Is Operator-Based Mutant Selection Superior to Random Mutant Selection?

Abstract :

This paper addresses the critical question in mutation testing: whether operator-based mutant selection outperforms random mutant selection in terms of efficiency and effectiveness. Mutation testing, a fundamental technique in software testing, involves generating mutants (faulty versions of the software) to evaluate the capability of test suites. However, due to the high computational costs associated with compiling and executing a large number of mutants, selecting a representative subset becomes essential. While operator-based selection has been the focus of most research, proposing that certain mutation operators are sufficient to represent the entire mutant set, this study challenges this notion by empirically comparing operator-based selections with random selections. The findings surprisingly reveal that operator-based selection does not necessarily provide significant advantages over random selection, indicating that random selection might even be a preferable choice in some contexts.

Chapter-by-Chapter Summary:

1. Introduction :

The introduction lays the groundwork for the study by outlining the importance of mutation testing in assessing the quality of software test suites. Mutation testing involves generating mutants of the software under test (SUT) by introducing small faults. These mutants are then used to challenge the test suites; the goal is for the test suite to detect (or "kill") the mutants, thereby demonstrating its effectiveness in uncovering real faults. However, the process is computationally expensive, motivating the need for efficient mutant selection techniques. The paper questions the prevailing assumption that operator-based mutant selection, which focuses on choosing mutants generated by a specific set of mutation operators, is superior to randomly selecting mutants.

2. Experimental Design :

This section details the comprehensive experimental setup designed to compare the effectiveness and stability of operator-based and random mutant selection techniques. The authors describe the selection of subject programs, mutation operators, and the metrics used for evaluation. A significant part of the experimental design involves outlining how the selected mutants will be compared across various dimensions, including their ability to represent the full set of generated mutants and their impact on the mutation testing process's overall computational costs.

3. Results :

The results section presents the findings from the empirical comparison between operator-based and random mutant selection techniques. Contrary to common beliefs, the study finds no significant advantage of operator-based selections over random selections in terms of representing the full set of mutants. These results suggest that the efficiency of mutant selection may not hinge on the specific selection strategy but rather on the particular characteristics of the mutants themselves and the context in which they are used.

4. Discussion :

The discussion delves into the implications of the findings, suggesting a reevaluation of the efficacy of operator-based mutant selection. The authors propose that the lack of a clear advantage for operator-based selection challenges the current understanding of mutation testing's best practices and calls for further research into alternative mutant selection strategies. They also speculate on the potential for combining operator-based and random selection methods to achieve a more effective balance between computational efficiency and testing thoroughness.

5. Related Work :

This section reviews the landscape of research in mutant selection for mutation testing, situating the current study within the broader context of efforts to improve the efficiency of mutation testing. The authors provide an overview of previous studies that have explored both operator-based and random mutant selection, highlighting the gaps in knowledge that their research aims to fill.

6. Conclusion and Future Work :

Concluding the paper, the authors reiterate their finding that operator-based mutant selection does not necessarily offer a significant advantage over random selection. This conclusion calls into question the current focus on developing and refining operator-based selection techniques in mutation testing research. The authors suggest directions for future research, including exploring new criteria for mutant selection and investigating the potential benefits of hybrid selection strategies that combine elements of both operator-based and random selection.