STUDY ON THE COST/BENEFIT/OPTIMIZATION OF
SOFTWARE SAFETY TEST

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1. Introduction

Although the safety-critical system has high demand on safety, the cost of software test therefore must be taken account of. In the test of railway computer interlocking software carried out, the safety test for a station software last several months, therefore, in order to reduce the test time, it is practical to choose functions from the function set to test through optimization. Software safety test is realized by running testing cases at the cost of labor and time. It is expected to detect dangerous function defects and reduce system loss to gain benefit. Optimization strategy is a best choice to consider testing cases.

2. The Benefit and Cost of Software Safety Test in Railway Interlocking System

Software testing benefit is considered from the angle of damage degree caused by function defects and its detection frequency. According to correlative standard, there are five safety importance degree levels, D={d0,d1,d2,d3,d4}, m=4, and five failure frequency levels, R={r1,r2,r3,r4,r5}, n=5. As to a certain function fijk, whether testing or not should be decided first (λijk designates 0 and 1 in turn). If testing is chosen, gijk is the defect detection probability and the defects should be modified. Therefore, the general benefit H is:

\[ H = \sum_{i=0}^{4} \sum_{j=1}^{5} \sum_{k=1}^{4} \lambda_{ijk} (a_{ijk} P_{ijk} + g_{ijk} a_{ijk} P_{ijk} + \text{other terms}) \]

where H is the discount of fijk’s benefit, lijk is the probability of fijk’s not causing accident when fijk has not been verified.

CSST is related to many factors, according to the fact and the test flow, we can conclude that:

\[ C = c_1(\text{software cost}) + c_2(\text{hardware cost}) + c_3(\text{wages of the testers}) + c_4(\text{the cost of error repairing}) \]

\[ \sum_{i=0}^{4} \sum_{j=1}^{5} \sum_{k=1}^{4} \lambda_{ijk} (a_{ijk} P_{ijk} + g_{ijk} a_{ijk} P_{ijk} + \text{other terms}) \]

3. Optimization Strategy

How to choose functions from the function set to form a function test set so as to increase the benefit and reduce the cost as much as possible, is what we are concerning. This is a linear programming problem, the formal form of it is:

\[ \text{min} \sum_{i=0}^{4} \sum_{j=1}^{5} \sum_{k=1}^{4} \lambda_{ijk} (a_{ijk} P_{ijk} + g_{ijk} a_{ijk} P_{ijk} + \text{other terms}) \]

\[ \text{s.t.} \sum_{i=0}^{4} \sum_{j=1}^{5} \sum_{k=1}^{4} (\mu e^{\alpha} + \rho)(\sigma e^{\beta} + \omega)[l_{ijk} + \lambda_{ijk} (s_{ijk} - l_{ijk})] \geq H_0 \]

where H is the value of benefit that must be obtained. This expression is used in calculating the minimum value of C under the condition that H is no smaller than H0. A programming equation also can be built to calculate the maximum value of H under the condition that C is no larger than C0.

On this basis, with the characteristics of railway computer interlocking test considered, the cost and benefit of the necessary function testing part can be calculated first and optimization strategy be applied in the remaining part.