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RESEARCH ARTICLE

One-Dimension Multi-Objective Bin Packing Problem using Memetic Algorithm

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Abstract— Memetic Algorithm has been proven to be successful to find the nearest optimum solution to hard combinatorial optimization problems. In this paper, Memetic algorithm is designed for One-dimension Multi-Objective Bin Packing Problem. Memetic Algorithm is a combination of power of Genetic algorithm with the powerful local search technique to focus on the population of local optima. In this paper memetic algorithm is performing local search on each chromosome; it is guaranteed to give near to optimal solution than Genetic Algorithm.

Keywords— One-dimension Multi-Objective Bin Packing Problem (ODMOBPP); Memetic Algorithm; Local Search; Optimization problems

I .INTRODUCTION

In one dimensional bin packing problem the objects have one dimension. Object's value is weight, size, cost or time. In bin packing problem, main objective is pack all the objects in minimum number of bins or maximize the profit associated with bins. The term "bin" here is in fact a generic name which could stand for a "container", as in the "transportation" context, "work stations " in industrial assembly lines (line balancing), "a space in time" in scheduling, or a "surface area", as in metal working, for example.[1] The various applications of BPP in our day to day life can include Loading trucks with weight capacity constraints ,Creating file backups in removable media ,Filling up containers, Storing a large collection of music onto tapes/CD's,Computer processor selection with job assignment, In metal working where steel sheets of different sizes must be cut from "master" sheets. In this way, a solution to the BPP would really prove to be beneficial.[12] BPP has been solved by various optimization techniques but Memetic Algorithms have been proven to be successful to find the nearest optimum solution to Bin Packing Problem as it is a combination of power of Genetic algorithm with the powerful local search technique to focus on the population of local optima. Because of performing local search on each chromosome, it is guaranteed to give near to optimal solution than Genetic Algorithm.[2] Memetic algorithms (MA) represent one of the recent growing areas of research in evolutionary computation. MAs are intrinsically concerned with exploiting all available knowledge about the problem under study. This method is proved to be of practical success for the approximate solution of NP optimization problems.

The organization of the paper is as following; in section 2 Optimization problems have been explained. In section 3 BPP and its variations introduced. The following section is Literature Review, In this section memetic algorithm and fitness function, crossover method and local search method has been explained and The proposed memetic algorithm. Last section contains the conclusion about the study that is done so far and so forth future work.

II. OPTIMIZATION PROBLEMS

Any problem that involves the identification of optimal cost (minimum or maximum) is called optimization problem. The algorithm for optimization problem is called optimization algorithm.There are 2 groups in which a problem can be classified.(1)P class problem:-problems that can be solved in polynomial time, like sorting of elements, searching of key element.(2) NP class problems :-It stand for "non-deterministic polynomial time",Like Travelling Salesman Problem, Bin Packing Problem.[3]The problem is an example of NP (Non deterministic Polynomial) hard problem in which no known algorithms that are guaranteed to run in a polynomial time. Examples include: Travelling salesman problem, Hamilton Circuit Problem, Bin Packing Problem, Clique Problem and the knapsack Problem.Evolutionary Algorithms have shown to be well suited for high-quality solutions to larger NP problems and currently they are the most efficient methods for finding approximate optimal solution for optimization problems. [2]

III. BIN PACKING PROBLEM AND ITS VARIATION

In Multi-objective Bin Packing Problem n objects to be placed in bins of capacity L each and different profit associated with each bin. Object i requires l_i units of bin capacity. Here Objective is Minimize number of bins used to pack all objects and maximize profit in bin packing problem.

- ***Variation of BPP is 2-D bin packing problem***

In 2-D bin packing problem a set of *n* rectangular items $j \in J = \{1,...n\}$,each having *width* w_j and *height* h_j and an unlimited number of finite identical rectangular *bins*, having width *W* and height *H* given. Objective is allocate, without overlapping, all the items to the minimum number of bins, with their edges parallel to those of the bins.The items have fixed orientation, i.e., they cannot be rotated.[4][6][7]

In 2-D bin packing problem using Bottom Left Fill approach The input parameters of *BLF* function are the dimensions of the rectangle i, width and height and the width of a current bin. *BLF* function returns the coordinates (x, y) for the rectangle. The first rectangle is placed at null coordinates of the bin. It is created a list of points. In general, for a position j, for each rectangle is chosen the closer bottom left point (xj , yj) where it can be placed the rectangle. This point is removed from the list and are inserted two new points: (xj +widthj , yj) and (xj , yj +heightj). If the point is not founded in the points list, it is necessary to add to the list a point with coordinates 0 and max(height+ y) based on the previous rectangle. The following conditions need to be accomplished in order to decide if it can be placed a rectangle k in a given position. • Accomplish the inequality x+width ≤ width1, where width1 is the width of the first rectangle from thebin. • The intersection with all previous rectangles – from 1 to k − 1 - need to be null. In order to prevent some of the already mentioned conditions it is better to store the points in a sorted list. *Bottom Left Fill* technique allows the representation of the solution as a permutation. [5]

In one-dimension Bin Packing Problem n objects to be placed in bins of capacity L each. Object i requires l_i units of bin capacity. Here Objective is Minimize number of bins used to pack all objects. [1]

IV. LITERATURE REVIEW

A. MEMETIC ALGORITHM

Memetic algorithm (MA) is motivated by Dawkin's notion of a meme as a unit of information is processed and enhanced by the communicating parts.This method is proved to be of practical success for the approximate solution of NP optimization problems. Memetic Algorithms exploit all available knowledge about the problem. Memetic algorithms combine the power of genetic algorithm and local search.[8]

1) ***Outline of General Memetic Algorithm:*** [9]

1. [Start] Generate random population of n chromosomes
2. [Fitness] Evaluate the fitness f(x) of each chromosome x in the population.

3. [New population] Create a new population by repeating following steps until the new population is complete.
    - [Selection] Select parent chromosomes from a population according to their fitness (better the fitness , bigger the chance to be selected)
    - [Crossover] With a crossover probability, cross over the parents to form new offspring. If no crossover was performed, offspring is exact copy of parents.
    - [Mutation] With a mutation probability, mutate new offspring at each position in chromosome.
    - Perform Local search on available population.
    - Evaluate each chromosome.
    - [Accepting] Place new offspring in the new population.

5. [Replace] Use new generated population for a further run of the algorithm.
6. [Test] If the end condition is satisfied, stop, and return the best solution in current population. If not, return the best solution from current population and go to step 2.

2) steps used in Memetic Algorithm:

❖ Selection: [13]

Selection is usually first operator applied on population. From the population, the chromosomes are selected to be parents to crossover and produce offspring. Selection process is based on the fitness function. Chromosomes having the highest fitness values are most likely to be selected, and chromosomes with lower values will be discarded. Population size must be constant for each generation. There are many selection methods exist such as Roulette Wheel Selection, Tournament Selection, Rank Selection.

- **Roulette Wheel Selection:** Each current string in the population has a slot assigned to it which is proportion to it's fitness.Spin the weighted roulette wheel n times.Each time roulette wheel stops, the string corresponding to that slot is created.Probability of being selected is pi=fitness of that string/ sum of fitness of all strings here N is the number of individuals in the population.
- **Rank *Selection*:** If the best chromosome fitness is 90%, its circumference occupies 90% of Roulette wheel, and then other chromosomes have too few chances to be selected. The proposed method ranks the population first and taken every chromosome, receives fitness from ranking. The worst chromosome will have fitness 1 and the best will have fitness N where N is the number of chromosomes in the population. It preserves diversity and results in slow convergence.
- **Tournament Selection:** The Tournament selection strategy provides selective pressure by holding a tournament competition among N individuals. The best individual from the tournament is the one with the highest fitness, which is the winner of tournament. Tournament competitions and the winner are then inserted into the mating pool.
- **Elitism**: It is a method, which copies first the best chromosome or few best chromosomes to the new population before crossover and mutation. It has been found that, it significantly improves the performance of Memetic Algorithm as it prevents losing the best-found solutions.

❖ Crossover:[10]

Crossover combines two chromosomes to produce a new chromosome. The idea behind crossover is that the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents.
Crossover Methods are:

- Single Point Crossover
- Two Point Crossover
- Multi point crossover
- Uniform Crossover

❖ Mutation: [14]

Mutation is a process of changing a random gene in an individual. Mutation takes place after crossover is performed. Mutation changes the new offspring by flipping bits from 1 to 0 or from 0 to 1. Mutation can occur at each bit position in the string with some probability usually very small (Ex 0.001).
Mutation Types:

- Flipping
- Interchanging
- Random

B. Fitness function for Multi-objective Bin Packing problem

In multi-objective bin packing problem for fitness function consider all the objectives. Here one objective is profit so first calculate sum of profit of chromosome and second objective is less number of bins so calculate total number of bins require to pack all object for each chromosome.

F1=total sum of profit of each chromosome
F2=total number of bins require to pack all objects for each chromosome

So, Fitness Function F is calculate as =F1/F2

C. One-Point Cross over

In this method, In step 1 first select one point in chromosome after some bin,In step 2 copy that number of bin from parent 1 to child 1 and from patent 2 to child 2. Then in step 3 copy those number of bins which are not copied at sep 2 from parent 2 to child 1 and from parent 1 to child 2, preserving their order.

Example:

Parent 1 12 | 56 | 34 | 71 | 325

Parent 2 57 | 23 | 156 |47| 132

Child 1 12| 56 | 156| 47 | 132

Child 2 57 | 23 | 34 | 71 | 325

Fig. 1 Example of One-Point Crossover

D. Local search method for Bin packing problem.

Local Search is used to improve chromosomes and the chromosomes are replaced with improved ones. Local search is one of the basic methods used to find approximate solutions for hard combinatorial optimization problems, in particular those known as NP hard.[11] In every solution, the n least full bins are opened and their contents are made free. Items in the remaining bins are replaced by larger free items. This gives fuller bins with larger items and smaller free items to reinsert. The free items are reinserted via BFD**.**The procedure is repeated until no further improvement is possible.

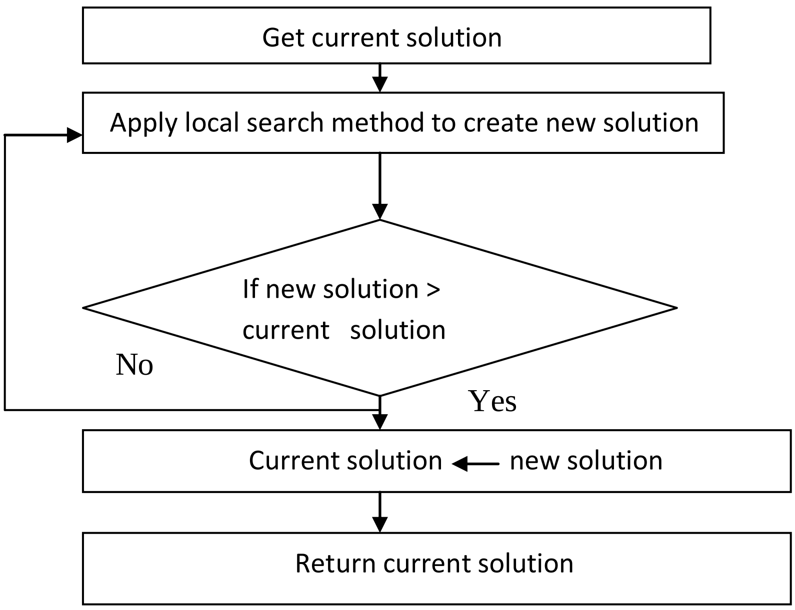

Fig. 2 Local Search Procedure

V. THE PROPOSED MEMETIC ALGORITHM

Fig. 3 represents the proposed MA. To solve Bin Packing Problem first define all the user define value.Then make the efficient fitness function and create the initial population and evaluate fitness of each chromosomes in population.Using selection method select best parents and create mating pool. To create new population apply reproduction operator on chromosomes and then apply local search method on that chromosomes.Then check if termination criteria satisfied, if yes then stop otherwise again evaluate fitness of new generated chromosomes and repeat the process until termination condition satisfied.

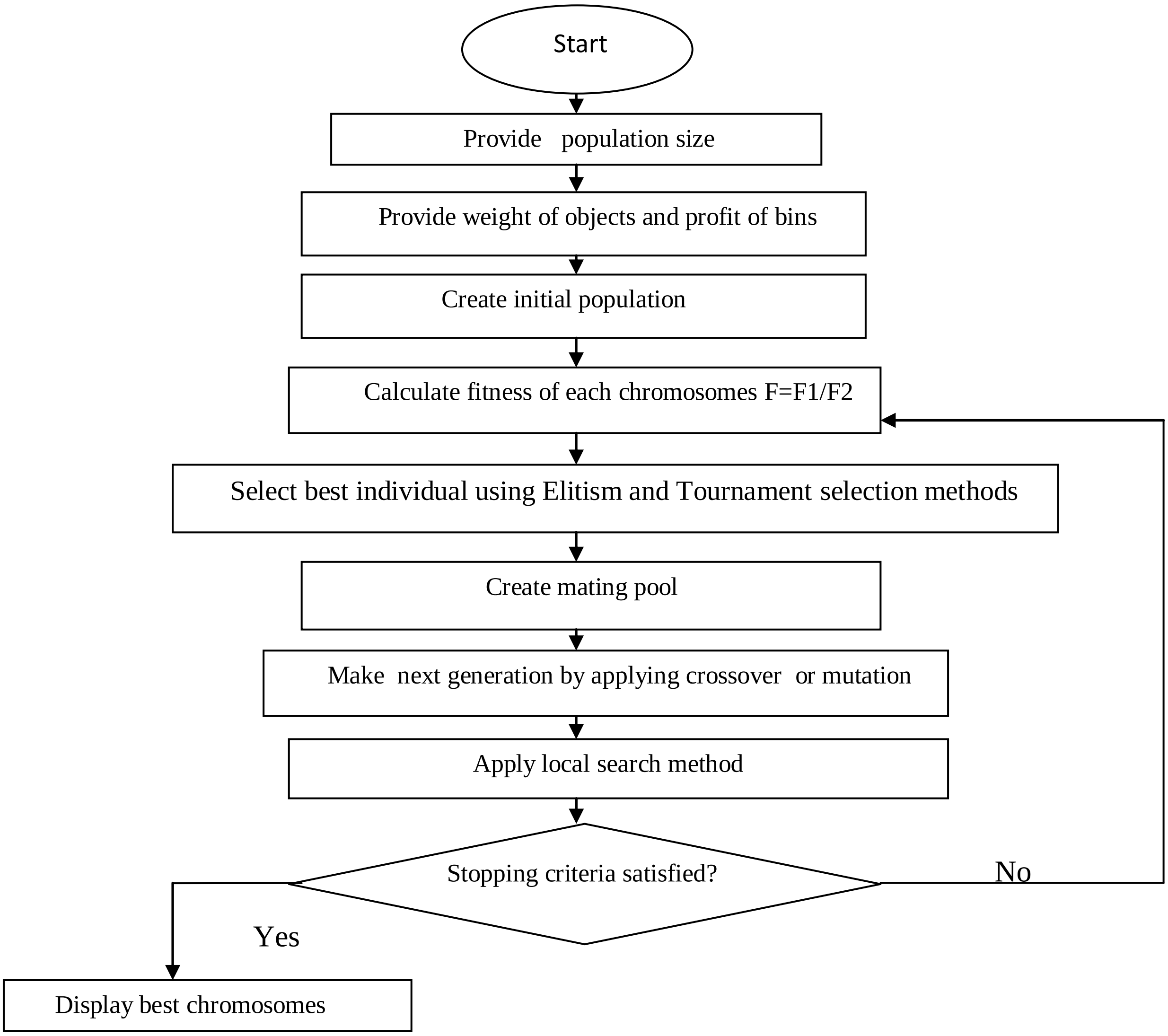

Fig. 3 Steps to implement Memetic Algorithm for multi objective bin packing problem

VI. CONCLUSION AND FUTURE WORK

In this paper, an introduction of a Memetic algorithm to solve multi-objective Bin packing problem is done .In two objective one is less number of bins require to pack all objects and second is maximize profite associate with bins. In future, the proposed Memetic algorithm will be implemented and the results will generated for different population size.

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