International Journal of Applied Metaheuristic Computing
Volume 8 • Issue 4 • October-December 2017

Empirical Evaluation of Hill Climbing Algorithm

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ABSTRACT

The software is growing in size and complexity every day due to which strong need is felt by the research community to search for the techniques which can optimize test cases effectively. The current study is inspired by the collective behavior of finding paths from the colony of food and uses different versions of Hill Climbing Algorithm (HCA) such as Stochastic, and Steepest Ascent HCA for the purpose of finding a good optimal solution. The performance of the proposed algorithm is verified on the basis of three parameters comprising of optimized test cases, time is taken during the optimization process, and the percentage of optimization achieved. The results suggest that proposed Stochastic HCA is significantly average percentage better than Steepest Ascent HCA in reducing the number of test cases in order to accomplish the optimization target.

KEYWORDS

Hill Climbing, Local Optima, Optimization, Steepest Ascent, Stochastic, Test Suite

1. INTRODUCTION

Software testing is defined as a process of executing a program with the intent of finding the errors. It is an investigation technique conducted to provide stakeholders the information about the quality of the product/ service under test. Since the testing process accounts for nearly 50% of the total project development in terms of the time, effort and cost, it is essential that testing has to be performed within the stipulated time period. Any impediment in the testing process would ultimately delay the completion of the project and hamper the growth of the industry in the software market. Exhaustive testing is never possible because it would be an extremely time-consuming task. In order to test the software within stipulated time period, often the testing criteria are used which help the process of optimization and helps the tester to finish their testing process within a time bound (Souze et al., 2016).

Researcher defines optimization as hard problems because they cannot achieve guaranteed optimal solution within a reasonable time limit by using any deterministic method known till date to the community. These problems can be divided into several categories such as continuous versus discrete, constrained versus unconstrained, mono versus multi-objective and static versus dynamic. In order to find reasonably optimal solution for these optimization problems within specific time limits, often metaheuristics techniques are used since there does not exist problem-specific heuristics algorithms for them. Heuristic by nature, these techniques are capable of solving a wide range of hard optimization problems at a higher level without deeply endorsing in them (Hoffmann, 2000; Reeves, 1993). Hence emerged in last three decades, they are successfully used in industries to solve complex problems related to finance, production management, engineering (Chalup and Maire, 1999) etc. There exist three main characteristics which make the metaheuristics algorithms powerful

DOI: 10.4018/IJAMC.2017100102

as well as popular. Firstly, they are nature-inspired and based on some well-established principles of physics, biology or ethology. Secondly, they make use of the stochastic components involving random variables. Thirdly, and most importantly, instead of the using gradient or hessian matrix for the objective function; it tries to fit various parameters such as optimized test data, the percentage of optimized test data and duration to the problem at hand.

In test data generation paradigm, various heuristic and metaheuristic techniques have been applied to the local and global maxima problem in the past research. Demilli and Offut (1991) and Ali et al. (2010) present a recent review on the application of evolutionary algorithms in software testing. Most of the papers included use of genetic algorithms (GAs) to find test data. In fact, only a few articles listed in the review include other techniques such as firefly algorithm (Kumar et al., 2016; Chakraborty et al., 2016), simulated annealing, tabu search, cuckoo search algorithm, artificial bee colony, hill climbing and ant colony algorithm.

Test data generation is one of the most critical, time-consuming, expensive and labour-intensive activity. Even after several years of research to be able to generate test data automatically, existing techniques are yet not able to produce results satisfactorily. Hence, it is performed manually which is very much susceptible to errors (DeMilli and Offutt, 1991). Although test data generation is an undecidable problem, however, in the current study an effort has been made to find the near optimal solution in the given specific time limits using one of the most efficient metaheuristics technique known as 'Hill Climbing Algorithm (HCA) (Reeves, 1993; Tsamardinos et al., 2006)'.

HCA technique is capable of generating optimized test case data with reasonably good quality within stipulated time period. Although researchers have applied several other nature-inspired techniques such as genetic algorithm, Simulated Annealing for the purpose of automated test data generation (Lim et al., 2006), however, interest in HCA technique is also gaining momentum during the last decade because they are very much cost effective. HCA is a method that uses differential information to lead the searching process. As a matter of fact, new steps always try to climb up the local gradient. The advantage of exploitation is that it usually leads to very high convergence rates.

Authors want to find a best test case for each independent path using a control flow graph at the least cost and time by comparing the two versions of HCA. Author propose a method that optimizes test cases using two versions of HCA on three parameters. In order to analyze HCA author evaluate it using fifty real time programs written in C language. The program set contains programs ranging from 35 to 350 lines of source code and includes from very basic to very complex programs.

The rest paper is structured as follows in Section 2, related work is summarized, in Section 3 describes the variant of HCA. In Section 4 proposed method is introduced, in Section 5- experiments are presented and results are discussed. In Section 6, a thorough statistical analysis including the algorithms considered in this study is presented and In Section 7, conclusion and future scope of the present study is mentioned.

2. RELATED WORK

HCA is a technique for optimization of mathematics-based problems which belong to the category of search classified as "local search". It is an algorithm which is iterative in nature, providing a solution to the specified problem by initially supplying with a capricious solution and then endeavors to find an improved solution by incrementally modifying an element at a time of the solution. If the modification is producing a superior solution, the iterative change made is declared as the new solution. This step is repeated until improvements in the solution come to a standstill. Under the category of local search in Computer Science (Ali et al., 2010), HCA is a technique for analytical optimization. It starts by proposing a capricious solution to a problem at hand in its inception phase and then iteratively finds an improved version of the solution by making changes to a single element present in the solution, incrementally (Chalup and Maire, 1999). This iteration continues till a better solution is being produced and no more development or advancement is observed.

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