Fundamentals of Test Case Selection: Diversity, Diversity, Diversity

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***Abstract*—Our recent investigations in software testing reveal that diversity constitutes the underlying foundation in many test case selection strategies. This talk attempts to provide an overview of the concept of diversity in test case selection through two families of test case selection strategies, namely, random testing and partition testing. We also present some areas of software testing where the application of data mining techniques shows great potential in identifying key aspects of diversity in various forms.**

***Keywords*: Adaptive Random Testing, Partition Testing, Proportional Sampling Strategy, Software Testing.**

When comparing the failure detection effectiveness of test case selection strategies, there are two common approaches. One approach involves using the same number of test cases for each strategy. In this approach, we may compare the probability of detecting at least one failure or the number of failures detected. The other approach looks at how many test cases would be required to detect the first failure. Since each effectiveness metric only measures certain aspects of effectiveness, a test case selection strategy that outperforms another strategy with respect to one particular effectiveness metric does not necessarily have a better performance with respect to another effectiveness metric.

Partition testing basically divides the set of all possible inputs (referred to as the input domain) into disjoint partitions from which test cases are selected. Since partitioning the input domain unavoidably incurs some overheads, it is natural to investigate under what conditions partition testing will perform better than alternative strategies without partitioning [7]. If the test case selection strategy for each partition is random, a sufficient condition for better performance is known as the proportional sampling strategy [5]. In the proportional sampling strategy, the number of test cases selected from a partition is proportional to the size of the corresponding partition. Proportional sampling strategy is guaranteed to have a probability of detecting at least one failure, not smaller than that of random testing.

Random testing is a simple but basic test case selection strategy. Based on the intuition that inputs which reveal failures (referred to as the failure-causing inputs), tend to cluster together, an approach to improve random testing is to evenly spread the random test cases, which gives rise to the family of adaptive random testing methods [3]. There are various techniques to achieve an even spreading of test cases [1, 6]. Experimental results show that adaptive random testing normally uses fewer test cases than random testing to detect the first failure. Adaptive random testing can also be classified as a failure-based testing technique. By failure-based testing techniques, we mean those techniques which make use of the information about the failure-causing inputs such as the shape, size, distribution, etc, of the failure patterns formed by the failure-causing inputs to guide the testing [4]. We believe the data mining techniques have great potential in the area of failure-based testing.

Intuitively speaking, the proportional sampling strategy also imposes an even spread of random test cases, that is, a form of adaptive random testing. However, the development of proportional sampling strategy does not make use of any assumptions about the failure patterns; by contrast, adaptive random testing does make use of the assumption that failure-causing inputs tend to cluster together. So, is there a more basic intuition underlying both of these testing strategies? We believe that the answer is *diversity*. This has triggered us to consider the role of diversity in various test case selection strategies. For readers who are interested to have more detailed description, they may consult Chen *et al.* [2].

Apart from fault-based techniques which assume certain types of faults as targets, diversity seems to be implicitly considered, if not explicitly, in the design of many test case selection strategies. This is understandable because there is never an impossible way to make a fault. Intuitively speaking, diversity attempts to cover various possibilities. Consider the control coverage testing techniques, such as, statement coverage, branch coverage, path coverage, which effectively achieve diversity with respect to statements, branches, paths. Similarly,

diversity is implied in data-flow coverage testing, equivalence class testing, category-choice testing, combinatorial testing, etc.

Our identification of *diversity* (or equivalently, *dissimilarity*) as a core factor in many test case selection strategies and the investigation of adaptive random testing have given rise to several potential research projects as follows:

1) Random sequence has been used as a benchmark in various fields of computer science. It is worthwhile to investigate the use of adaptive random sequence instead of random sequence [2].
2) A theory of software testing [4].
3) Application of data mining techniques to software testing - failure-based testing and test case diversity [2].
4) Mirroring - a problem solving technique [1].

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