A Unified Strategy for Sequence and Sequence-less T-way Test Suite Generation

Abdullah B. Nasser, Fadhl Hujainah, Abdulrahman A. Alsewari, Kamal Z. Zamli
Fakulti Sistem Komputer & Kejuruteraan Perisian, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Pahang, MALAYSIA
abdullahnasser83@gmail.com, fadelhogina@gmail.com, alsewari@gmail.com, k.z.zamli@gmail.com

Highlights: In the last 20 years, many useful t-way strategies (where *t* indicates the interaction strength) have been developed to help generate test suite for detecting fault due to interaction of inputs. Although useful, existing t-way strategies have assumed sequence-less interactions amongst input parameters. In the case of reactive system, such an assumption is invalid. This paper presents a unified strategy based on the new meta-heuristic algorithm, called the Elitist Flower Pollination Algorithm (eFPA), for sequence and sequence-less coverage. Experimental results demonstrate the proposed strategy gives sufficiently competitive results as compared with existing works.

Key words: *Software Testing, T-way Testing; search-based strategy; Event Sequence Testing; Combinatorial Problem; Meta-Heuristics; Optimization Problem.*

Introduction

Nowadays, software usage is entering into every corner of social life, from the television remote control and mobile phone applications to the airplane control systems. Smart software facilitates our daily chores; however, unwarranted glitches can lead to undesirable consequences.

Software testing is the main activity for ensuring the quality of any software (i.e. ensuring that the software meets the user's needs, business and technical requirements. Software testing refers to the process of finding errors/defects and/of ensuring that a particular software of interest meets its specification.

Perhaps, the ideal way for testing any software system is to test all possible combinations of input parameters. However, exhaustively testing all possible input/output possibilities are extremely difficult in practice owing to the huge number of combinations needs to be considered. Often, a sampling mechanism is needed to find a subset of effective test case for testing consideration. As a result, a number of test design techniques have been proposed to reduce the size of test cases and save time and effort such as Random Testing (Arcuri & Briand, 2012), Partition Testing (Burnstein, 2003), and Parallel Testing (Burnstein, 2003).

Recently, researchers are turning to t-way testing(Ahmed & Zamli, 2011), as complementary alternatives to the aforementioned sampling techniques. The central concern of many researchers into t-way testing is on how to obtain the minimal number of test cases. One of the interesting properties of t-way testing is that all interaction possible of input values with strength t are involved in generated test suite.

The literature provides many t-way testing techniques. The most emerging technique is adopting nature inspired algorithm for test design techniques such as strategies based on Hill Climbing (HC), Tabu Search (TS), Simulated Annealing (SA), Genetic Algorithm(GA), Ant Colony Algorithm(ACA), Particle Swarm Optimization

(PSO), Late Harmony Search (HS), Acceptance Hill Climbing (LAHC), and Cuckoo Search (CS) to name a few(Nasser et al., 2015).

In order to enhance the effectiveness of t-way strategies, there is a need for a unified strategy that is able to cater for both sequence-less and sequence interactions (Zamli et al., 2011). To date, the design of a unified strategy for sequence-less and sequence t-way testing has not been sufficiently explored in the literature. In fact, this work is the first attempt to investigate the problem of generating both sequence and sequence-less t-way test suite within the same strategy implementation.

For this reason, this research proposes the design and implementation of a unified strategy for integration of sequence and sequence-less t-way test generation based on the Elitist Flower Pollination Algorithm (eFPA).

Contributions

Given such prospects, this research proposes a new Flower Pollination Algorithm based t-way strategy, called Elitist Flower Pollination Algorithm (eFPA), for t-way test suite generation. Our contributions can be summarized as follows:

- eFPA is the first t-way strategy that adopts Flower Pollination Algorithm (FPA) (Yang, 2012) as its core implementation. Additionally, we also enhance FPA with elitism feature and integrate as well as benchmark with our eFPA implementation.
- The implementation of eFPA establishes a unified strategy for integration of sequence and sequence-less t-way test generation. Experimental results show that eFPA is capable of

producing good quality solution when compared with existing strategies for both sequence and sequence-less t-way test suite generation.

Tool Development Processes

The research methodology is partitioned mainly into three stages involves Review the Literature, Design and Deployment, and Benchmarking and Analysis.

- **Review the Literature:** During this phase the strengths and limitations of existing work will be identify in order to ensure focused research problem.
- **Design and Deployment**: In this phase the adoption of FPA as a core implementation of our proposed strategy is established which involves modelling, designing, and implementing of the new strategy, eFPA, for t-way sequence and sequence-less testing.
- **Benchmarking and Analysis phase:** in this phase the proposed strategy is compared with other existing strategies.

Flower Strategy

Elitist Flower Pollination Algorithm (eFPA) is a new t-way strategy for test suite generation based on FPA (Yang, 2012). In general, eFPA can be represented as two core parties: Global Pollination step and Local Pollination step. In global pollination, the flower pollen is transferred by pollinators such as insects, over a long distance using lévy flight. Local pollination transfer pollen from male parts to female parts in the same flower.

In eFPA, each test case represents as a flower or pollen (i.e. solutions). The fitness function for any pollen is the number of interactions that the pollen can cover, therefore, eFPA begins by initializing the interaction elements list according to input values (i.e. interaction strength t, number of parameters and parameters values). Then, eFPA randomly generates a population of pollen.

During the iteration of the algorithm, each pollen repeatedly subjects to generating new pollen phrase by performing the global pollination or local pollination. The new pollens will be chosen as current pollens if the new pollens are better than current pollens. The generation of new pollen is repeated until the maximum number of improvement has been satisfied.

Here, the current best pollen is added to final test suite, and covered interaction elements are deleted from the interaction elements list. This cycle continues all the interaction elements are covered(Nasser et al., 2015).

Results

In order to evaluate the proposed strategy, we compare eFPA with most well-known existing t-way testing such as GA, PSO, HS, CS, ASP and t-seq. From the initial results, eFPA has the potential to outperform the existing strategies as shown in Table 1. In fact, eFPA is able to produce the optimal test size in many cases (as marked with *).

Table 1 comparison with existing strategies

Sequence-less t-way strategies							**Sequence-less t-way strategies**					
Systems Configurations	*t*	**GA**	**PSO**	**HS**	**CS**	**eFPA**	**Systems Configurations**	*t*	**ASP**	**t-seq**	**BA**	**eFPA**
4 3-valued parameters	2	9	9	9	9	9*	4 events	3	NA	NA	6	6*
13 3-valued parameters	2	17	17	18	20	17	5 events	3	7	8	8	7*
10 10-valued parameters	2	157	NA	155	NA	153*	6 events	4	NA	8	38	36*
10 15-valued parameters	2	NA	NA	342	NA	344*	7 events	4	NA	10	50	45*
10 5-valued parameters	2	NA	45	43	NA	42*	6 events	5	NS	NA	159	147*
6 3-valued parameters	3	33	42	39	43	42	7 events	5	NS	NA	212	194*
6 4-valued parameters	3	64	102	70	105	101	8 events	5	NS	NA	271	234*
20 2-valued parameters	4	NA	37	37	36	36*	7 events	6	NS	NA	NA	960*
10 2-valued parameters	5	NA	82	81	79	75*	8 events	6	NS	NA	NA	1279*

Benefit of this research

There are many online testing tools involve free open source as well as licensed web test tools. In order to marketing eFPA, eFPA has been implemented as executable file that can be run using any machine (Figure 1). eFPA tool can be used in the actual testing of the software application. However it can also be used for many purposes as follows:

- It can be used as a testing tool in the Software testing lab's subject.
- It can be used by in UMP Labs. So, the researchers will use it to generate a proper sequence of combinations.
- In order to ensure products quality in Malaysia, the companies can be used our tools to test their products as well as generate test cases through the planning based on the requirement (software product line).
- It can be used in information management system (IMS)

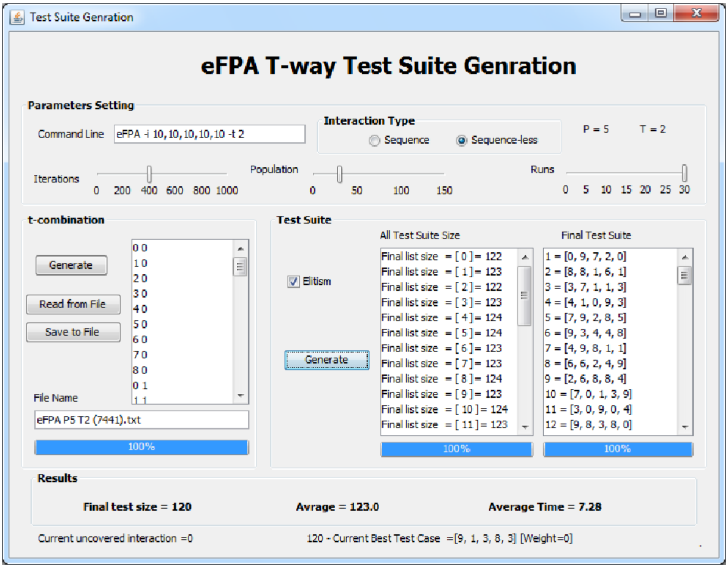

Figure 1: eFPA implementation interface

Acknowledgement

The authors would like to thank Universiti Malaysia Pahang for the contribution and support. Mr. Abdullah B.

Nasser is the recipient of the Postgraduate Research Grants Scheme (PGRS) from Universiti Malaysia Pahang.

References

Ahmed, B. S., & Zamli, K. Z. (2011). A Variable Strength Interaction Test Suites Generation Strategy Using Particle Swarm Optimization. *Journal of Systems and Software, 84*(12), 2171-2185.

Arcuri, A., & Briand, L. (2012). Formal Analysis of The Probability of Interaction Fault Detection Using Random Testing. *Software Engineering, IEEE Transactions on, 38*(5), 1088-1099.

Burnstein, I. (2003). *Practical Software Testing: A Process-Oriented Approach*. New York: Springer Inc.

Nasser, A. B., et al. (2015). *Assessing Optimization Based Strategies for t-way Test Suite Generation: The Case for Flower-based Strategy*. Paper presented at the 5th IEEE International Conference on Control Systems, Computing and Engineering, Pinang, Malaysia.

Yang, X.-S. (2012). Flower Pollination Algorithm For Global Optimization *Unconventional computation and natural computation* (pp. 240-249): Springer.

Zamli, K. Z., et al. (2011). *On Sequence Based Interaction Testing*. Paper presented at the Computers & Informatics (ISCI), 2011 IEEE Symposium on.