Optimization Of Multi-Objective Problem Using Evolutionary Algorithms

S. Jose , C. Vijayalakshmi

Abstract— This paper deals with the introduction of Multi-objective optimization and Evolutionary Algorithms. The short discussion about Genetic Algorithms, Evolution Strategies, Evolution programming Genetic programming, Artificial intelligence NSGA-II and MODE. Then the applications of Evolutionary Algorithm in real-world problems are analysed.

Keywords: Multi-objective problem; Evolutionary Algorithm; Genetic Algorithm; Evolution Strategies; Evolution Programming; MOEA;

1 INTRODUCTION

Optimization is a kind of decision making, in which to get the best optimal solutions. The optimization problems are single or multi objective problems that can be maximized or minimized in specified set of constraints and these constraints in the form inequalities and equalities such problems are called optimization problem [14]. In 1960 Evolutionary Algorithm was approached by Charles Darwin theory. Evolutionary Algorithm is inspired by biological evolution, such as reproduction, Mutation, crossover and selection are used for solving optimization problem. In recent this algorithm uses in many real life situations and to find best solutions [3].

Multi-objective Problem

The general formula for multi-objective problem is stated in [[1], [2]]:

$$max / min f_m(x),\ m = 1,2,3,...,m;$$

$$subject$$

$$to,$$

$$g_i \geq 0,\ j = 1,2,3,...,J;$$

$$h_k = 0,\ k = 1,2,3,...,K;$$

$$x^L{}_i \leq x_i \leq x^U{}_i, i = 1,2,3,...,n.$$

Evolutionary Algorithm

Evolutionary Algorithm deals with survival of the fittest in biological world from the method of natural selection. In Evolutionary Algorithm randomly initialize population of solutions and then determine fitness. From the fitness select parents of population and perform recombination and mutation on parents until best individuals is achieved. Evolutionary algorithm mainly stochastic and population- based algorithms which involves variation parameters namely crossover and mutation [3]. In Evolutionary Algorithm have four major branches:

- Evolution strategies.
- Evolutionary Programming.
- Genetic Algorithm.
- Genetic Programming.

EVOLUTION STRATEGIES

Evolution Strategies were developed in Germany and have been extensively studied in Europe [5]. They can be use real-coding of design parameters since they model the organic evolution at the level of individuals phenotypes and depend on deterministic selection and mutation for its evolution [4].It can be used in strategic parameters such as online self-adaptation of mutability parameters. The selection of parents to form offspring is less constrained than it is genetic algorithms and genetic programming [6]. Evolution strategies involved uniform and random selection of μ number of parents. The number of offspring produced through crossover and mutation are greater than μ, from which μ deterministic survivors are chosen. The survivors are chosen either from the λ offspring (μ, λ)-ES) or from the best $\mu + \lambda$ parents and offspring-($\mu + \lambda$)-ES [7]. Certain optimization factors in hydraulics could not resolve the mathematical programming technique [8], [9].

GENETIC ALGORITHM

Genetic Algorithm was invented by John Holland in the early 1970s.The natural evolution was found by Charles Darwin. Genetic Algorithm was inspired by the process of genetic evolution and one of several evolutionary approaches to optimization. In genetic algorithm the process begins with selection of initial population followed by selection of the fit candidates as per the fitness function. The fit individuals are hence considered to form new generation.

GENETIC PROGRAMMING

Genetic Programming is found by John Koza.GP is similar to Genetic Algorithm. In GP, no genotype and phenotype distinction. Genetic Programming reproduction is process through crossover and mutation. Let the candidates are represented as parse trees. A swapping branches of the tree is implemented by crossover and deleting and regrowing branches involves the mutation.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence is used for computer programs and produce for automatic generation in certain inputs. The

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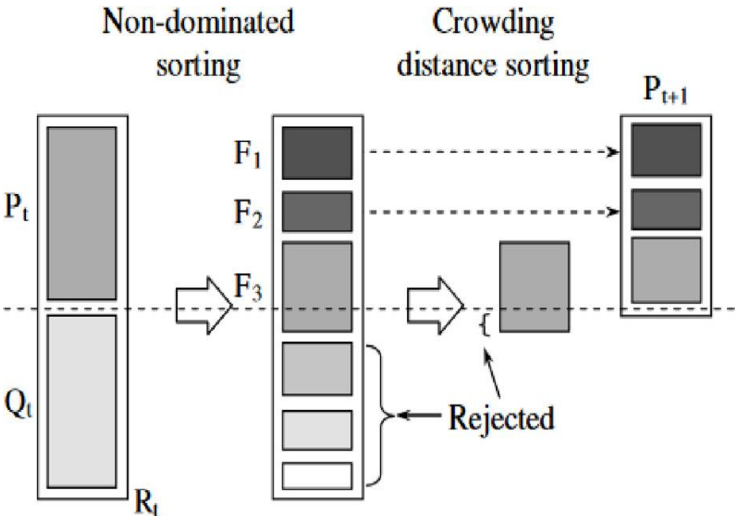
Artificial Intelligence could be tested for several years in the certain program will be technique to produce programs there are invalid or sufficient. In early years automatic programming was tested in Evolutionary Mathematics but they were failed in Artificial Intelligence. After some years, the researchers fined the main issue in automatic programming task in Evolutionary Algorithm and they encoding adopted. In the time, Koza suggested Genetic Algorithm encoding that can be used in tree-based. This approach was simplify in original implementation and this sort of approach called Genetic programming.

NSGA-II

NSGA is one of the method proposed in Evolutionary Algorithm for to solve the optimization problem based on individuals ans NSGA have another version named as NSGA-II to finding the best solutions from the initial population. NSGA-II starts with ranks individuals and sorts from non-domination level and it creates new offspring in Evolutionary operators. Then the combines the offspring and parents in the new combined pool into fronts.



Notations

- P_t - Parents population.
- Q_t - offspring population.
- F_1 - Best solutions from the parents and offspring.
- F_2 - Second best solutions.

MODE

MODE is one of the proposed method in Evolutionary Algorithm that used for solving multiobjective problem over a continuous domain. This algorithm used in many successful applications. The components of approach in MODE are:

- Reproduction.
- Evaluation.
- Selection.

$$P_i' = \gamma P_b + (1-\gamma)P_i + F\sum_{k=1}^{K}(P_i - P_i)$$

Notations

- P_b - Best individuals in the parent solution.
- γ - Voracity operator.
- K - Number of perturbation vectors.
- P_q^k and P_b^k - Randomly selected the parent solution.
- P_i' - Generated offspring.
- γ, K, F - Algorithm^{0}s Parameter.

REAL-WORLD APPLICATIONS

K. Bharathi et al was found the ”Bipartite Graph” by using multi-objective optimization transportation problem using evolutionary algorithm. The applications was mainly found for transportation, supply, cost of parameters. They have represented the economic world life by using a linear optimization problem of encoding method. The problem can be encoding as Bipartite graph and parent solution [12]. K. Bharathi et al was found a salesman problem by using Multi Travelling salesman problem in evolutionary algorithm. The model was proposed basic constraints of Multi objective problem with EAs. The main goal to get Minimum and maximum salesman working [13]. Ibrahim Muita fanuel was found watter allocation, crop pattern irrigation by optimization are using Multi-objective optimization. There are three major waters users in Industries, Agriculture and Domestic activities. The applications are used in Genetic Algorithm, NSGA-II, MODE are analyzed [15]. M. Anusha et al worked on optimizing Intra-Cluster distance and Inter-Cluster distance by minimizing the former and maximizing the later using K-means Genetic Algorithms [17]. Jorn Mehnen et al found the dynamic test functions using Evolutionary Algorithms and discussed about Pareto sets and Pareto fonts used in many real-world problems for different dynamic Multi-objective problem [18]. Andreas Mieben worked on Development of Multi-objective Evolutionary and discussed the history of MOEA, Pareto Dominance, Pareto based algorithms ,Elitist Pareto multi-objective optimization algorithm for finding the solution of optimal trade-offs between the multi-objective[16].

CONCLUSION

In this paper discussed about evolutionary algorithms and its types and also explained multi-objective optimization problem. A detailed explanation of genetic algorithm, evolutionary programming, NSGA-II and Multi-objective differential evolution how it works in some real world applications is presented in this study.

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