A Hybrid Genetic Algorithm for Solving Facility Location-Allocation Problem

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Abstract — Today’s logistic systems in companies depend on optimum solutions of Facility Location-Allocation (FLA) problems in order to minimize cost values the company is dealing with. Therefore, FLA plays an important role in nowadays business environment. In this paper, a Hybrid Genetic Algorithm (HGA) is proposed to solve FLA. The HGA is a combination of Genetic Algorithm and Tabu Search while NSGA II is used as the main genetic algorithm. This algorithm has the capability of solving NP-hard multi-objective problems using ranking algorithm and diversity control function. Tabu Search is used to improve solutions resulted from NSGA II. Finally, the proposed algorithm is investigated providing problem samples.

Keywords—location-allocation problem; hybrid genetic algorithm; facility layout; tabu search.

I. INTRODUCTION

In Facility Location (FL) problem, the objective is to minimize the total cost for assigning facilities to satisfy the demand of customers. Cooper [1] extends the FL problem to Facility Location-Allocation (FLA) problem by adding the determination of physical location of the sites to FL. This step made the problem closer to realistic environment while adds to the problem complexity.

This paper investigates Multi- Facility Location Allocation Problem (MFLAP) presented by Drezner [2] and Drezner and Hamacher [3]. As discussed in Megiddo and Supowit [4], the problem is known to be NP-hard; therefore many researchers used metaheuristics to solve this problem.

Bischoff and Dachert [5] presented the known approaches to solve location-allocation problems. It should be noted that the solution approaches can be considered in two different categories:

(1) Metaheuristics i.e. Variable Neighborhood Search (VNS), Tabu search (TS), Simulated annealing (SA) and Genetic algorithm (GA);

(2) Designed Algorithm i.e. Self-organizing feature maps (SOFM) and Alternate location-allocation (LA).

The first heuristic to solve this problem was proposed by Cooper [6] and the next known research in this field is the work by Love and Juel [7] where they proposed neighborhood search heuristics for to solve large location-allocation problems. Using metaheuristics to solve this problem continued by using Tabu Search (Brimberg and Mladenovic [8]) and a variable Neighborhood Search Method (Brimberg and Mladenovic [9]). Houck et al. [10] developed a genetic algorithm for (MFLP) and compare it with several heuristics to obtain a good initial solution. Doong et al. [11] used a combination of sub-gradient iterative algorithm and Genetic Algorithm to solve this problem.

In this paper, we focused on designing a hybrid Genetic algorithm (a combination of Genetic Algorithm and Tabu Search) to solve the problem from a multi-objective point of view. This paper is organized as follows. In section 2, the problem is described and next, in section 3, the proposed hybrid genetic algorithm is described in details. The proposed algorithm is investigated in section 4 and finally, section 5 includes the conclusion.
II. PROBLEM DESCRIPTION

The problem is to minimize the sum of cost functions resulted from locating M new facilities in R2 plane. In the following, the problem mathematical formulation is described in details as was proposed by Bischoff and Dachert (2009) [5].

A. The Input parameters:

N Number of existing facilities
M Number of new facilities
(u_i, v_i) Coordination of new facility i
(a_i, b_i) Coordination of existing facility j
C_{ij} Cost of assigning existing facility j to new facility i where
f_j Cost of assigning a new facility to existing facility j
d_j Demand of existing facility j

Decision Variables:

x_{ij} \in \{1 \quad \text{if existing facility } j \text{ assigned to new facility } i, \}
0 \quad \text{otherwise.}

y_j \in \{1 \quad \text{if existing facility } j \text{ selected to be assigned}, \}
0 \quad \text{otherwise.}

Mathematical formulation:

\text{Min } Z_1 = \sum_i y_i f_i \quad (1)
\text{Min } Z_2 = \sum_{i,j} x_{ij} d_j c_{ij} \quad (2)

Subject to:
\sum_{i=1}^m x_{ij} = 1 \quad \forall \ j=1,\ldots,n \quad (3)
\sum_{i=1}^m x_{ij} = y_j \quad \forall \ j=1,\ldots,n \quad (4)

x_{ij} \in \{0,1\} \quad \forall \ i = 1,\ldots,m, \quad \forall \ j=1,\ldots,n
y_i \in \{0,1\} \quad \forall \ i = 1,\ldots,m

Equation (1) is the first objective function that is equal to total cost of assigning existing facilities and Equation (2) is the summation of total cost of assigning existing facility j to new facility i considering existing facility demand and. Equation (2) is to make sure each existing facility is being assigned and Equation (3) deals with the relationship between x_{ij} and y_j. Finally, we make sure that x_{ij} and y_i are constrained to 0 and 1 values.

III. HYBRID GENETIC ALGORITHM

Holland [12] invented Genetic Algorithm (GA), in the early 1970s, in his try to emulate the process of natural selection in a search procedure. GA has the capability of solving the complex combinatorial problems in practical time and finding optimum and near optimum solutions.

On the other hand, Tabu search initially developed by Glover [13] and is an iterative improvement solving combinatorial optimization problem. Tabu search mechanism is based on exploring the solution space of a problem by moving from one region of the search space to another in order to look for a better solution while avoiding terminating prematurely in a local optimum [14].
In this paper, we used Genetic algorithm along with Tabu search to solve the problem. The main concept of the solution strategy is shown in Fig.1. The GA characteristics i.e. crossover and mutation used in this paper are hired from Doong et al. [11] and combined with NSGA II proposed by Deb et al. [15]. Deb et al. proposed Non-dominated Sorting Genetic Algorithm II (NSGA II) with three new innovations in MOGA literature i.e.:

1) A fast non-dominated sorting procedure,
2) A fast crowd distance estimation procedure,
3) A simple crowded comparison operator. NSGA II is an upgraded GA used to solve Multi-objective problems.

![HGA Main Concept](image)

After implementing NSGA II, Tabu search is used to improve solutions. Tabu search select each individual in the NSGA II population and searches in the solution space to find if there is another solution that may dominate the selected individual. The Tabu search algorithm is as follows:

**Tabu Search Algorithm:**

For i = 1 to |EM|
Set X = EM[i]
1: X* = X
For j=1 to |NumberObj|
   \( f_j(X^*) = f_j(X) \)
Next j
2: JobSwamp(X)
IsBetter (X) = True
For j=1 to |NumberObj|
If \( f_j(X) > f_j(X^*) \) then
   IsBetter (X) = False
Next
CheckTabuList()
If (IsBetter (X) = True) then
   If (IsTabu(X) = True) then
      RemovefromTabu(X)
End If
Goto 1
Else
If (TabuListisFull = True) then
    RemoveFromTabu(T)
End IF
AddTabu(X)
Gotto 2
End IF
Next i

Finally, the best solution is selected from the final improved population.

IV. EXPERIMENTAL RESULTS

Extensive numerical experiments are conducted to evaluate the performance of proposed approaches. The experiments are designed based on randomly generated problems. We generate some samples according to Doong et al. [11] and experiment the proposed HGA on the samples. The results are shown in Table 1.

Table 1. Results from Algorithms implementations

<table>
<thead>
<tr>
<th>Samples</th>
<th>HGA (Obj)</th>
<th>HGA (Time)</th>
<th>NSGA II (Obj)</th>
<th>NSGA II (Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20178</td>
<td>1:20</td>
<td>21646</td>
<td>00:58</td>
</tr>
<tr>
<td>2</td>
<td>22341</td>
<td>3:58</td>
<td>23535</td>
<td>2:54</td>
</tr>
<tr>
<td>3</td>
<td>26535</td>
<td>5:32</td>
<td>28645</td>
<td>04:33</td>
</tr>
</tbody>
</table>

Note that the results shown in Table 1, are average values of 10 times implementations of each algorithm.

4.1. Result discussion

As it is obvious in Table 1, HGA results in better objective values (lower cost values) while NSGA II has upper objective values. From time view, HGA solves the problems in upper time while NSGA II finds results in lower time. It is because of the fact that HGA is a combination of two different algorithms which takes up upper time to solve the problems.

V. CONCLUSION AND FUTURE RESEARCH

In this paper, the location-allocation problem is investigated and a hybrid genetic algorithm is proposed to solve the problem. The HGA is a combination of Genetic Algorithm and Tabu Search. NSGA II is used as genetic algorithm. This algorithm has the capability of solving NP-hard multi-objective problems using ranking algorithms and diversity control function. Tabu Search is used to improve solutions resulted from NSGA II. Using this algorithm, better solutions are found comparing to NSGA II.

Further research can be focused on using fuzzy Lp-metric linear programming via the mathematical model. The fuzzy mathematical programming approach incorporates the uncertainties associated with estimation of time dependent parameters directly into the optimization model.

REFERENCES

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BIOGRAPHY

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