Testability integrated evaluation method based on testability virtual test data

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Abstract Testability virtual test is a new test method for testability verification, which has the advantages such as low cost, few restrictions and large sample of test data. It can be used to make up the deficiency of testability physical test. In order to take the advantage of testability virtual test data effectively and to improve the accuracy of testability evaluation, a testability integrated evaluation method is proposed in this paper based on testability virtual test data. Considering the characteristic of testability virtual test data, the credibility analysis method for testability virtual test data is studied firstly. Then the integrated calculation method is proposed fusing the testability virtual and physical test data. Finally, certain helicopter heading and attitude system is presented to demonstrate the proposed method. The results show that the testability integrated evaluation method is feasible and effective.

1. Introduction

Testability, which is a key design feature of equipment, is regarded seriously in the aeronautics field. Testability verification is an important instrumentality to test and evaluate whether the testability level of the unit under test (UUT) is achieved according to the requirements stated in the compact. Generally, testability verification usually focuses on the physical test method that is based on the faults injection. With test data, the testability of the UUT can be evaluated with the classical statistical theory.[1,2] However, due to the physical location restrictions of some faults and the destructive of fault injection, the testability physical test data (TPTD) is usually poor, so the accuracy of evaluation results is affected.[2–4]

In order to adapt to the new requirements of equipments for the evaluation accuracy, period, funding and test risk, more and more attention has been paid to the testability virtual test, which is a new verification technology.[5,6] The testability virtual test data (TVTD) is acquired by the virtual injection and virtual measurement of faults. With the advantages of virtual test, such as low cost, high efficiency, low risk, process controllability, fewer restrictions to fault injection and so on, a wealth of test data can be acquired in testability virtual test. Theoretically, the testability can be evaluated by using the TVTD directly, if the TVTD is credible completely. So the problem that the TPTD is lacking can be solved well and the accuracy of the evaluation conclusion can be improved. Nevertheless, because the testability virtual test is still

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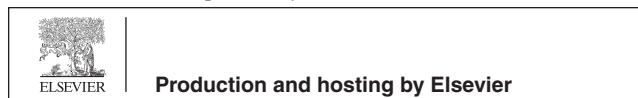
in the beginning, and the technology is still immature, meanwhile, owing to the limitations of modeling and simulation technology, the credibility of the TVTD is not high.[7] In this situation, if the testability index is calculated only based on the TVTD, the credibility of the evaluation conclusion must be low. Therefore, it is significant to find a way to evaluate the equipment' testability index with TVTD.

The credibility of the TPTD is high while the sample size is usually small. Meanwhile, the sample size of the TVTD is large while the credibility is low. Therefore, it is obvious that the TPTD and TVTD are of the complementary relationship on the sample size and credibility. In order to take advantage of testability virtual test data and improve the accuracy of testability evaluation, the TVTD and TPTD are integrated to compute the testability index in this paper. Up to now, though the research of integrated calculation based on information fusion is plenty, the research of testability integrated evaluation method fusing the TVTD and TPTD is few.

To achieve this idea, an integrated evaluation method that is based on the TVTD is proposed in this paper firstly. Then the key technologies are studied: how to analyze the credibility of virtual test data qualitatively and quantitatively, and how to fuse the TVTD and TPTD to evaluate the testability considering the credibility of the virtual test data. At last, certain helicopter heading and attitude system is presented to demonstrate the proposed method.

2. Overall structure of the integrated evaluation method

Considering the characters of TPTD and TVTD, the TPTD and TVTD are integrated to evaluate the testability index in this paper. The overall structure of the integrated evaluation method is shown in Fig. 1.

Firstly, the TPTD is taken as the standard to analyze the credibility of the TVTD, including dynamic consistency check, credibility calculation and static consistency check. Secondly, the TVTD is taken as the prior information to ascertain the prior distribution of testability index. Then the posterior distribution calculation of testability index is obtained. At last, the TPTD and TVTD are integrated together to calculate the testability index.
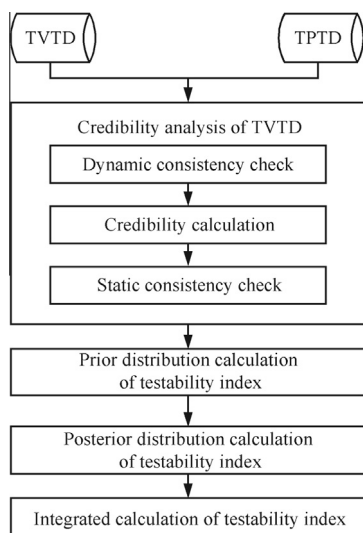

Fig. 1 Overall structure of the integrated evaluation method.

3. Credibility analysis of the TVTD

In engineering practice, there is always a credibility problem that whether the simulation model could represent the real system, and whether the simulation results could represent the true performance of the system. The low simulation credibility will lead to a corresponding risk increase in decision-making. To reduce the risk of analysis and results that introduced by the errors of system simulation model, the verification, validation and accreditation (VV&A) of the simulation model that is used to make sure the simulation quality and credibility received sufficient attention in recent years.[8–10] In testability virtual test, the test is taken on the simulation models of the UUT and the TVTD is acquired after the faults virtual injection and virtual measurement. Currently, because of the limitations of technology, the credibility of TVTD is affected by two factors. One is the differences between the testability virtual prototype and the physical prototype, and the other one is the differences between the actual test process and the virtual test. Based on the upper analysis and the general VV&A theory, the TVTD credibility analysis process is shown in Fig. 2.

As shown in Fig. 2, the testability test data can be classified into the two categories: the dynamic test data and the static test data. Correspondingly, the consistency check can be classified into two categories: the dynamic consistency check and the static consistency check. The dynamic test data is the output sequences of the key monitoring signals when the prototype is running with fault, while the static test data is the success-fail result of the fault detection or isolation. The dynamic consistency check is to guarantee the description accuracy of the virtual prototype of the UUT's physical structure and the failure mechanism, and that the dynamic test data is the check objective. The static consistency check is to ensure the consistency between the physical and virtual test data and among the
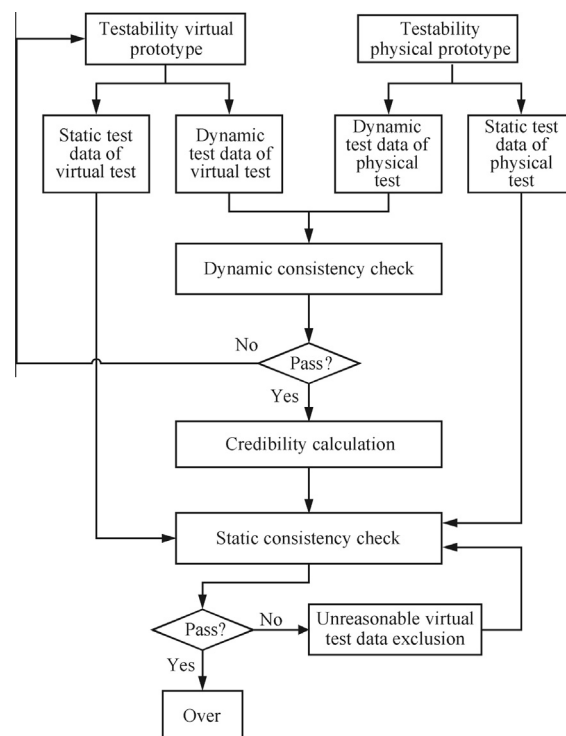

Fig. 2 Process of credibility analysis of the TVTD.