however, that if a certain standard is to be met (namely, ISO) then reliability is one of the requirements.

(b) [2 points] Give some reasons when you would **not** recommend the use of operational profiles.

Solution

Operational profiles are used when dealing with:

- (i) Large scale software.
- (ii) Many users (diversified groups of users).
- (iii) Diverse usage environment.
- (iv) Detailed statistical information about the usage of the software system.

If some of these properties are not met, it is not recommended to use operational profiles.

(c) [2 points] Why would you consider using constraints in the development of cause-effect graphs? In other words, in which sense are they useful?

Solution

Reduction of number of required test cases.

(d) [2 points] What is the difference between software validation and software verification?

Solution

Validation concerns a product; building the right product.

Verification concerns a process; building product right.

(e) [2 points] Explain a concept of coincidental correctness.

Solution

Coincidental correctness is when a specific test point follows an incorrect path, but the output variables coincidentally are the same as if the test point were to follow the correct one.

(g) [2 points] What is the relationship between Petri nets and finite-state machines? Under which condition does Petri net become a finite state machine?

Solution

A finite state machine is a special case of a Petri net. When each transition of the Petri net has a single input place and a single output place, we have a finite-state machine.

(h) [2 points] In realizing testing for a given configuration problem, considered are the following components: printers - 2, plug-ins - 3, browsers - 3, operating systems - 3, servers - 3, monitors - 2, e-mail systems - 3, software packages of numeric optimization - 3.

Solution

Combinatorial testing; $2^2 * 3^6 = 2,916$ test cases when running all combinations.

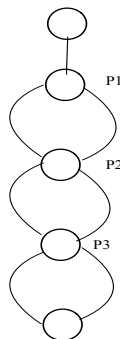
3. [10 points] Given is the following pseudocode:

```
begin program domain_test
var a, b, x, y: real;
read(x, y)
if y <= 5 then          (P1)
    a := x - y - 2;
else
    a := x + y - 2;
if a <= 3.0 then        (P2)
    b := a + x + 2y + 3;
else
    b := a - 7y + 3;
if b > 7 then           (P3)
    print(x);
else
    print(y);
end program
```

- (i) Draw a control flow graph for this pseudocode.
- (ii) Determine its cyclomatic complexity.

Solution

(i)



(ii) Cyclomatic complexity:

$$e - n + 2 = 7 - 5 + 2 = 4$$

Or alternatively number of binary decision nodes + 1 = 4

Or number of planar regions = 4

4. [10 points] Consider a program that solves the following system of linear equations with a vector of unknown variables \mathbf{x} :

$$\mathbf{Ax} = \mathbf{b}$$

where $\mathbf{A} = [a_{ij}]$, $i = 1, 2, \dots, n$, $j = 1, 2, \dots, n$, $\mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ \dots \\ b_n \end{bmatrix}$ and $\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \dots \\ x_n \end{bmatrix}$.

(a) Discuss a testing strategy using equivalence classes. Elaborate on the valid and invalid equivalence classes.

(b) How can you proceed with testing when the number of equations is larger than the number of variables, namely $\dim(\mathbf{b}) = n$, $\dim(\mathbf{x}) = m$, and $m < n$?

Solution

The equivalence classes are associated with the condition expressing whether the above set of equations is solvable. We have two valid equivalence classes in the $n \times n$ space of values of \mathbf{A} , namely, $\{a_{11}, a_{12}, \dots, a_{nn}\}$.

(i) $\{a_{11}, a_{12}, \dots, a_{nn} \mid \det(\mathbf{A}) = 0\}$, and

(ii) $\{a_{11}, a_{12}, \dots, a_{nn} \mid \det(\mathbf{A}) \neq 0\}$

Invalid equivalence classes might be related with non-numeric entries of \mathbf{A} .

In case when the number of equations is larger than the number of unknown variables, there is only an approximate solution expressed in the form $\mathbf{a} = (\mathbf{A}^T \mathbf{A})^{-1} \mathbf{A}^T \mathbf{b}$.

Here one considers two equivalence classes expressed as

(i) $\{a_{11}, a_{12}, \dots, a_{nn} \mid \det(\mathbf{A}^T \mathbf{A}) = 0\}$, and

(ii) $\{a_{11}, a_{12}, \dots, a_{nn} \mid \det(\mathbf{A}^T \mathbf{A}) \neq 0\}$

5. [10 points] The subdomain is described by the following relationships:

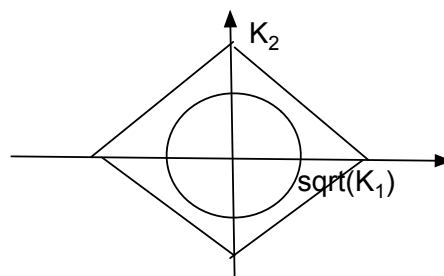
$$\begin{aligned} x_1^2 + x_2^2 &> K_1 \\ |x_1| + |x_2| &\leq K_2 \end{aligned}$$

where $0 < K_1 < K_2$.

- Plot the subdomain.
- Is the subdomain open or closed?
- Propose an EPC strategy to complete testing here; show the test cases on the plot.
- Show test cases produced by the weak $n \times 1$ strategy.

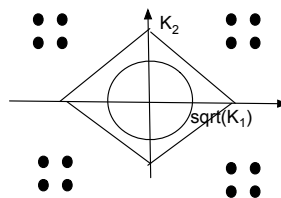
Solution

(a)



(b) Neither closed nor open.

(c) Test cases are shown below:
EPC



(d) Weak $n \times 1$ strategy; one of the boundaries is nonlinear (circle) so the number of test cases depends upon the number of linear segments used in the approximation of the nonlinear boundary.