Fuzzy Adaptive Tuning of a Particle Swarm Optimization Algorithm for Variable-Strength Combinatorial Test Suite Generation

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Abstract

Combinatorial interaction testing is an important software testing technique that has seen lots of recent interest. It can reduce the number of test cases needed by considering interactions between combinations of input parameters. Empirical evidence shows that it effectively detects faults, in particular, for highly configurable software systems. In real-world software testing, the input variables may vary in how strongly they interact; variable strength combinatorial interaction testing (VS-CIT) can exploit this for higher effectiveness. The generation of variable strength test suites is a non-deterministic polynomial-time (NP) hard computational problem [1]. Research has shown that stochastic population-based algorithms such as particle swarm optimization (PSO) can be efficient compared to alternatives for VS-CIT problems. Nevertheless, they require detailed control for the exploitation and exploration trade-off to avoid premature convergence (i.e. being trapped in local optima) as well as to enhance the solution diversity. Here, we present a new variant of PSO based on Mamdani fuzzy inference system [2, 3, 4], to permit adaptive selection of its global and local search operations. We detail the design of this combined algorithm and evaluate it through experiments on multiple synthetic and benchmark problems.

We conclude that fuzzy adaptive selection of global and local search operations is, at least, feasible as it performs only second-best to a discrete variant of PSO, called DPSO. Concerning obtaining the best mean test suite size, the fuzzy adaptation even outperforms DPSO occasionally. We discuss the reasons behind this performance and outline relevant areas of future work.

1. Introduction

Interaction of input parameters for software systems has been introduced as one of the primary sources of failure. Traditional test design techniques are useful for fault discovery and prevention when a single input value causes the fault at a time. However, they may not be adequate to handle faults caused by the interaction of several inputs. Combinatorial Interaction Testing (CIT) (sometimes called t-way testing where t is the combination strength) addressed this problem properly by taking the interaction of two or more inputs and generating a combinatorial test suite that helps in early fault detection in the testing life cycle [5, 6]. The key insight of this testing approach is