

Dynamic symbolic execution (concolic execution)

Seminar: Understanding of configurable software systems

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1 Abstract

Concolic execution [7] is a software verification technique that performs symbolic execution together with concrete input values. Concrete values are selected with the help of a constraint solver to guide a program flow in a particular direction. The selection of concrete values helps to scale the verification to a larger program as it makes the symbolic constraints smaller by selecting specific branches in the program. Compared to random execution, this allows us to guide the analysis in a direction likely to have bugs which makes this technique powerful. However, in doing so we sacrifice the completeness of the analysis in favor of the depth of analysis. The sheer number of branches in a large program makes it difficult to perform a complete analysis, so we have to prioritize the branches likely to contribute to finding a bug. There have been a lot of studies to deal with this path explosion problem. In this paper, I have presented state-of-the-art methods to deal with this problem.

2 Introduction

- What is it?
- Where did it start?
- How does it work?
- Give an example
- Why is it important?
- It's contributions
- It's limitations
- Example of the use of this technique in finding bugs in configurable system
eg result of SAGE, EXE, etc.

3 Body

3.1 2007: Performing dynamic test generation compositionally

[6, paper]

Gist: The general idea behind this new search algorithm is to perform dynamic test generation compositionally, by adapting (dualizing) known techniques for interprocedural static analysis to the context of automated dynamic test generation.

Methodology: new search algorithm called SMART which stands for *duce a new algorithm, dubbed SMART for Systematic Modular Automated Random Testing*, a more efficient search method than DART without compromising completeness. It tests functions in isolation, collects testing results as function summaries expressed using preconditions on function inputs and postconditions on function outputs, and then re-use those summaries when testing higher-level functions.

A SMART search performs dynamic test generation compositionally, using function summaries as defined previously. Those summaries are dynamically computed in a top-down manner through the call-flow graph *GP*. Starting from the top-level function, one executes the program (initially on some random inputs) until one reaches a first function whose execution terminates on a return or halt statement. One then backtracks inside as much as possible using DART, computing summaries for that function and each of those DART-triggered executions. When this search (backtracking) is over, one then resumes the original execution where it was called, this time treating it essentially as a black-box, i.e., without analyzing it and re-using its previously computed summary instead.

Result: SMART can perform dynamic test generation compositionally without any reduction in program path coverage. We also show that, given a bound on the maximum number of feasible paths in individual program functions, the number of program executions explored by SMART is linear in that bound, while the number of program executions explored by DART can be exponential in that bound. SMART = scalable DART

3.2 2006: Software Partitioning for Effective Automated Unit Testing

[5]

Gist: present an approach that identifies control and data inter-dependencies between software components using static program analysis, and divides the source code into units where highly-intertwined components are grouped together. Those units can then be tested in isolation using automated test generation techniques and tools, such as dynamic software model checkers

Methodology: group together functions or components that share interfaces of complexity higher than a particular threshold. Complexity is determined by the popularity and sharing of code. The idea is that if the function is very popular and is being called from a lot of places then it is likely that it is not closely liked

to any component. And, the sharing of code meaning if two functions share many of the same functions then it is likely that the higher level operation they perform is close to each other.

Configurability part: evaluated the effectiveness by applying the algorithm to the open source implementation of oSIP protocol (<http://www.gnu.org/software/osip/osip.html>) which is a telephony protocol for call establishment.

Result: showing that auto-matic software partitioning can significantly increase testcoverage without generating too many false alarms causedby unrealistic inputs being injected at interfaces betweenunits

3.3 2007: Hybrid concolic testing (**)

Gist:

Methodology:

Configurability part:

Result:

3.4 paper??

Gist:

Methodology:

Configurability part:

Result:

4 Different catagorical bodies

- summerize, give an overview of the main points of each source and combine them into a coherent whole
- Analyze and interpret: don't just paraphrase other researchers—add your own interpretations where possible, discussing the significance of findings in relation to the literature as a whole
- Critically evaluate: mention the strengths and weaknesses of your sources
- Write in well-structured paragraphs: use transition words and topic sentences to draw connections, comparisons and contrasts

5 Conclusion

6 Papers

- 2006: they worked on backtracking algorithms for search heuristics [17]
- 2007: they combined the fuzzing techniques to improve the coverage [11] [6] [8]
- 2008: Heuristic based approach to select the branches [1]
- 2009: they worked on the fitness guided approach to improve the coverage [16]
- 2013: they boosted concolic testing by subsuming paths that are guaranteed to not hit a bug with their interpolation technique [9]
- 2014: they introduced a concept of context guided search strategy [13]
- 2018: automatic selection of suitable heuristic [2]
- 2018: template guided approach [3]
- 2018: based on probability of program paths and the cost of constraint solving [14]
- 2018: they improved the speed of SMT solver by removing the IR layer making it more practical to keep bigger constraints [18]
- 2019: fuzzy search strategy [12]
- 2019: adaptably changing search heuristics [4]
- 2021: Pathcrawler: proposed different strategies to improve the performance of concolic execution on exhaustive branch coverage [15]
- 2022: Dr. Pathfinder [10] combined concolic execution with deep reinforcement learning to prioritize deep paths over shallow ones for hybrid fuzzing

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