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A hybrid fuzzy-GA algorithm for the integrated machine allocation problem with fuzzy demands

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ABSTRACT

The integrated machine allocation and facility layout problem (IMALP) is a branch of the general facility layout problem in which, besides selecting machine locations, the processing route of each product is determined. Most research in this area suppose that the flow of material is certain and exact, which is an unrealistic assumption in today's dynamic and uncertain business environment. Therefore, in this paper the demand volume has been assumed as fuzzy numbers with different membership functions. To solve this problem, the deterministic model is first integrated with a fuzzy implication via the expected value model, and thereafter an intelligent hybrid algorithm, including a genetic algorithm and a fuzzy simulation approach has been applied. Finally, the efficiency of the proposed algorithm is evaluated with a set of numerical examples. The results show the effectiveness of the hybrid algorithm in finding the IMALP solutions.

Introduction

In the domain of supply chain management two complementary issues may be considered for most manufacturing systems: facility layout and facility location. The facility location problem deals with the optimization of manufacturing facilities, e.g. machines and departments, in the shop floor, and has been an attraction for researches for many years. Even though the contexts in which these models are situated may differ, their main features are similar in all cases [1]. The general objective may be defined as serving a set of nodes (customers) by creating/using a set of access points (facilities) which provide high efficiency and incur minimum costs. By reviewing 38 papers in this field, facility location problems may be classified into many distinguished categories as presented in Table 1. Other classifications are also stated in ReVelle and Nickel [1,3].

The material handling process consists of the movement of parts, supplies, work-in-process parts, spares, tools and other equipment supplies between machines/workstations and storage locations [6]. Due to the variety of considerations found in the articles, researchers do not agree on a common and exact definition of layout problems [4]. Koopmans and Beckmann [8] were of the first researchers who defined the facility layout problem as a common issue in industrial environments. They introduced a basic formulation, which determined the relative locations of facilities to minimize the total materials flow. After their research, a lot of studies have been carried out in the discussed area, as mentioned in the review articles of Heragu and Kusiak [9], Meller and Gau [10] and Drira et al. [7].

Discrete facility location problems are generally modeled by mixed integer programming techniques and models, which present high complexity and are considered as NP-hard. The difference of the facility location problem and the facility layout problem may be distinguished by the former being regarded as a strategic decision while the latter is more operational [2]. A facility layout is the arrangement of all needs for the production of goods or the delivery of services [4]. Facility layout problems deal with the position of manufacturing machines, stores, and manpower inside a firm. Facility layout problems have attracted the attention of many researchers as they can considerably reduce the operational cost (i.e. material handling costs) and yet increase the flexibility of the manufacturing system [2]. A good placement of facilities contributes to the overall efficiency of operations and can reduce up to 50% of the total operating expenses [5]. The most commonly considered criterion in developing a facility layout arrangement is the minimization of total material handling distance/cost.

Shayan and Chittilappilly [11] defined the layout problem as an optimization model that tries to increase the overall layout efficiency while considering facility and material handling system relations. Chiang et al. [12] studied the impact of workflow

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Table 1
Classification of facility location problems.

No.	Authors	Structure		Data				Planning horizon		Type of solution		Types and numbers of depots			
				Certainty	Uncertainty							Single depot		Multiple depot	
		Basic LRP	Hierarchical LRP		Stochastic	Fuzzy	Gray	Dynamic	Static	Discrete	Continues	Capacitated depot	Uncapacitated depot	Capacitated depot	Uncapacitated depot
1	Wu et al. (2002)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
2	Liu and Lee (2003)	*	–	–	*	–	–	*	–	*	–	–	–	–	*
3	Melechovsky et al. (2005)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
4	Albareda et al. (2005)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
5	Schwardt and Dethloff (2005)	*	–	*	–	–	–	*	–	–	*	–	*	–	–
6	Prins et al. (2006)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
7	Prins et al. (2006)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
8	Lin and Kwok (2006)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
9	Caballero et al. (2007)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
10	Prins et al. (2007)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
11	Barreto et al. (2007)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
12	Alumur and Kara (2007)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
13	Albareda et al. (2007)	*	–	–	*	–	–	*	–	*	–	–	–	*	–
14	Aksen and Altinkemer (2008)	–	*	*	–	–	–	*	–	*	–	–	–	–	*
15	Lopes et al. (2008)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
16	Schwardt and Fischer (2008)	*	–	*	–	–	–	*	–	–	*	–	*	–	–
17	Marinakis and Marinaki (2008)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
18	Ambrosino et al. (2009)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
19	Salhi and Nagy (2009)	*	–	*	–	–	–	*	–	–	*	–	–	–	*
20	Nikbakhsh and Zegordi (2010)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
21	Yu et al. (2010)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
22	Duhamel et al. (2010)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
23	Tavakkoli-Moghadam et al. (2010)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
24	Zarandi et al. (2011)	*	–	–	–	–	–	*	–	*	–	–	–	*	–
25	Belenguer et al. (2011)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
26	Prodhon (2011)	*	–	*	–	–	–	–	*	*	–	–	–	*	–
27	Karaoglan et al. (2011)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
28	Nadizadeh et al. (2011)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
29	Baldacci et al. (2011)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
30	Karaoglan et al. (2012)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
31	Nguyen et al. (2012b)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
32	Nguyen et al. (2012a)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
33	Manzour-al-Ajdad et al. (2012)	*	–	*	–	–	–	*	–	–	*	–	*	–	–
34	Derbel et al. (2012)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
35	Albareda-Sambola et al. (2012)	*	–	*	–	–	–	–	*	*	–	–	–	*	–
36	Karaoglan et al. (2012)	*	–	*	–	–	–	*	–	*	–	–	–	*	–
37	Contardo et al. (2012)	–	*	*	–	–	–	*	–	*	–	–	–	*	–
38	Toyoglu et al. (2012)	–	*	*	–	–	–	*	–	*	–	–	–	*	–