Ain Shams University

Faculty of Engineering

Multi-Criteria Facility Layout

Thesis

By

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MSc. Mechanical Engineering (Production)

A dissertation submitted in partial fulfillment of the requirements for the degree of

Ph.D. in Mechanical Engineering

Supervised By

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Statement

This thesis is submitted in the partial fulfillment of Ph.D. in Mechanical Engineering, to Ain Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

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Multi-Criteria Facility Layout

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ABSTRACT

Facility layout problem is about arranging departments within the factory to achieve the desired product quantity and quality. The majority of previous research work has tackled the problem in terms of one objective. Few researches have considered Multi-Objective Facility Layout Problem. In this work, Material Handling Cost (MHC) and Closeness Rating (CR) represent quantitative and qualitative objectives respectively, these objectives are combined together into single objective function to solve multi-criteria facility layout problem. This thesis develops Genetic Algorithm to address Multi-Objective Facility Layout Problem (MOFLP). The developed heuristic algorithm introduces a new normalization technique with the use of objectives relative weights. It applies new crossover operator, modified selection behavior of Roulette-wheel, and dynamic crossover and mutation probabilities with only fixed upper values. The proposed model is evaluated through performing set of experimental runs. The evaluation process is divided into two categories. The first category is evaluating the model in terms of single-objective facility layout problem. The second one is evaluating the model in terms of multi-objective facility layout problem. The later one is divided into two phases. First phase is based on using created closeness rating data for number of facilities up to 30. In this phase, the model output is verified against single objective facility layout problem results considering these results as the reference for how far each objective deviates from its best solution. Second phase is based on using available benchmark instances for facility numbers up to 20. In this case the proposed model output is compared to recent published results.

For single-objective facility layout, the results reveal that the proposed algorithm is capable of obtaining the best known benchmark published solutions for number of facilities up to 24. Furthermore it achieves best known material handling cost for 24 departments arranged in 30 locations. For multi-objective facility layout, first phase results reveal that the proposed algorithm is capable of obtaining solutions, which deviate between 0 and 15% maximum from its respective single objective best solution for number of facilities up to 30. Second phase results outperform or achieve the published solutions for number of facilities up to 20.

Key Words: Facility layout Problem; Genetic Algorithm; Multi Objective Facility Layout Problem; Quadratic Assignment Problem; Material Handling Cost; Closeness Rating.

SUMMARY OF THE Ph.D. THESIS

"Multi-Criteria Facility Layout"

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Over the last few years solving Multi-Objective Facility Layout Problem (MOFLP) has received attention. The challenges in solving MOFLP are problem formulations and then developing or selecting the capable tool to solve it. In terms of problem formulation most of researchers have developed the Quadratic Assignment Problem (QAP) formulation to combine qualitative and quantitative objectives of Facility Layout Problem (FLP) into single objective criterion. This approach suffers from main drawbacks in view of dealing with the different measurement units of each objective and the dominance of objective with higher value relative to the other. In addition to the suitability of the normalization technique used to convert quantitative and qualitative objectives into comparable units. To overcome the above mentioned drawbacks, only recently researchers have developed approach to find a set of Pareto optimal layout solutions optimizing both quantitative and qualitative objectives. Yet objectives normalization approach is still used up till now. Many efforts are exerted to solve FLP optimally. However as the problem is NP hard and has combinatorial nature, reaching the optimal solution is not an easy task. Thus efforts are diverted to heuristic techniques and algorithms, opting to reach near optimal solutions. In order to solve such problem different types of algorithms are used, such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO),

and Artificial Neural Network (ANN), Simulated Annealing (SA), and Tabu Search (TS).

The aim of this research is to develop a heuristic algorithm to solve MOFLP in terms of Material Handling Cost (MHC) as a quantitative objective and Closeness Rating (CR) as a qualitative objective. Using GA as a tool for solving FLP is based on that GA is powerful optimization technique, GA is good at dealing with huge search spaces and navigating through them looking for optimal combinations of solutions. The model develops new technique for objective normalization, this technique avoids previous models normalization techniques drawback. In addition to applying new crossover operator, modifying the selection behavior of Roulette-Wheel and using dynamic crossover and mutation probabilities with only fixed upper values.

GA proposed model for solving MOFLP is tested using the available benchmark problems. The evaluation process is divided into two categories. First category is evaluating the proposed model in terms of single objective FLP. Second category is evaluating the proposed model in terms of MOFLP dealing simultaneously with MHC as quantitative objective and CR as qualitative objective. It is worth mentioning that the aims to solve single-objective FLP are determining the GA parameters and single-objective best values, in order to be adopted in solving MOFLP.

The proposed model results with respect to single FLP is capable of obtaining the best known values and it achieves the new best-found material handling cost for 24 departments allocated in thirty locations. Only exception is in the case of 30 departments, where it fails to achieve the best known result by a slight margin. In terms of MOFLP, the model results which divided into two phases show that the proposed model is capable of finding a set of solutions that minimizes material handling cost and maximizes closeness rating score simultaneously throughout the evolutionary process. First phase results deviate between 0 and 15% maximum from its respective single objective best solution for number of facilities up to 30, since these are the best achievable in case of single and multi-objective FLP. Second phase results outperform or achieve the published solutions for number of facilities up to 20. The proposed GA model for solving MOFLP is simple but proven to be effective.

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