

# Chapter 40

## Bio-Inspired Computational Intelligence and Its Application to Software Testing

**Abhishek Pandey**  
UPES Dehradun, India

**Soumya Banerjee**  
BIT Mesra, India

### ABSTRACT

*Bio inspired algorithms are computational procedure inspired by the evolutionary process of nature and swarm intelligence to solve complex engineering problems. In the recent times it has gained much popularity in terms of applications to diverse engineering disciplines. Now a days bio inspired algorithms are also applied to optimize the software testing process. In this chapter authors will discuss some of the popular bio inspired algorithms and also gives the framework of application of these algorithms for software testing problems such as test case generation, test case selection, test case prioritization, test case minimization. Bio inspired computational algorithms includes genetic algorithm (GA), genetic programming (GP), evolutionary strategies (ES), evolutionary programming (EP) and differential evolution(DE) in the evolutionary algorithms category and Ant colony optimization(ACO), Particle swarm optimization(PSO), Artificial Bee Colony(ABC), Firefly algorithm(FA), Cuckoo search(CS), Bat algorithm(BA) etc. in the Swarm Intelligence category(SI).*

### 1. INTRODUCTION

During the last few decades many new algorithms has been developed in order to solve complex mathematical problems. The development of such algorithms was mandatory due to the fact that many of the computational problems form the set of complex problems that are known to be NP complete problem (M.R Garey, & D.S Johnson, 1979). Bio inspired computational intelligence algorithms are gaining its popularity by the fact that these algorithms performed well on various parameters and give the converged

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optimized solution. Here it will be worth noting that many conventional methods such as newton's method or gradient descent method, simplex method requires lot of assumption in order to model the problem and thus unable to model the real world problem correctly and precisely. Linear programming methods are also unable to model the real world problem because many of the real world problems had been proved as a nonlinear problem. These algorithms fail to find the feasible solution in large and highly nonlinear environment. Many of the software testing problems such as test data generation problem, test suite selection and minimization problems has been modeled as a search based problems in order to find the optimized solutions. These problems too fall in the category of nonlinear optimization problem. In the next section authors will review the various bio inspired computational intelligence algorithms and then discuss its application to various software testing problems. A brief but complete description of popular Genetic Algorithm and some other evolutionary algorithms will be discussed with proposing algorithms to solve test data generation problem.

## **2. BACKGROUNDS**

### **2.1. Computational Methods Inspired by Biological Processes of Nature**

Inspiration from nature and biological processes have motivated to the development of various computational algorithms in order to solve complex problems. These algorithms are classified as evolutionary and swarm intelligence based algorithms. Evolutionary algorithms are based on the principle of survival of the fittest or natural selection (J.H Holland, 1975). Swarm intelligence is based on the cooperative group intelligence of swarms or collective behavior of insect colonies and other animal colonies (E.Bonabeau, M. Dorigo, & G.Theraulaz, 1999).

### **2.2. Evolutionary Algorithms**

Evolutionary algorithms are inspired by the evolutionary process of nature. According to natural selection theory of evolution, competition among individual to survive in the nature results in the survival of the fittest individual over weaker one. This results in the success of achieving variety of life and its suitability for the nature. Evolutionary algorithms are generic Meta heuristic based optimization algorithms. An EA uses the mechanism inspired by biological process such as reproduction, mutation, recombination and selection (J.H Holland, 1975). An objective function is defined based on the problem and initial population is randomly generated; randomization helps in elimination of local minima problem, now the operators such as selection, recombination and mutation are applied iteratively to find the best individuals survived in the environment of objective function. The progress in search is achieved by evaluating the fitness of individuals and selecting the individual with highest fitness. In general any abstract task to be accomplished can be thought of as solving a problem. This can also be assumed to have a search through a space of the potential solution. Here comes the existence of optimization because search is for the best solution. The method of evolutionary computation is among this category, they are stochastic methods whose search spaces models some of the natural phenomena, survival of the fittest (L. Davis, & (ed.), 1991) . Evolutionary algorithms are widely used to solve complex engineering and science problems. Here it is very important to realize to find the problems that are most suited for the application of evolutionary algorithms. The major goal of research in evolutionary algorithm is to find

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