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# Sensitivity analysis of dynamic cell formation problem through meta-heuristic

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**Abstract**

In spite of many researches in literature investigating dynamic of cell formation (CF) problem, further research needs to be elaborated to assay hidden aspects of cellular manufacturing system (CMS), due to inherent complexity and uncertainty on optimizing this problem. In this paper, sensitivity analysis of modified self-adaptive differential evolution (MSDE) algorithm is proposed for basic parameters of CF problem, considering to the graphical representation supported by statistical analysis. Hence, a dynamic integer model of CF problem is first presented as the NP-hard problem. Then, the two basic test CF problems are introduced thereby the performance of MSDE algorithm assessed by diverse problems sizes through 140 runs from aspects of the average runtime of algorithm and the best local optimum objective function. Finally, statistical analysis is implemented on behavior of objective function values in order to validate our computational results graphically as well as statistically, giving some insights related to importance of CF parameters on designing CMS.


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*Keywords*: Meta-heuristic; Modified self-adaptive differential evolution algorithm; Sensitivity analysis; Cell formation problem.

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## 1. Introduction

Nowadays, according to fast technology improvement, shorter lifetime of products and speedy introduction of new products, managers are seeking to production styles that have higher efficiency and flexibility than traditional systems. Therefore, CMS has been introduced as a mixture of the work area of work-shop manufacturing and line-production system. One of the difficult steps of cell manufacturing design is CF problem in which parts with similar manufacturing processes will be made in one cell. As a NP-hard problem [1,2], most of recent researches attended to solve CF problem through meta-heuristics [3, 4, 5]. In spite of many researches on applying evolutionary algorithms to solve CF problem, the literature on differential evolution (DE) is rather poor than other algorithms [6], which motivated us to propose the modified version of DE and apply it on CF problem, aiming to assess the validity of this algorithm on CMS.

DE algorithm, initially proposed by Price and Storn [7], is a population-based algorithm that is applied for optimizing non-differentiable, non-convex, nonlinear and multi-objective functions [8-12]. It is a simple, powerful, parallel and direct search method with good convergence and fast implementation properties [7]. DE uses a simple mutation operator based on differences between pairs of solutions with aim of finding a search direction in current population. It also constitutes a rather efficient way to self-adapt the mutation operator, where the newly generated offspring competes against its corresponding parent and replaces it if the offspring has a higher fitness value. Moreover, DE rectifies the problem of premature convergence which previously observed in genetic algorithm (GA), where the population converges to some local optima of a multi-objective function [13]. It has been preferred to many other evolutionary techniques like GA and particle swarm optimization (PSO) due to its attractive characteristics such as its simple structure, convergence speed, versatility and robustness with only a few parameters required to be set by a user [14]. This paper proposes MSDE algorithm as the modified version of DE, trying to tackle the limits of the original version. Several researches in literature attempted to modify the original DE algorithm. For instance, Tasgetiren et al. [15] solved the generalized traveling salesman problem (TSP) using discrete DE. Das et al. [16] used a modified version of DE in pattern recognition of adaptive clustering. Ali and Torn [17] introduced a modified version of DE algorithm to improve efficiency and robustness. The modified DE algorithm proposed by Babu and Jehan [18] utilizes only one set of population against the two sets of original DE algorithm. Brest et al. [19] introduced self-adapting control parameter settings of DE algorithm.

Since the performance of meta-heuristics on multi-objective functions are affected by complexity of problems, due to the nature of these algorithms, the main contribution of this paper would be analysing validity of a modified version of DE for parameters of CF model by means of the two test problems to prove the convergence power of aforementioned algorithm. Since real-life cases mostly deal with large-scale problems with numerous variables, we aim to assess the performance of MSDE algorithm by varying the basic parameters of CF problem. Our focus is on behaviour of algorithm, especially in large-scale problems which will be complemented through statistical analysis. To our knowledge, this is the first research with focus on sensitivity of DE algorithm for dynamic multi-objective CF model so that the result can be used on construction of multi-objective CF models. The paper is organized as follows: The multi-objective integer CF model is described in section 2. Section 3 includes the proposed MSDE algorithm for solving the CF problem. Section 4 indicates the computational results and statistical analysis and finally, the paper is concluded in section 5.

## 2. Dynamic CF model

### *2.1. Assumptions*

The following assumptions are considered in the proposed dynamic cell formation problem:

- The operating times for all part type operations on different machine types are known.
- The demand for each part type in different period is dynamic and deterministic.
- Each machine type can perform several operations (machine flexibility).
- Operating cost of each machine type per hour is known and constant in each period.
- Machines are available at the start of each period (no installation time).