Capability-Based Facility Layout Design with Unequal-Area Departments

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Abstract

Capability based facility layout approach was proposed by Baykasoğlu two decades ago in order to better utilize the hidden flexibility of manufacturing resources. However, in the previous capability-based layout design approaches only equally sized departments are considered and they are assigned to the pre-specified facility locations. To the best of our knowledge, there is no previous work on the capability-based facility layout design with unequal area departments. Based on this motivation, a new unequal-area capability-based facility layout design (UA-CBFLD) problem is introduced in this research first time in the literature. Indeed, machines' processing capabilities that are described in terms of Resource Elements (REs) are taken into consideration while designing the facility layout. Because, designing facility layouts by using the machining capabilities or REs is more advantageous as it enables facility designers to expose hidden flexibility that is available in manufacturing systems. We firstly developed a mixed-integer non-linear programming model for the proposed UA-CBFLD problem. Because of the NP-completeness and highly nonlinear structure of the stated problem, a polyhedral inner-approximation method is employed for the nonlinear department area constraints. Therefore, we also provided a mixed-integer linear programming (MILP) model formulation of the stated problem. However, department areas in the resulting solutions may be too little higher or equal to the required areas since this linear approximation method guarantees a given maximum deviation error for the required areas. In order to demonstrate validity and applicability of the proposed MILP model of the UA-CBFLD problem, an illustrative numerical example was first presented in order to analyze the effects of different machine-capability overlapping cases (i.e., no, low, medium and high overlaps) on the optimization results. Afterwards, its performance is also tested on a real-life manufacturing case study. The computational experiments have shown that applicable and efficient layout design alternatives can be generated by making use of the proposed model.

Keywords
Unequal area facility layout problem, capability-based layout approach, inner-approximation method, mixed-integer linear programming.

Biographies

Bilge Varol is an MSc student at Faculty of Engineering, Department of Industrial Engineering in Dokuz Eylul University, Izmir, Turkey. She earned her BSc in Industrial Engineering from Dokuz Eylul University, Izmir, Turkey. She is a research assistant in Bahcesehir University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering. Her interests include, but are not limited to, Fuzzy Mathematical Modeling, Stochastic Optimization, Metaheuristic Algorithms, Facility Planning, Production Planning and Scheduling. She plans to pursue a PhD degree in Industrial Engineering and further her studies.

Kemal Subulan has been working as an Associate Professor in the Industrial Engineering Department of Dokuz Eylul University since 2020, and his research interests focus on operations research, logistics and supply chain management, fuzzy logic, meta-heuristic algorithms and artificial intelligence. His articles have been published in many international scientific journals and peer-reviewed congresses. He served as a referee in many international journals. He received publication incentive awards from TUBITAK and Dokuz Eylul University for his international scientific studies. He is also responsible for the intelligent optimization and decision-making laboratory and the CANIAS Enterprise Resource Planning laboratory.

Adil Baykasoğlu received his B.Sc., M.Sc. and Ph.D. degrees from Mechanical and Industrial Engineering areas in Turkey (Gaziantep) and England (Nottingham). He is presently a full Professor and chair at the Industrial Engineering Department at the Dokuz Eylul University. He has published numerous academic papers, books and edited several conference books on operational research, computational intelligence, engineering management, and manufacturing systems design.