Prioritizing Test Cases for Resource Constraint Environments Using Historical Test Case Performance Data

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Introduction

• Changing the software
  – the SW may regress

• Regression Testing (RT)?
  – the re-running of all test cases
  – be costly or even infeasible

• To reduce the cost of RT
  – regression test selection (RTS)
  – test cases prioritization
Introduction (cont’d)

- Most prioritization techniques
  - memoryless
  - based only on the analysis of source code and test case
  - ignoring historical test case performance data
  - taking a one-time testing model

- History-based regression testing
  - considers only effect of last execution of test cases to calculate the selection probability of test cases

- A new equation
  - considers the environment time and resource constraints
  - historical effectiveness in fault detection, each test case’s execution history, the last priority
Background

- Test Case Prioritization

The Test Case Prioritization Problem. Given: $T$, a test suite; $PT$, the set of permutations of $T$; $f$, a function from $PT$ to the real numbers.

Problem: Find $T' \in PT$ such that

$$(\forall T'' \ (T'' \in PT) \ (T'' \neq T') \ [f(T') \geq (T'')].)$$

Search Algorithms for Regression Test Case Prioritization, TSE(2007)
Zheng Li at al.

- NP-Hard basically
- heuristic or sub-optimal solutions: code-based (coverage, fault-exposing potential prioritization), model-based prioritization, history-based test prioritization etc.
Background (cont’d)

• History-Based Test Case Prioritization
  – \( P_{tc,t}(H_{tc}, \alpha) \): selection probability of each test case based upon execution history
    • \( H_{tc} \): a set of \( t \), time-ordered \( \{h_1, h_2, ..., h_t\} \) observations drawn from previous runs of TC

\[
\begin{align*}
P_0 &= h_1 \\
P_k &= \alpha h_k + (1 - \alpha)P_{k-1}, \ 0 \leq \alpha \leq 1, \ k \geq 1
\end{align*}
\]

Jung-Min Kim et al.

– Ways to define \( H_{tc} \)
  • Execution history
  • Demonstrated fault detection effectiveness
  • Coverage of program entities
The proposed Approach

• Priority factor 1
  – Number of regression test sessions the test case executes: $f_{c_k}$
  – Number of test sessions it reveals fault(s): $e_{c_k}$

$$PR_k \approx \frac{f_{c_k}}{e_{c_k}}$$

$$f_{c_k} = \sum_{i=1}^{k-1} f_i, f_i = \begin{cases} 1 & \text{if tc has revealed fault in test session } i \\ 0 & \text{otherwise} \end{cases}$$

$$e_{c_k} = \sum_{i=1}^{k-1} e_i, e_i = \begin{cases} 1 & \text{if tc has been executed in test session } i \\ 0 & \text{otherwise} \end{cases}$$

Historical Fault Detection Effectiveness
The proposed Approach

• Priority factor 2
  – A period of time that a test case is not being executed

\[ h_0 = 0 \]
\[ h_k = \begin{cases} h_{k-1} + 1 & \text{if tc has been executed in test session } i \\ 0 & \text{otherwise} \end{cases} \]
The proposed Approach

• Priority factor 3
  – the recent priority of each test case in each test suit during past executions

\[ PR_{k-1} \]
The proposed Approach

- Equation of each test case priority in the $k_{th}$ execution

$$PR_k = \alpha \frac{fc_k}{ec_k} + \beta PR_k + \gamma h_k \quad 0 \leq \alpha, \beta, \gamma < 1, \ k \geq 1 \quad (8)$$

- $PR_0$: the percentage of code coverage of the test case
Empirical Studies

- Proposed approach vs random ordering approach
  - 7 programs from Siemens suite, one program from Space benchmark program
  - 1000 test suits

- Evaluation Metric: Average Percentage of Fault Detection
  
  \[ APFD = 1 - \frac{TF_1 + TF_2 + \ldots + TF_m}{nm} + \frac{1}{2n} \]

  - \( n \): the number of test cases
  - \( m \): the number of existing faults
  - \( TF_i \): the place of a test case in ordered suite which first reveals the fault \( i \)
Empirical Studies

H. space
References

- **Research papers**

- **Survey papers**
Appendix

Regression Test Selection Techniques: A Survey

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Overview paper

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Regression testing is an important and expensive activity that is undertaken every time a program is modified to ensure that the modifications do not introduce new bugs into previously validated code. An important research problem, in this context, is the selection of a relevant subset of test cases from the initial test suite that would minimize both the regression testing time and effort without sacrificing the thoroughness of regression testing. Researchers have proposed a number of regression test selection techniques for different programming paradigms such as procedural, object-oriented, component-based, database, aspect, and web applications. In this paper, we review the important regression test selection techniques proposed for various categories of programs and identify the emerging trends.

Povzetek: Podan je pregled tehnik izbora testov za regresijsko testiranje programov.

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Regression testing minimization, selection and prioritization: a survey

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SUMMARY

Regression testing is a testing activity that is performed to provide confidence that changes do not harm the existing behaviour of the software. Test suites tend to grow in size as software evolves, often making it too costly to execute entire test suites. A number of different approaches have been studied to maximize the value of the accrued test suite: minimization, selection and prioritization. Test suite minimization seeks to eliminate redundant test cases in order to reduce the number of tests to run. Test case selection seeks to identify the test cases that are relevant to some set of recent changes. Test case prioritization seeks to order test cases in such a way that early fault detection is maximized. This paper surveys each area of minimization, selection and prioritization technique and discusses open problems and potential directions for future research. Copyright © 2010 John Wiley & Sons, Ltd.