Test Case Selection Strategies III

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This lecture covers

- Effectiveness metrics
- Proportional Sampling Strategy

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Notation

- Input Domain : D
- Domain size : d
- Number of failure-causing inputs : m
- Number of test cases : n
- Failure rate : $\theta = \frac{m}{d}$
- Sampling rate : $\sigma = \frac{n}{d}$

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Notation (continued)

Suppose we have an input domain with

- Domain size : d = 100
- Number of failure-causing inputs : m = 5
- Number of test cases : n = 20

Then, we have

- Failure rate = 5/100 = 0.05
- Sampling rate = 20/100 = 0.2

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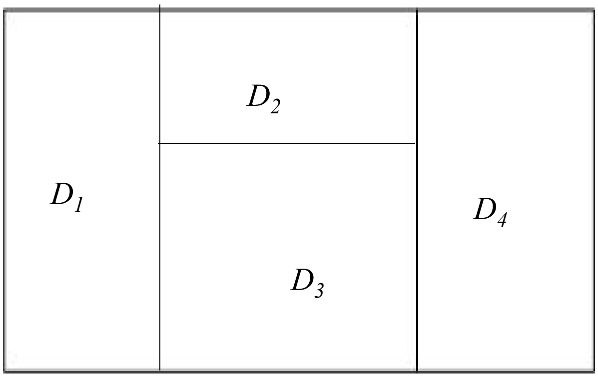
Example

Consider the following partitioning scheme



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Example (continued)

- $k = 4$, $d = 100$, $m = 5$, $n = 20$
- $d_1 = 10$, $d_2 = 20$, $d_3 = 30$, $d_4 = 40$
- $m_1 = 0$, $m_2 = 0$, $m_3 = 3$, $m_4 = 2$
- $n_1 = 2$, $n_2 = 2$, $n_3 = 6$, $n_4 = 10$

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Notation (continued)

- k partitions: $D_1, \ldots, D_k$

$$d = \sum_{i=1}^{k} d_i$$

$$m = \sum_{i=1}^{k} m_i$$

$$n = \sum_{i=1}^{k} n_i$$

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Effectiveness Measures

- Probability of detecting at least one failure (P-measure)
- Expected number of failures (E-measure)
- Expected number of test cases to detect the first failure (F-measure)

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P-measure

- Random Testing

$$P_r = 1 - (1-\theta)^n$$

- Partition Testing

$$P_p = 1 - \prod_{i=1}^{k} (1-\theta_i)^{n_i}$$

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Example (continued)

- $k = 4$
- $d_1 = 10$, $d_2 = 20$, $d_3 = 30$, $d_4 = 40$
- $m_1 = 0$, $m_2 = 0$, $m_3 = 3$, $m_4 = 2$
- $n_1 = 2$, $n_2 = 2$, $n_3 = 6$, $n_4 = 10$

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Example (continued)

- $d = 100$, $m = 5$, $n = 20$
- $m/d = 5/100 = 0.05$

$P_r = 1 - (1 - 0.05)^{**}20 = 1 - (0.95^{**}20)$
$= 0.6415$

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Example (continued)

- $m_1/d_1 = 0/10 = 0$
- $m_2/d_2 = 0/20 = 0$
- $m_3/d_3 = 3/30 = 0.1$
- $m_4/d_4 = 2/40 = 0.05$
- $n_1 = 2$, $n_2 = 2$, $n_3 = 6$, $n_4 = 10$

$P_p = 1 - ((1 - 0)^{**}2)^* ((1 - 0)^{**}2)^*$
$((1 - 0.1)^{**}6)^* ((1 - 0.05)^{**}10)$
$= 1 - (0.9^{**}6) * (0.95^{**}10) = 0.6818$

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E-measure

- Random Testing

$$E_r = n\theta$$

- Partition Testing

$$E_p = \sum_{i=1}^{k} n_i \theta_i$$

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Example (continued)

- m/d = 5/100 = 0.05
- n = 20

E_r = 20 * 0.05 = 1

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Example (continued)

- $m_1/d_1 = 0/10 = 0$
- $m_2/d_2 = 0/20 = 0$
- $m_3/d_3 = 3/30 = 0.1$
- $m_4/d_4 = 2/40 = 0.05$
- $n_1 = 2,\ n_2 = 2,\ n_3 = 6,\ n_4 = 10$

$E_p = 2*0 + 2*0 + 6*0.1 + 10*0.05$

$= 1.1$

Partition Testing versus Random Testing

Consider a case that the input domain is divided into two partitions of different sizes

Partition Testing versus Random Testing (continued)

- Random Testing - randomly select 2 test cases from the input domain
- Partition Testing - randomly select 1 test case from each partition

Partition Testing versus Random Testing (continued)

Which method is better?

Partition Testing versus Random Testing (continued)

Suppose

$d = 100$, $m = 1$, $n = 2$,

$d_1 = 80$, $d_2 = 20$, $n_1 = 1$, $n_2 = 1$

Then, we have

- $E_r = 2 * (1/100) = 0.02$
- $P_r = 1 – (1 – (1/100))**2 = 1 – (1 – 0.01)**2$
  $= 0.0199$

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Partition Testing versus Random Testing (continued)

$E_r = 0.02$ and $P_r = 0.0199$

Consider the following scenarios: $m_1 = 1$, $m_2 = 0$

We have

- $E_p = 1 * (1/80) + 1* (0/20) = 0.0125$
- $P_p = 1 – ((1 – 1/80)**1)* ((1 – 0/20)**1)$
  $= 0.0125$

Then, RT is better than PT

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Partition Testing versus Random Testing (continued)

$E_r = 0.02$ and $P_r = 0.0199$

Consider the following scenarios: $m_1 = 0$, $m_2 = 1$

We have

- $E_p = 1 * (0/80) + 1* (1/20) = 0.05$
- $P_p = 1 – ((1 – 0/80)**1)* ((1 – 1/20)**1)$
  $= 0.05$

Then, PT is better than RT

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Partition Testing versus Random Testing (continued)

Partition Testing may not be better than Random Testing

But, partition testing needs more resources!

How to make PT better than RT?

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Proportional Sampling Strategy (PSS)

- All partitions have the same sampling rates
- Random selection of test cases

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Example for PSS

- $k = 4$, $d = 100$, $n = 20$
- d_1=10, d_2=20, d_3=30, d_4=40

For n=20, if we allocate test cases as follows:

- $n_1 = 2$, $n_2 = 4$, $n_3 = 6$, $n_4 = 8$

Then, we have PSS because

$(n_1 / d_1) = (n_2 / d_2) = (n_3 / d_3) = (n_4 / d_4) = 0.2$

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Proportional Sampling Strategy (continued)

- Assumptions
  - Random selection with replacement
  - Uniform probability distribution
- The P-measure of PSS is not less than that of random testing
- The E-measures of PSS and random testing are equal

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Proportional Sampling Strategy (continued)

- conceptually simple
- applicable to any partitioning scheme
- need only to know the relative size ratios of the partitons
- in practice, the PSS may not be followed strictly

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Proportional Sampling Strategy (continued)

- $k = 4$, $d = 100$,
- $d_1 = 10$, $d_2 = 20$, $d_3 = 30$, $d_4 = 40$

If $n=13$, then impossible to have strictly PSS, that is, $n_1 = ?$, $n_2 = ?$, $n_3 = ?$, $n_4 = ?$ such that $(n_1 / d_1) = (n_2 / d_2) = (n_3 / d_3) = (n_4 / d_4)$

The Basic Maximin Algorithm

1. Set $n_i := 1$ and $\sigma_i := 1/d_i$ for $i = 1, 2, \ldots, k$
2. Set $q := n - k$
3. While $q > 0$, repeat the following:
   (a) Find j such that $\sigma_j = \min \sigma_i$
   (b) Set $n_j := n_j + 1$
   (c) Set $\sigma_j := \sigma_j + 1/d_j$
   (d) Set $q := q - 1$

Summary

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