**Genetic algorithm for path testing using adjustment**

***Abstract***

**1. Introduction**

Testing is a critical but expensive part of the software development life cycle. There is considerable interest in waystoautomate testing, to reduce the cost and to gain more confidencein the result. A major task in software testing is test data generation. Search-based test data generation aims to automate this task, by searching for test cases (inputs, or pairs of input–output) that satisfy chosen testing criteria.

Most research in this area considers “white box” testing, or structural coverage, in which the aim is to ensure that executing a collection of test cases results in all parts of a program being tested. This can be interpreted in various ways, including “statement coverage” (when the program is tested with all of the test cases, somewhere along the line every statement in the programis executed at least once), ‘‘branch coverage’’ (both outcomes at every logical branch in the program are executed at least once), and “path coverage” (every distinct path through the code is executedat least once). Path coverage is the strongest form of structural coverage [5]. This paper considers path coverage.

Many approaches have been used in path testing [cần dẫn ra đây các ]. Evolutionary path testing, which uses an evolutionary algorithm (e.g. genetic algorithm “GA”) as the search engine has been found effective[6,7]. In this research, GA is used as the search engine.

A challenge for any search-based approach is làm sao để sinh được những input test data mà có thể phủ được những test path có các điều kiện so sánh phức tạp.

Chúng tôi đề xuất một phương pháp để có thể sinh ra được input test data để phủ được các test path có xác suất đi qua là thấp trong giải thuật di truyền.

This paper is organized as follows: Section 2 presents some theoretical background to understanding this research. Section 3 describes related work, and Section 4 describes the proposed approach in detail. Section 5 presents the evaluation. Section 6 concludes the paper.

**2. Background**

*2.1. Path testing*

The objective of path testing is to search for a collection of test cases (inputs to a program) that between them lead to the traversal of all logical paths through the program. In general, path testing process consists of two major steps: targetpaths generation, and test data generation.

*2.1.1. Target paths generation*

Target paths generation means identifying a set of logical executionpathways through the program, that we hope should allbe exercised during testing.The source code is needed to construct its logical control flow,which can be presented in a control flow graph (CFG). This graphcan be automatically generated by using appropriate programminglanguage grammar in which the program is written.

From the CFG, the different logical paths through the programneed to be enumerated. A logical path is a particular flow of executionthrough the program, which is determined by the decisionsmade at each decision point between the program’s entry pointand its exit point.

*2.1.2. Test data generation*

Generating test data that fulfill path coverage is the main task inpath testing. It is the process of creating test data, either heuristicallyor randomly. In a heuristic approach, the process is guided by some rules to search for required test data; the alternative is thatrandom test data is generated.

*2.2. Evolutionary path testing*

Path testing that uses any methods from the evolutionary algorithmsfamily is called evolutionary path testing. In this work, genetic algorithm (GA) is used as the test data generator.　A chromosome represents one set of test data (a collectionof input values that represents a single test case). Thus the population is a collection of test cases. Each test case causes one target path to be executed; most of the time a target path can be coveredby many test cases. The aim is to evolve a set of test cases that causes all target paths to be executed.

Generic steps in GA are (1) Initialization, (2) Evaluation, and (3)Do the following until any stopping criteria is met: (3.a) Selection,(3.b) Perturbation, and (3.c) Go back to Step (2). Initialization generatesthe first population, randomly or with some knowledge. Step (2) evaluates all members of the population using a given fitnessfunction. In (3.a) some members of the population are selectedfor perturbation using genetic operators. Section (3.b) applies those operators: crossover is responsible for mixing the genetictraits, and mutation for introducing new genetic traits.

The generator keeps a list of target paths that have not yet been covered. At the beginning of the evolution, every target path is in that list. In each generation, each test case in the population is evaluated (its fitness is calculated) against each uncovered target path. When a test case is found to cover a target path, it is rememberedand that target path is removed from the list. As the searchprogresses, the list of paths for which test data is sought changesdynamically. Searching can stop if the list becomes empty, or whensome other stopping criterion is reached. If the list of target pathscontains infeasible paths, the list of uncovered paths will never beempty, and another stopping criterion is essential.

**3. Related work**

**4. Proposed approach**

Các tiếp cận của chúng tôi có hai bước chính như sau:

Step 1: Tìm các đường dẫn mà có xác suất phủ được là thấp trong chương trình.

Step 2: Với các đường dẫn mà có xác suất được phủ thấp, thì với các câu điều kiện rẽ nhánh của path này, điều chỉnh ở thủ tục sinh ra cá thể mới (thực hiện trong bước (3.a) Selection và (3.b) Perturbation ở trên) của giải thuật di truyền.

**N**

**Y**

Test function

CFG generation

Target paths list generation

Tìm các path khó phủ

Tìm các điều kiện khó sinh test data thỏa mãn

Initialization

Evaluation

Selection

Perturbation

Stopping criteria?

End

Adjustment

**Genetic algorithm**

Quay trở lại chương trình phân loại tam giác Tritype ở trên, các câu lệnh điều kiện mà cần điều chỉnh trong giải thuật di truyền là branch #2 và branch #3. Điều kiện so sánh mà cần điều chỉnh khi sinh ra các cá thể ở trong giải thuật di truyền là (a==b) và (a==b && b==c). Với các điều chỉnh này, thu được kết quả khi chạy như sau:

Run No. 1 : Wait Please .........

Path 4: a = 14.744746849514955 b = 4.817243648636693 c = 12.301081756217084

Objective call: 1

Path 1: a = 7.768767568484256 b = 1.3747887684823534 c = 2.6602222750788584

Objective call: 3

Path 3: a = 10.153558006964193 b = 10.6389422858413 c = 10.6389422858413

Objective call: 462

Run No. 2 : Wait Please .........

Path 2: a = 0.18596209465759556 b = 0.18596209465759556 c = 0.18596209465759556

Objective call: 57595

**5. Experiments**

Bài báo này đã thực hiện thí nghiệm với các test function như sau:

- tA2008 determines whether three given numbers that representthree lengths on a plane form a scalene, isosceles, equilateral,or not a triangle.

- tritypeBueno2002 accepts three numbers representing sides of atriangle, classifies its type, and computes its area.

- triangleMansour2004 classifies three numbers representing triangleside lengths into five type triangles: scalene, isosceles, right,iso-right, or equilateral.

Kết quả phân tích tĩnh của từng test function này thu được tập target paths, xác suất sinh data để có thể phủ cùng điều kiện cần điều chỉnh các path tương ứng là:

|  |  |  |  |
| --- | --- | --- | --- |
| Function | PathID | Target paths | Điều kiện cần điều chỉnh |
| tritypeBueno2002 | 1 | {[1,F], [2,F], [3,F], [4,F], [5,F]} | b = c |
|  | 2 | {[1,F], [2,F], [3,F], [4,F], [5,T]} | a = b |
|  | 3 | {[1,F], [2,F], [3,F], [4,T]} | a = b = c |
|  | 4 | {[1,F], [2,F], [3,T], [6,F], [7,F]} |  |
|  | 5 | {[1,F], [2,F], [3,T], [6,F], [7,T]} |  |
|  | 6 | {[1,F], [2,F], [3,T], [6,T]} | a\*a = b\*b + c\*c |
|  | 7 | {[1,F], [2,T]} |  |
|  | 8 | {[1,T]} |  |
| triangleMansour2004 | 1 | {[1,F], [2,F], [3,F]} |  |
|  | 2 | {[1,F], [2,F], [3,T]} | a\*a = b\*b + c\*c |
|  | 3 | {[1,F], [2,T], [3,F]} | b = c |
|  | 4 | {[1,F], [2,T], [3,T]} | (a\*a = b\*b + c\*c)&&(b = c) |
|  | 5 | {[1,T], [2,F], [3,F]} | a = b |
|  | 6 | {[1,T], [2,F], [3,T]} |  |
|  | 7 | {[1,T], [2,T], [3,F]} | a = b = c |
|  | 8 | {[1,T], [2,T], [3,T]} |  |
| tA2008\_Triangle | 1 | {[1,F]} |  |
|  | 2 | {[1,T], [2,F], [3,F]} | a = b |
|  | 3 | {[1,T], [2,F], [3,T]} | a = b = c |
|  | 4 | {[1,T], [2,T]} |  |
| QuadraticEquation2 | 1 | {[1,F], [2,F], [3,F]} |  |
|  | 2 | {[1,F], [2,F], [3,T]} | b\*b = 4\*a\*c |
|  | 3 | {[1,F], [2,T]} |  |
|  | 4 | {[1,T], [4,F]} | a = 0 |
|  | 5 | {[1,T], [4,T]} | (a = 0)&&(b = 0) |

Sau khi áp dụng phương pháp phân tích tĩnh kết hợp với giải thuật di truyền, so sánh với sử dụng giải thuật di truyền truyền thống, thu được kết quả như trong bảng sau:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Function | Target paths | Không điều chỉnh | | Có điều chỉnh | |
| Path ID | Object call | Path ID | Object call |
| tritypeBueno2002 | 8 | 8 | 1 | 8 | 1 |
|  |  | 7 | 4 | 7 | 4 |
|  |  | 5 | 10 | 5 | 10 |
|  |  | 4 | 16 | 4 | 16 |
|  |  |  |  | 2 | 924 |
|  |  |  |  | 1 | 3,900 |
|  |  |  |  | 6 | 31,434 |
|  |  |  |  | 3 | 129,295 |
| triangleMansour2004 | 8 | 1 | 1 | 1 | 1 |
|  |  |  |  | 3 | 1,370 |
|  |  |  |  | 5 | 2,358 |
|  |  |  |  | 2 | 8,882 |
|  |  |  |  | 7 | 18,374 |
|  |  |  |  | 4 | 25,080 |
| tA2008\_Triangle | 4 | 3 | 1 | 3 | 1 |
|  |  | 0 | 3 | 0 | 3 |
|  |  |  |  | 2 | 462 |
|  |  |  |  | 1 | 57,595 |
| QuadraticEquation2 | 5 | 3 | 1 | 3 | 1 |
|  |  | 1 | 5 | 1 | 5 |
|  |  |  |  | 5 | 2,086 |
|  |  |  |  | 4 | 11,610 |
|  |  |  |  | 2 | 14,468 |

**6. Conclusion**

**7. References**

[1] I. Hermadi, Path Testing Using Genetic Algorithm, Ph.D. Thesis, University of New South Wales, Canberra, Australia, August 2012 (submitted for examination).

[2] I. Hermadi, C. Lokan, R. Sarker, Dynamic stopping criteria for search-based test data generation for path testing, Information and Software Technology, Volume 56 Issue 4, April, 2014, Pages 395-407.