

Writing Effective Test Oracles

Software Testing
(3104313)

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What Should Be Checked?

A **test oracle strategy** is a rule or a set of rules that specify which program states to check.

- **Precision:** how much of the output state should be checked.
- **Frequency:** when and how often the output state should be checked.

What Should be Checked?

General Guidelines

- It is important to check **some outputs**.
- It is important to check the **right outputs**.
- It is **not** necessary to check **a lot of outputs**.
- It is **not** necessary to check the output state **multiple times**.

Determining Correct Values?

Specification-Based Direct Verification of Outputs

- Specification clearly determines what output accompanies a given input.

```
Input: Structure S
    Make copy T of S
    Sort S
    // Verify S is a permutation of T
    Check S and T are of the same size
    For each object in S
        Check if object appears in S and T same number of times
    // Verify S is ordered
    For each index i but last in S
        Check if S[i] <= S[i+1]
```

Specification-Based Direct Verification of Outputs

- Specification clearly determines what output accompanies a given input.
- × Need Specification
- × Sometimes we use software to find answers that we cannot find ourselves, so we do not know the correct answer.

Redundant Computation

- The program under test is labeled P , and $P(t)$ is the output of P on test t .
- A specification S of P also specifies an output $S(t)$.

$$S(t) = P(t)$$

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- Regression Testing

Consistency Check

- External Checks: examine the outputs.
 - E.g., negative, larger than unity,
- Internal Checks
 - E.g., invariants, pre-/post-conditions, ...

Metamorphic Testing

Traffic Collision and Avoidance System (TCAS)

- Rerun the TCAS software with **slightly different positions**
- The **metamorphic relation** is that similar configurations of aircraft result in similar resolution advisories.
- This technique can be applied to many systems where the input space has some notion of **continuity**.

The Oracle Problem in Software Testing: A Survey

Earl T. Barr, Mark Harman, Phil McMinn, Muzammil Shahbaz and Shin Yoo

Abstract—Testing involves examining the behaviour of a system in order to discover potential faults. Given an input for a system, the challenge of distinguishing the corresponding desired, correct behaviour from potentially incorrect behavior is called the “test oracle problem”. Test oracle automation is important to remove a current bottleneck that inhibits greater overall test automation. Without test oracle automation, the human has to determine whether observed behaviour is correct. The literature on test oracles has introduced techniques for oracle automation, including modelling, specifications, contract-driven development and metamorphic testing. When none of these is completely adequate, the final source of test oracle information remains the human, who may be aware of informal specifications, expectations, norms and domain specific information that provide informal oracle guidance. All forms of test oracles, even the humble human, involve challenges of reducing cost and increasing benefit. This paper provides a comprehensive survey of current approaches to the test oracle problem and an analysis of trends in this important area of software testing research and practice.

Index Terms—Test oracle; Automatic testing; Testing formalism.

Barr, Earl T., et al. "The oracle problem in software testing: A survey." IEEE transactions on software engineering 41.5 (2014): 507-525