

Test Case Selection Strategies V

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Contents

- Effectiveness and efficiency of Adaptive Random Testing (ART)
- Various ART Algorithms

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Adaptive Random Testing

for non-point failure patterns –
an even spread of random test cases will enhance
the fault detection capabilities

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Effectiveness Metrics

- P-measure
- E-measure
- F-measure is defined as the expected number of test cases required to detect the first failure

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Adaptive Random Testing

Simulation and empirical results showed that
as compared with random testing,
fewer test cases required to detect the first
failure, can be about
 $\cong 50\text{-}60\%$ of that of RT with replacement

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How to achieve “even spread”?

Different intuitions:

1. notion of the best
2. notion of exclusion
3. notion of partitioning
4.
5.
6.

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ART by the best candidate

Intuition

- Generate a set of random candidates
- Select the best candidate amongst this candidate set as the next test case; and discard the remaining candidates
 - according to a specific “*best*” criterion
 - various criteria for the best

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Fixed-Size-Candidate-Set ART

- Generate a fixed size set of random candidates
- For each candidate, find its nearest already executed test case
- Select the candidate with the greatest distance to its nearest already executed test case, as the next test case
 - this criterion also known as the maximin criterion

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ART by exclusion

Intuition

- Define an exclusion region for each already executed test case
- Repeat generating a random candidate until getting a candidate that is outside the exclusion regions of all already executed test cases, as the next test case

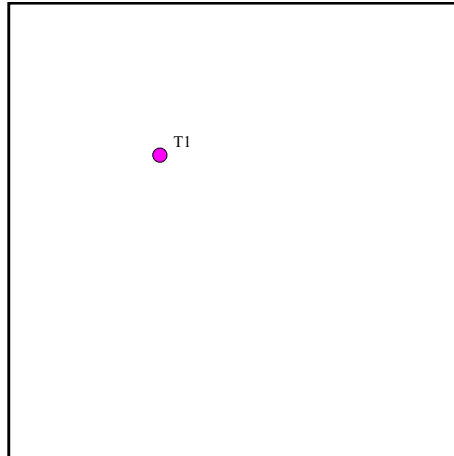
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Restricted Random Testing (RRT)

- Define an exclusion ratio which is the ratio of the size of all exclusion regions to the size of the input domain
- Define the shape for the exclusion region
- Construct the exclusion region for each of the already executed test cases

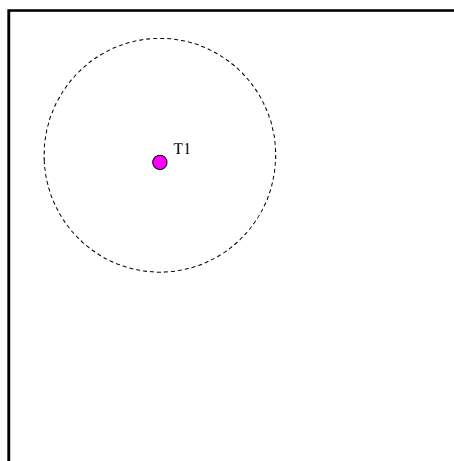
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ART by exclusion



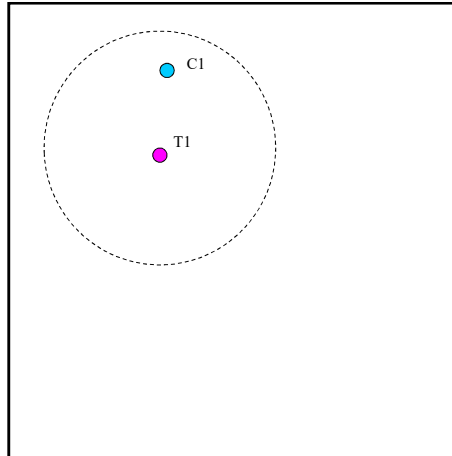
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ART by exclusion



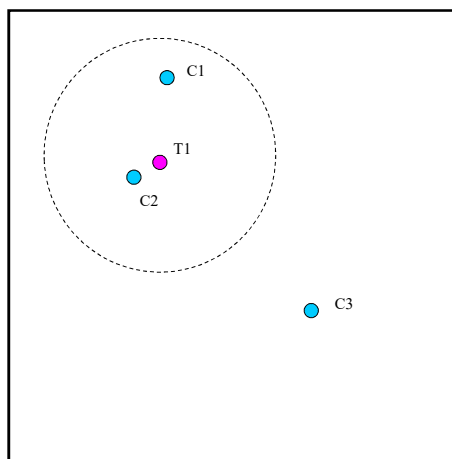
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ART by exclusion



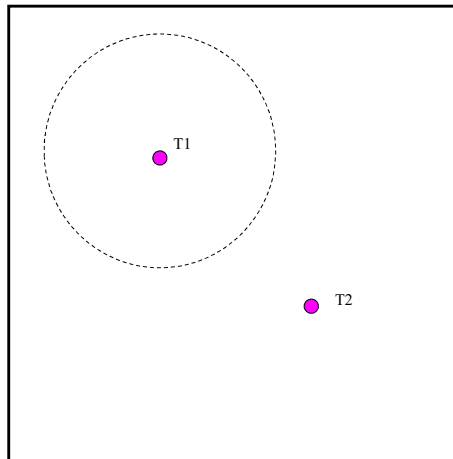
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ART by exclusion



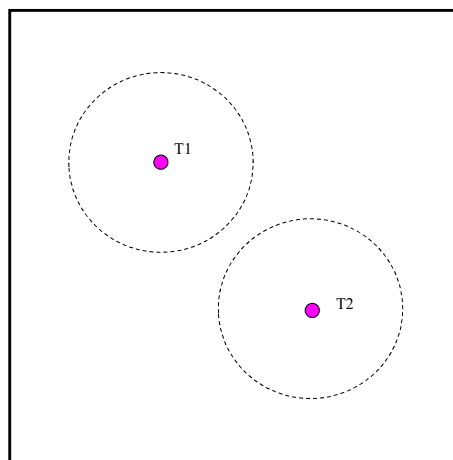
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ART by exclusion



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ART by exclusion



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ART by partition

Intuition

- Divide the input domain into partitions
- Select a partition as the target partition
- Select a random input from the target partition as the next test case

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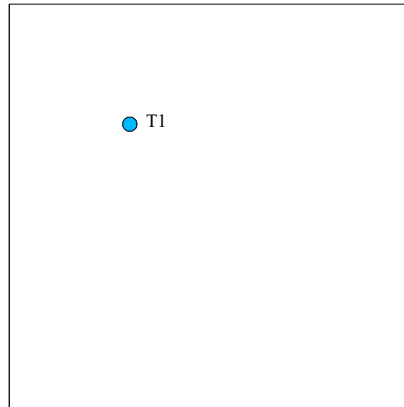
ART by partition

ART by random partition

- Use the most recent already executed test case to divide the input domain
- Select the partition with the largest size as the target partition
- Select a random input from the target partition as the next test case

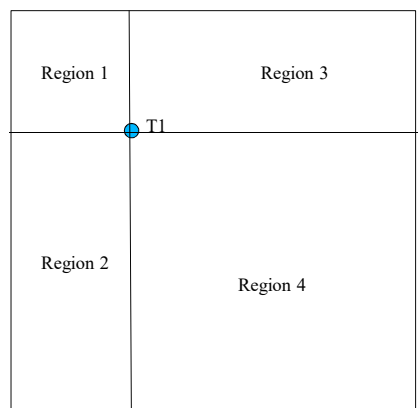
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ART by Random Partition



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ART by Random Partition



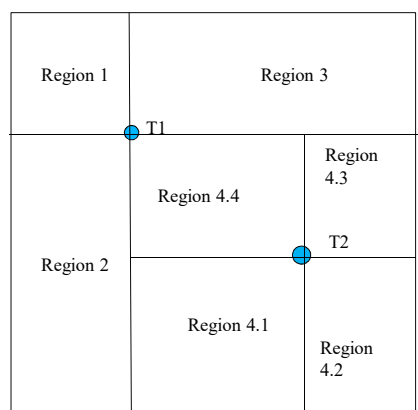
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ART by Random Partition



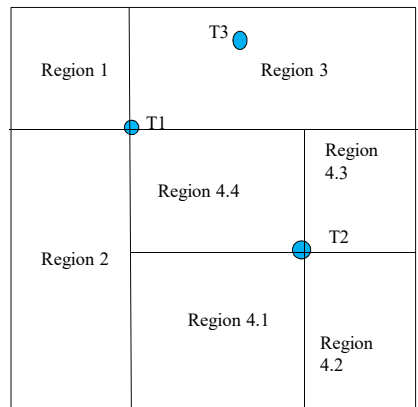
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ART by Random Partition



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ART by Random Partition



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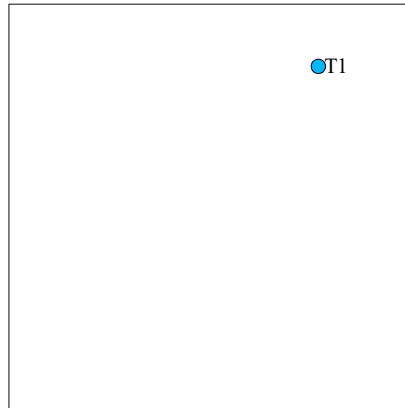
ART by partition

ART by bisection

- Bisect the partitions whenever necessary
- Select the partition without containing any already executed test cases as the target partition
- Select a random input from the target partition as the next test case

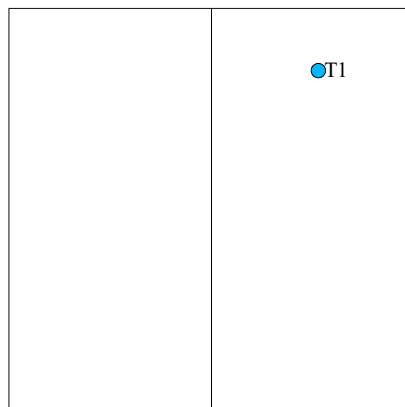
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ART by Bisection



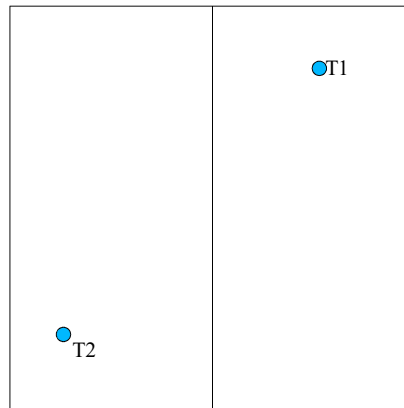
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ART by Bisection



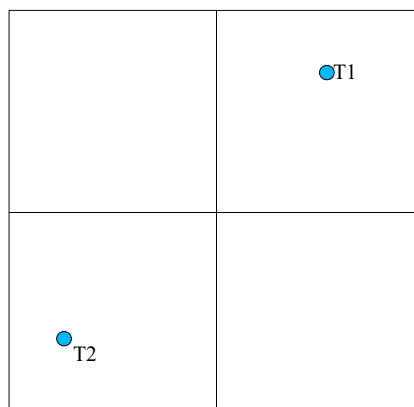
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ART by Bisection



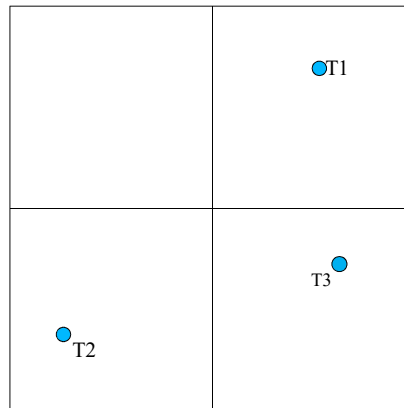
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ART by Bisection



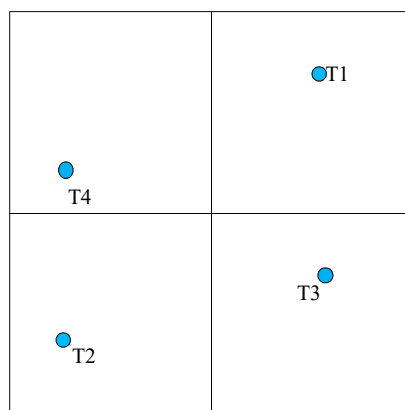
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ART by Bisection



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ART by Bisection



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Efficiency of ART

As compared with RT, ART requires more computation times to generate test cases.

Efficiency – uses of time and memory

Effectiveness – failure detection capability

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Improvement of Efficiency of ART

Two common approaches:

- Forgetting
- Mirroring

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Forgetting

Intuition

Forget some or all of the already executed test cases

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Forgetting (continued)

Process:

- start the forgetting process whenever the number of already executed test cases reaches a threshold

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Forgetting (continued)

- Random forgetting
 - Randomly forget a previously executed test case
- Forget the oldest
 - Forget the first test case amongst the previously executed test cases which are currently available
- Total forgetting
 - Forget all previously executed test cases which are currently available

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Adaptive Random Testing

Simulation and empirical results showed that as compared with random testing, fewer test cases required to detect the first failure, can be about $\cong 50\text{-}60\%$ of that of RT with replacement

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ART may be a cost-effective alternate to RT

Factors to be considered:

- Effectiveness – F-measure
- Efficiency – test case generation time
- Program execution time

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Summary

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References

- R. Huang, W. Sun, Y. Xu, H. Chen, D. Towey and X. Xia, A Survey on Adaptive Random Testing, IEEE Transactions on Software Engineering, in press.
- Z. Zhang, Y. Wang, Z. Wang and J. Qian, How to Effectively Reduce Tens of Millions of Tests: An Industrial Case Study on Adaptive Random Testing, IEEE Transactions on Reliability, Vol..68(4), 1429-1443, 2019.