[1.]Deepak NANDAL, [2.]Om Prakash SANGWAN, [3.]Nandal VIKAS

A COMPARATIVE STUDY OF POPULATION BASED META-HEURISTIC TECHNIQUES FOR VARIOUS APPLICATIONS IN SOFTWARE TESTING

[1.]Department of Computer Science and Engineering, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, INDIA
[2.]Department of Computer Science and Engineering, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, INDIA
[3.]Electronics and Communications (UIET), Maharishi Dyanand University, Rohtak, Haryana, INDIA

Abstract: Software testing is a process of evaluating the functionality of different software applications intending to find the errors and defects to ensure that the product is error and bug free so that a good quality software product can be achieved. It should also satisfies all the requirements as specified by the vender at the time of finalizing the SRS. This testing process tests the entire software with a sole objective of to produce a quality software. The quality will be compromised if the software product has bugs. The selection of testing data for the same is very crucial. Different population based meta-heuristic techniques are implemented for the automation and optimization of selection of the test data. There are some meta-heuristic techniques that are used in the field of engineering for optimization problems. This paper produces a comparative study of different researches that uses the meta-heuristic techniques in the field of software testing.
Keywords: Software testing, BAT, GA, Particle Swarm optimization, Test cases, Optimization

INTRODUCTION

Software Engineering is solely concerned with the idea of development of software applications to be economical with utmost efficiency as well. It comprises of a number of phases of the software development life cycle and these phases differ from one software development model to another, where software testing is a part of the development cycle that concentrates on producing a quality software product with no errors Mayan et al[1]. Testing part of it covers almost half of the total development cost of the software product[3,4]. So this has been a major field when it comes to the software engineering.

To achieve the main objective that is the quality of the software or error free software, test data generation as well as structural testing has been emerged as a major field of research for many researchers in the last decade and so.

The selection and creation of the test suite is the most crucial part of this phase, when it comes to applying the testing methodologies. As earlier discussed the software testing is a tedious, complex and a very expensive phase when it comes to the software development life cycle. Many modern optimizing techniques for selection of test cases may result in lowering the overall cost of software testing[2, 3].

Software testing gains the vendor's acceptance for the software, which extends the objective of doing software testing to acquire the assurance of quality of the software[5]. The overall cost of finding errors and bugs can be reduced by applied optimizing models such as ANN, ACO, GA and other meta-heuristic approaches, which also helps to meet the target of time deadlines associated with the software development. This research paper has sections, firstly the introduction part which is followed by the introduction of different meta-heuristic techniques such as BAT and PSO which both are populations based search techniques. Next sections discusses the literature review part and the criteria for selection of the above techniques. Last section discusses the observations of the analysis of the related papers of the techniques PSO and BAT followed by the conclusions.

POPULATION BASED META-HEURISTIC TECHNIQUES

The classification of meta-heuristic techniques can be done on the based on the solutions they focuses i.e. single solution and populations based approaches. The population based approaches focuses on improving the multiple candidate solutions where the population characteristics guides the search both local and global search[7, 18]. This paper focuses on two such population based meta-heuristic approaches BAT algorithm and Particle Swarm intelligence algorithm.

— BAT Algorithm

Bat algorithm demonstrates the hunting and routing behavior of the bat[9, 12]. Bat uses echolocation property i.e. identifying the location of any object or prey by the reflecting sound signal from that particular object or prey.

This algorithm assumes the ideal condition for the echolocation of the bat. It includes the automatic adjustment of the sound wavelength transmitted by the bat with respect to emission rate and loudness[8]. The algorithm focuses on both the local search as well as global search.

— Particle Swarm Optimization Algorithm

Particle swarm optimization is inspired from the simulation social behavior related to bird clustering and swarming theory[17]. A swarm can be defined as a structured collection of interacting agents. It focuses straight to the center of the swarm then matches the neighbor's velocity to avoid the collisions. It intelligently combines the self-experience with the social experience.

The agents which are also known as particles that constitute a swarm moving around in the search space looking for the best solution[17]. Each agent adjust its search space according to its own experience and as well as the others[19]. The particle swarm intelligence is one the majorly used population based optimization technique that is applied to various fields of engineering for optimization problems.

ESTIMATION CRITERIA

A process must be followed in order to implement software testing, so that the implementation on software results in finding the bugs effectively. For the same a thorough literature review has been conducted so find out the research gaps of the existing technologies. Major databases which were used to gather the required information and research papers (Table (a)).

This table (a) shows the keywords used for searching the related research papers. Some research questions are observed that analyzes the applications of BAT as well as PSO in the field of software testing. It also shows the number of aspects that are used for evaluating the testing techniques[14, 15, 16, 19, 20, 21]. The (Table (b)) shows the final result.

Table: a Keywords used in searching papers

S. No.	Keywords
1	Meta-heuristic techniques used in software testing
2	Implementation of BAT in Software Testing
3	Implementation of PSO in Software Testing
4	Implementation of BAT and PSO in Software Testing

Table: 2 Analysis of aspects satisfied

Aspects	[3]	[4]	[16]	[20]	[21]	[28]
A1	√	√		√	√	√
A2		√	√	√		
A3		√	√		√	
A4		√		√	√	
A5	√			√	√	√
A6			√		√	
A7		√			√	
Total no of aspects satisfied	2	5	3	4	6	2

≡ A1: Can the model reduces the efforts required for test case generation?

The efforts related to a software development comprises of mainly the person per hour, as the human factor is the most important aspect when it comes to cost of a software product and software testing is a time consuming process. The test case generation is a complex process and to figure out the suitable test suits cases which covers all the desired aspects evenly is even more complicated[22]. So this is an important aspect that must be reduced to lower the cost which is directly dependent on the effort of the software product.

≡ A2: Does the model reduces the testing time?

When it comes to test a software it is clear that it will take an ample amount of the testing team. It is almost not possible to test the entire software with in a given time frame, so testing the unnecessary content should be avoided.

≡ A3: Does the model generated test data automatically?

The test case data are the basis of testing a software and manually selection may be a very time consuming process[24]. So it is the demand of time to generate the test cases automatically by the models.

≡ A4: Does the model focuses on global optimum solution?

There are local search space and as well as global search space, the global optimum solution is most crucial as it finds the optimum solution among the possible solutions. The optimizing algorithm must not only be bidirectional in the local search space, it should also include the global search space as well.

≡ A5: Does the model reduces redundancy?

As discussed in the A1 and A2 that effort, cost and time are most important when it comes to software testing and must be reduced. For the same if the test cases focuses on the remove the redundancy, helps a lot to reduce the effort as well as time consumed[25].

≡ A6: Does the model reduces the cost of software testing?

To reduce the cost is critical to overall development of any system, which is also applied to the field of software engineering as well. Almost 50% of the total cost of software product development goes to software testing itself. If the test cases are selected properly and data redundancy is controlled then cost itself will be reduced.

≡ A7: Does the model reduces the size of test suite?

As the test suite size reduces the effort of the software development decreases, which directly related to the cost as well[26]. Large test suits may increase the chances of data redundancy.

ANALYSIS OF BAT AND PSO

Bat algorithm and particle swarm optimization technique are both population based meta-heuristic approaches, which are here applied to optimization of software testing[26, 27]. The results after implementation of these techniques gives better solutions than other customary techniques. Both the meta-heuristic approaches generates global optimum solution.

Following are some research papers that are analyzed for the study of application of these techniques in the field of software engineering.

— BAT Algorithm

Srivastava et al. [3] suggested a model that examines the performance of BAT algorithm. When this model is applied on UCP and TPA and the estimations have directed to the conclusions that test effort can be optimized by using BAT. The results were compared with those obtained from other existing methods, and it was found that the results are better and closer to the actual effort.

Yazan A. et al. [4] suggested a model that evaluates that the performance for interaction testing. The case study results are promising, especially with the prospect of supporting a high interaction strength. The optimizing of the test suite of the case study is different among traditional strategies, which perform a simple number of processes during generation due to the use of the meta-heuristic algorithm.

Yazan A et al. [8] suggested a model that uses the BAT algorithm and studies the benchmarking of BAT for real-world software systems to show it applicability in real-world test suite generation scenarios. BAT produces competitive test suite sizes compared to its counterparts. BAT was able to achieve 3 of the best test suite sizes.

Srivastava et al. [12] suggested a model that generates a satisfactory test sequence generation in stat-based testing implements BAT algorithm. The results observed are better than existing techniques such as GA , ACO techniques, intelligent water drop & cuckoo search algorithm in terms of optimality & coverage of generated sequences.

Kaur A. et al. [13] suggested a model that combines the BAT and cuckoo search algorithms for selecting test cases. With the objective of reducing the overall cost in regression testing and also reduce the cost of maintenance as well.

Sugave S.R et al. [16] suggested a model for test suite reduction in software testing. This model illustrations that the reduced test suite with the implementation of DIV-TBAT underperforms the entire existing methods when it comes to the test suite reduction problem.

— Particle Swarm Intelligence

Windisch A. et al. [20] suggested a model that applies PSO to software testing. This research paper takes 25 artificial test objects and 13 more complex test objects. The outcomes from the research papers shows that PSO out preforms GAs for most code elements to be covered in terms of effectiveness and efficiency.

Chen X. et al. [21] suggested a model that performs pairwise testing and applies particle swarm optimization. This paper analyze the impact factors of the approach and compare that approach to other well-known approaches. Final empirical results show the effectiveness and efficiency of the approach.

Zhang S. et al. [24] suggested a model based on a hybrid of GA and PSO for automatic test data generation. The model proved effective by a representative test of the "triangle type of discrimination". The experiment shows that the new algorithm has higher performance when the value of Φ is around 20%.

Ai-guo Li et al. [27] suggested a model that is based in PSO for automatic generation of test data. This model show that the approach is more efficient than GA based approach: when the number of particles of PSO is equal to the size of GA, the mean number of iteration of proposed approach is about 1/16 as many as that of GA-based approach.

Zhu X. et al. [28] proposed a model that implements adaptive particle swarm optimizer for test case generation. The outcome illustrations that Adaptive PSO is a better performer but also advanced to the immune genetic algorithm (IGA) as well as outperforms PSO, and has a wide-ranging applications for software testing.

Table 2 displays various research questions represented by A1-A7 alongside the research papers from which these questions were assumed[3, 4, 16, 20, 21, 28]. The tick mark represents the identified aspects which depicts as satisfied by that resultant research paper.

CONCLUSION

The results and applications of BAT algorithm and Particle Swarm Optimization algorithm are presented in this research paper by survey various research papers from different repositories. It is observed that PSO and BAT algorithm both individually as well as combination of both can be used for extensive software testing fields such as test data generations, optimization of test suite, automatic generation of test cases, and minimization of test suite. It is also observed that there are some limitations of both the meta-heuristic algorithms. This research paper provides future guidance to the researchers to use more meta-heuristics in the field of software testing, as well as the combination of the two approaches can be applied that may be considered as a hybrid meta-heuristic approach.

References

[1] Mayan, J.A., Ravi, T.: Test case optimization using hybrid search. In: International Conference on Interdisciplinary Advances in Applied Computing. New York, NY, USA (2014)

[2] B. Jones, H. Sthamer, and D. Eyres. Automatic structural testing using genetic algorithms. Software Engineering Journal, 11(5):299-306, 1996.

[3] Srivastava PR, Bidwai A, Khan A, Rathore K, Sharma R, Yang XS. An empirical study of test effort estimation based on bat algorithm. International Journal of Bio-Inspired Computation. 2014 Jan 1;6(1):57-70.

[4] Kiran A., Haider W., Waseem M., Azam A.F., Maqbool B. "A Comprehensive Investigation of Modern Test

Suite Optimization Trends Tools and Techniques", Access IEEE, vol. 7, pp. 89093-89117, 2019.
[5] Alsariera YA, Majid MA, Zamli KZ. Adopting the bat-inspired algorithm for interaction testing. InThe 8th edition of annual conference for software testing 2015 (Vol. 14).
[6] Nakamura RY, Pereira LA, Costa KA, Rodrigues D, Papa JP, Yang XS. BBA: a binary bat algorithm for feature selection. In2012 25th SIBGRAPI conference on graphics, patterns and images 2012 Aug 22 (pp. 291-297). IEEE.
[7] Biswal S, Barisal AK, Behera A, Prakash T. Optimal power dispatch using BAT algorithm. In2013 International conference on energy efficient technologies for sustainability 2013 Apr 10 (pp. 1018-1023). IEEE.
[8] Sugave SR, Patil SH, Reddy BE. A Cost-Aware Test Suite Minimization Approach Using TAP Measure and Greedy Search Algorithm. International Journal of Intelligent Engineering and Systems. 2017;10(4):60-9.
[9] Alsariera YA, Zamli KZ. A real-world test suite generation using the bat-inspired t-way strategy. InThe 10th Asia Software Testing Conference (SOFTEC2017) 2017 (Vol. 10, pp. 71-79).
[10] De Souza LS, Prudêncio RB, Barros FD. Multi-Objective Test Case Selection: A study of the influence of the Catfish effect on PSO based strategies. InAnais do XV Workshop de Testes e Tolerância a Falhas-WTF 2014 (pp. 3-16).
[11] Wang G, Guo L. A novel hybrid bat algorithm with harmony search for global numerical optimization. Journal of Applied Mathematics. 2013; 2013.
[12] Nachiyappan S, Vimaladevi A, SelvaLakshmi CB. An evolutionary algorithm for regression test suite reduction. In2010 International Conference on Communication and Computational Intelligence (INCOCCI) 2010 Dec 27 (pp. 503-508). IEEE.
[13] Srivastava PR, Pradyot K, Sharma D, Gouthami KP. Favourable test sequence generation in state-based testing using bat algorithm. International Journal of Computer Applications in Technology. 2015; 51(4):334-43.
[14] Kaur A, Agrawal AP. A comparative study of bat and cuckoo search algorithm for regression test case selection. In2017 7th International Conference on Cloud Computing, Data Science & Engineering-Confluence 2017 Jan 12 (pp. 164-170). IEEE.
[15] Lin CT, Tang KW, Kapfhammer GM. Test suite reduction methods that decrease regression testing costs by identifying irreplaceable tests. Information and Software Technology. 2014 Oct 1;56(10):1322-44.
[16] Sugave SR, Patil SH, Reddy BE. A Cost-Aware Test Suite Minimization Approach Using TAP Measure and Greedy Search Algorithm. International Journal of Intelligent Engineering and Systems. 2017;10(4):60-9.
[17] Sugave SR, Patil SH, Reddy BE. DIV-TBAT algorithm for test suite reduction in software testing. IET Software. 2018 Mar 13;12(3):271-9.
[18] Qu X, Cohen MB, Woolf KM. Combinatorial interaction regression testing: A study of test case generation and prioritization. In2007 IEEE International Conference on Software Maintenance 2007 Oct 2 (pp. 255-264). IEEE.
[19] Robinson J, Rahmat-Samii Y. Particle swarm optimization in electromagnetics. IEEE transactions on antennas and propagation. 2004 Apr 5;52(2):397-407.
[20] Tai KC, Lei Y. A test generation strategy for pairwise testing. IEEE transactions on software Engineering. 2002 Aug 7;28(1):109-11.
[21] Windisch A, Wappler S, Wegener J. Applying particle swarm optimization to software testing. InProceedings of the 9th annual conference on Genetic and evolutionary computation 2007 Jul 7 (pp. 1121-1128).
[22] Chen X, Gu Q, Qi J, Chen D. Applying particle swarm optimization to pairwise testing. In2010 IEEE 34th Annual Computer Software and Applications Conference 2010 Jul 19 (pp. 107-116). IEEE.
[23] Windisch A, Wappler S, Wegener J. Applying particle swarm optimization to software testing. InProceedings of the 9th annual conference on Genetic and evolutionary computation 2007 Jul 7 (pp. 1121-1128).
[24] Zhu H, Hall PA, May JH. Software unit test coverage and adequacy. Acm computing surveys (csur). 1997 Dec 1;29(4):366-427.
[25] Zhang S, Zhang Y, Zhou H, He Q. Automatic path test data generation based on GA-PSO. In2010 IEEE International Conference on intelligent computing and intelligent systems 2010 Oct 29 (Vol. 1, pp. 142-146). IEEE.
[26] Bo F. Automated software test data generation based on simulated annealing genetic algorithms [J]. Computer Engineering and Applications. 2005;12.
[27] Ding R, Feng X, Li S, Dong H. Automatic generation of software test data based on hybrid particle swarm genetic algorithm. In2012 IEEE Symposium on Electrical & Electronics Engineering (EEESYM) 2012 Jun 24 (pp. 670-673). IEEE.
[28] Zhang S, Zhang Y, Zhou H, He Q. Automatic path test data generation based on GA-PSO. In2010 IEEE International Conference on intelligent computing and intelligent systems 2010 Oct 29 (Vol. 1, pp. 142-146). IEEE.
[29] Zhu XM, Yang XF. Software test data generation automatically based on improved adaptive particle swarm optimizer. In2010 International Conference on Computational and Information Sciences 2010 Dec 17 (pp. 1300-1303). IEEE

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
ISSN: 2067-3809