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A Simulated Annealing for Multi Floor Facility Layout Problem

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Abstract—**The dynamic facility layout problem is the problem of assigning departments to the predetermined locations on the plant floor for multiple periods to minimize material handling and rearrangement costs. Nowadays, we encounters with shortage of lands to build factory, so we use of several floor. In this paper, we propose a simulated annealing algorithm for multi floor facility layout problem.**

Index Terms—**Facility Layout, Multi Floor, Genetic Algorithm.**

I. Introduction

One of the oldest activities done by industrial engineers is facilities planning. The term facilities planning can be divided into two parts: facility location and facility layout [22]. Determining the most efficient arrangement of physical departments within a facility is defined as a facility layout problem (FLP) [6]. Tompkins and White [21] stated that 8% of the United States gross national product (GNP) has been spent on new facilities annually since 1955. Layout problems are known to be complex and are generally NP-Hard [6].

There are several review research described facility layout problem carefully (see Loiola et al., [13], Kulturel-Konak, [9], Drira et al., [5], Gu et al., [7] and Liang and Chao, [12]). Loiola et al. [13] was about facility layout as branch of quadratic assignment problem (QAP), Kulturel-Konak [9] investigate facility layout problem under uncertain environment. Drira et al. [5] proposed a structure to analyze layout problem, Gu et el. [7] worked on warehouse layout, Liang and Chao [12] express using tabu search (TS) algorithm in facility layout problem.

In a basic layout design, each cell is represented by a rectilinear, but not necessarily convex polygon. The set of fully packed adjacent polygons is known as a block layout (Asef-Vaziri and Laporte, [2]). The two most general mechanisms in the literature for constructing such layouts are the flexible bay and the slicing tree (Arapoglu et al., [1]). A slicing structure can be represented by a binary tree whose leaves denote modules, and internal nodes specify horizontal or vertical cut lines (Wu et al., [23]). The bay-structured layout is a continuous layout representation allowing the departments to be located only in parallel bays with varying widths. The width of each bay depends on the total area of the departments in the bay (Konak et al., [8]).

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One of common representation for facility layout is discrete representation. This representation is commonly used for dynamic layout problems. There are two approaches to designing robust and/or flexible facilities. The first approach, the dynamic facility layout problem (DFLP), considers several production periods, and facility layout arrangements are determined for each period by balancing material handling costs with the relayout costs involved in changing the layout between periods (Kulturel-Konak, [10]).

Recently, there are many researches in DFLP, Tavakoli-Moghadam et al. (2008) present an integer linear programming formulation for dynamic cell formation problem to minimize machine cost and inter-cell movement at the same time. Şahin and Türkbey (2008) developed a tabu-simulated annealing (TABUSA) for DFLP, Dong et al. (2009) consider adding or removing department in DFLP using simulated annealing (SA) algorithm, McKendall and Hakobyan (2010) developed TS algorithm to solve DFLP in large sized problem.

Nowadays, when it comes to construct a factory in urban area, land supply is generally insufficient and expensive. The limitation of available horizontal space creates a need to use a vertical dimension of the workshop. Then, it can be relevant to locate the facilities on several floor (Drira et al. [5]). Here, we state some work on multi floor facility layout problem. Meller and Bozer (1997) compared approaches of multi-floor facility layout. Lee et al (2005) used GA multi-floor layout which minimize total cost of materials transportation and adjacency requirement between departments while satisfied constraints of area and aspect ratios of departments. a five-segmented chromosome represented multi-floor facility layout. Many firms are likely to consider renovating or constructing multi-floor buildings, particularly in those cases where land is limited (Bozer et al 1994). Matsuzaki et al (1999) developed a heuristic for multi-floor facility layout with considering capacity of elevator. Patsiatzis et al (2002), presented a mixed integer linear formulation for multi-floor facility layout problem. This work was extended model of the single floor work of Papageorgiou and Rotstein (1998).

II. SA

To solve combinatorial optimization problems, simulated annealing algorithm is first proposed by Kirkpatrick et al. Although the origin problem solve in a little time, however increasing number of regional and central warehouse increase complexity of solving the problem, so we use simulated annealing (SA) algorithm to find near optimum solution in large sized problem. SA is a neighborhood search problem that derive from heating and cooling process of metal. In SA, we start with a initial temperature and decrease with coefficient β , in ieach temperature, we move to neighborhood of current solution, we define neighborhood as

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changing location of central or regional warehouses, if the new solution is better than current solution, it is substitute instead of current solution and if it is not, it can be selected if

$$\text{Rand} < \exp\{-K''.(\Delta OF)/t\}$$

That Rand is random uniform number, ΔOF is deference between two solutions, t is current temperature and K'' is the convertor for converting objective function to temperature. In each temperature, we have predetermined move, Max-Move, and after it, current temperature is decrease as follows:

$$T_{new} = \gamma T_{old}$$

We optimize parameter of SA algorithm using several design of experiments. Parameters of SA algorithm are as follows:

T_0:	Initial temperature	100
T_{end}	Final temperature	10
Max_move	Maximum move per each temperature	150
β	Cooling coefficient	0.95
K''	Convertor coefficient of objective function	5

III. Computational Reults

We generate 5 test problems with 3, 5, 7, 10 and 15 departments. Input data include material flow matrix and parameters cost. For dynamic approach, we consider 4 periods. We solve model using MALAB 7 in a PC with 1.00 GB RAM and 2.4 GHz CPU. Table 1 and Table 2 show solution for static and dynamic multi floor facility layout problem.

Table 1. Computational results for static multi floor layout

	SA		Exact	
Size	Time (Sec)	Objective	Time (Sec)	Objective
3	10.0	145.6	35	145.6
5	50.0	256.3	102	256.3
7	298.6	563.2	798.6	563.2
10	745.3	765.3	4098	761.4
15	1054.6	954.3	11923	938.9

IV. Conclusion

The static facility layout problem is the problem of assigning departments to the predetermined locations on the plant floor to minimize material handling and rearrangement costs. Nowadays, we encounters with shortage of lands to build factory, so we use of several floor. In this paper, we proposed a SA algorithm for facility layout problem. For future research, it is proposed to consider input/output points location in designing facility layout problem.

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