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Fuzzy decision support system for manufacturing facilities layout planning

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Abstract

Manufacturing facility layout problem is an unstructured decision-making problem due to natural vagueness associated with the inputs to the models. Arbitrary numerical ratings are assigned for relationship chart to determine facility selection routine. This paper presents a distinct decision support system based on multifactor fuzzy inference system (FIS) for the development of facility layout with fixed pickup/drop-off points. The algorithm searches several candidate points with different orientation of incoming machine blocks in order to minimize flow cost, dead space and area required for the development of layout. The proposed methodology is coded in C^+ language and implemented in a Pentium III, 550-MHz machine. The experimental results with a test problem are illustrated with encouraging result with its advanced soft computational effectiveness.

Keywords: Facility layout; Fuzzy decision; Flow cost; Dead space; Minimum required area

1. Introduction

The most significant objective of any enterprise has been the maximum utilization of facilities available to achieve desired goal of productivity and profitability. Two-dimensional facility layout deals with the selection of most appropriate and effective arrangements of departments in the continuous plane to allow greater working efficiency [2,3]. Owing to the complex and unstructured nature of facility layout, many researchers have proposed various approaches, which had varying degrees of success in dealing with the complexities associated with the problem.

Regardless of the type of data, there is an element of vagueness or fuzziness in it [6]. Traditional layout method treats these data as exact and cannot satisfy the desire of managers in handling real problems [12]. Kawasaki and Evans [9] illustrated the potential application of fuzzy set theory to various areas of production management. One of the prominent areas identified by the authors was facility planning which includes such problem as facilities layout design. Raoot and Rakshit [10] have also presented a framework of an algorithm for the development and evaluation of a layout based on fuzzy linguistic variables

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and their fuzzy relation. The integrated expert system approach of Abdou and Dutta [1] determines the movement of material-handling equipments first to determine its effect on the layout.

Recently, Dweiri [6] proposed a fuzzy decision-making application for developing relationship charts and comparing the layouts generated with them. The concept has been applied to develop layout in the line of computer-relative layout programme that was not efficient as compared to conventional layout procedure. He suggested further research work to improve the procedure or developing a new algorithm for the facility layout design.

The facility layout problems fall in to the class of NP-complete solutions, and heuristic approaches are usually adopted to develop the layout [8]. Most of the models and algorithms available in the literature are based on the quadratic assignment problem with an objective to minimize transportation costs or maximize total closeness rating. The facility selection routine required for the development of layout was solved by considering a single quantitative factor as flow chart. Moreover, the move (distance) traversed is considered from center to center of the departments without considering the practical issue of entry and exit of the departments.

Most of the existing methods have been developed on the grid-based system without considering actual dimensions of departmental block and entry/exit locations, thus resulting in irregular shapes. Deb et al. [3] have already developed a hybrid modeling for the management of material-handling equipment selection planning while generating a manufacturing facility layout. The authors herein have also proposed different projects of integrating facility layout and material-handling equipment selection by using a knowledge base and optimization approach [5]. They utilized the material flow interaction matrix in finding the facility placement sequence. The authors have already developed a decision model and algorithm for material-handling equipment selection routine under facility layout planning by using fuzzy multi-criteria decision-making methods [4].

Therefore, the present research work follows in the same direction of author's previous work to integrate various linguistic assessments to evaluate facility selection routine and its impact on the development of facility layout. The applicability of the suggested methodology is demonstrated with a six-machine layout problem considering subjective factors such as supervision, information and environmental condition. The material flows between the different departments are assumed as the objective factor for the development of selection routine. The heuristic search algorithms proposed in this paper take care of optimal placement of incoming facilities based on a multi-criteria optimization function. The performance of the proposed multifactor fuzzy facility selection routine is compared with the multifactor normalized facility selection routine for the development of facility layout under the auspices of a manufacturing environment.

2. Fuzzy set and decision-making system

A fuzzy set can be thought of a class of concepts/objects in which no well-defined boundary exists between the concepts/objects that belong to the class and those which do not belong. Formally, if $B=\{x_i \mid i \varepsilon N\}$ is a set of objects, then the fuzzy set C on B is defined by its membership function $f_C(x)$ that assigns to each element $x \varepsilon B$ a real number in the interval [0,1] which represents the grade of membership of x in C or the degree to which x belongs to C. Thus, C can be written as

$$C = \{(f_C(x)/x) \mid x\varepsilon B\};\ B \rightarrow [0,1].$$

Linguistic variables are words in natural language, while numerical variables use numbers as values. Since words are usually less precise than numbers, linguistic variables provide a method to characterize complex systems that are ill structured to be described in traditional quantitative terms. A linguistic variable is defined by the name of the variable x, and the set term $S(x)$ of the linguistic values of x with each value being a fuzzy number defined on U. For example, if material flow (MF) is a linguistic variable, its term set S(MF)={Very High (VH), High (H), Medium (M), Low (L), Very Low (VL)}, where each term is characterized by a fuzzy set in a universe of discourse U.