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A MULTI-OBJECTIVE OPTIMIZATION PROBLEM WITH ITS APPROACHES AND APPLICATIONS

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Abstract—Optimization is used for finding one or more optimal or feasible solutions for single and multiple objective problems. A multi-objective optimization problemhave two or more objective, but in many real wordsMOP, objectivesunderconstraintmay conflict with each other and optimizing a particular solution with respect to a single objective can result in unacceptable results with respect to the other objectives. A reasonable solution to a multi-objective problem is to investigate a set of solutions, each of which satisfies the objectives at an acceptable level without being dominated by any other solution.This paper presents a multi-objective optimization problem, methods to solve MOP and their applications.

Keywords—Optimization,Multi-objective optimization problem

I. INTRODUCTION

Generally, many of real word problems in the field of science, medical, management, engineering are Multi-Objective Optimization Problem. The problem which has more than one objective and these objectives are conflicting each other simultaneously means if one objective gives better result, no guarantee that other objectives may give better results.So, one objective result conflict other objective results and we have to optimize multiple objectives simultaneously to find out the optimal solution[37].

Many Multi-Objective Optimization Problem involves a large (10 or more) number of objectives. There are various evolutionary algorithms to solve MOP like GS, ACO, PSO, SA and much more.Other heuristics and meta-heuristics are also available.

The rest of the paper is organized as follows, section II gives a brief literature survey of MOPs in some applications. Section III is about basic MOPs and its formulation. Section IV gives various approaches to solve MOPs, and section V gives applications of MOPs.

II. RELATED WORK

In literature survey of various literature we focus on application used technique, and its objectives.

In [36] Saman Hassanzadeh Amin et al.Have proposed A multi-objective facility location model for closed-loop supply chainnetwork under uncertain demand and return. In this paper, a CLSC network is established which includes multiple plants, collection centers, demand markets, and products. Mixed-integer linear programming model is proposed that minimizes the total cost.Result show that the model can handle demand and return uncertainties simultaneously.

In [35] Raul Banos et al. have proposed hybrid meta heuristic approach to solve multi-objective vehicle routing problems with time windows [MOVRP]. They considered not only the minimum distance required for delivery, but also the workload imbalance. The workload is in terms of the total distances travelled by vehicles and their respective loads. This paper first formulate a multi-objective formulations for vehicle routing problems with time windows and then hybrid meta heuristic approach is applied on it.

In [34] Reza Tavakkoli-Moghaddamet al.Proposed a new multi-objective imperialist competitive algorithm (MOICA) approach to solve tree hub location problem.The objectives of the work are minimization of total transportation cost as well as transportation time. Results are compared with NSGA-II approach shows the efficiency of the proposed algorithm.

In[19] AmolAdamuthet al.Have formulated multi-objective virtual machine placement problem with cloud computing. The objectives of the work are maximizing load balancing as well as profit and minimize resource wastage. Results of GA, NSGA, NSGA-II are compared with each other. NSGA-II gives good results as compare to other two.

In [33] Irina Harriset al. Proposed aMulti-Objective Uncapacitated Facility Location Problem. The objectives of the work are minimization of Cost, uncovered demand, environmental impact of transport. The author has proposed NSGA-II approach to solve this problem.

In [32] Gong Yue Jiao et al. have proposed multi-objective particle swarm optimization algorithms for solving multi-objective vehicle routing problems with time windows. This paper focus on main two objectives, first is to minimize the number of the vehicle routes and the second objective is to minimize the total travelling distance, with the same number of routes. A set based particle swarm optimization is used to find optimal result.

III. A Multi-Objective Optimization Problem

A single objective optimization problem only one objective function I considered. Most of the single objective optimization problem gives best results. But in multi objective optimization more than two objectives are considered. A general formulation of Multi-Objective Optimization Problem is taken from[31]. A MOP consist of n no of objective functions, m no of decision variables and set of k constraints.

Maximize $y = f(x) = f(f1(x),f2(x)\ldots.fk(x))$
Subject to $e(x) = (e1(x1),e2(x2)\ldots.ek(x))$
Where $m=(m1,m2\ldots.mk) \in M$

y=(y, y2….yk) € Y

Where, x is decision variable, y is objective and e is constraints and M is decision space and Y is objective space.

The Pareto optimal set consists of set of efficient solutions. Fig 3.1 shows Pareto optimal font where f1 (x) and f2 (x) are the objectives. (f2( ),f1( )) And (f2 ( ),f1( )) Shows Pareto front of both objectives [9]. The goal is to find set of optimal or feasible solutions which are close to pareto optimal fronts[19].

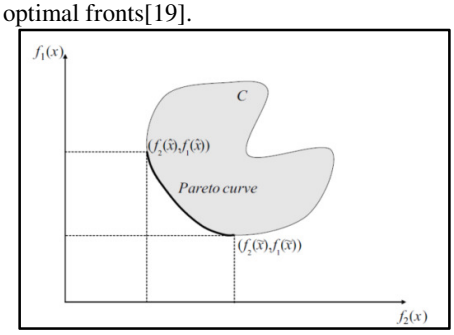

Fig 3.1Pareto optimal curve

IV. APPROACHES TO SOLVE MOP

There are various techniques available to solve Multi objective optimization problems, but no any approach gives best result when there is hard time window constraints and are large number of maximization and minimization objectives.

Lot of methods are available to solve Multi objective optimization problems[11].Some of the well known are illustrated in table 4.1.

Ant colony algorithm [1][2][3][4][5][6][15]
NSGA, NSGA-II [7][8][9][10][17]
Vector Evaluated Genetic Algorithm[11]
Simulated annealing[12][13]
Tabu search[16][18]
Goal Programming[22]
Genetic Algorithm[22][23][24]
Fuzzy logic [28][29]
Particle Swarm Optimization[25][26][27]
€-constraints Method[30]
Cultural Algorithm with Evolutionary Programming
Scalarization Technique
Strength Pareto Evolutionary Algorithm
Pareto Archived Evolution Strategy

Table 4.1. Well known Multi objective optimization approaches

V. APPLICATIONS

There are various applications of MOPs in daily life. Some of the real word MOPs are illustrated below[20]:

1. Car purchase - while purchasing car customer have focused on the comfort level of the caras well as cost. I.e maximize the comfort level with minimum cost.
2. Facilities allocation in hospital – objectives are, maximize focus on patient while minimizing investment cost as well as facilities.
3. Designing of product in factory – objectives are, minimization of development cost while maximizing performance
4. Land use – objectives are, maximizing return by minimizing erosion of soil
5. Load dispatch in power system – objectives are, minimization of fuel requirement as well as minimization of power.
6. Classification in machine learning – objectives are maximization of accuracy while minimizing errors or complexities

VI. SUMMARY

In survey of multi objective optimization problems, we have surveyed 37 literatures. A multi objective optimization problems have more than two objectives and no any single solution gives best results for the given problem. There are various techniques to solve the problem. The Number of real world applications are exists in daily life which are multi-objective. Most of the literature uses heuristics and meta-heuristics approach to solve this problem.

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