Chapter 51

Applying an Electromagnetism-Like Algorithm for Solving the Manufacturing Cell Design Problem

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ABSTRACT

Group technology has acquired a great consideration in the last years. This technique allows including the advantages of serial production to any manufacturing industry by dividing a manufacturing plant into a set of machine-part cells. The identification and formation of the cells are known as the Manufacturing Cell Design Problem (MCDP), which is an NP-hard problem. In this paper, the authors propose to solve the problem through a swarm intelligence metaheuristic called ElectroMagnetism-like (EM-like) algorithm, which is inspired by the attraction-repulsion mechanism of particles in the context of the electromagnetic theory. The original EM-like algorithm was designed for solving continuous optimization problems, while the MCDP is usually formulated by assuming a binary approach. Hence, the authors propose an adaptation of this algorithm for addressing the problem. Such adaptation is applied for solving a freely available dataset of the MCDP, obtaining competitive results compared to recent approaches.

DOI: 10.4018/978-1-5225-5643-5.ch051

INTRODUCTION

Group Technology (GT) is a manufacturing technique, which has acquired a special consideration in the last two decades. This is because it allows including the advantages of serial production to any manufacturing industry, generating additional economic and productivity benefits to practical environments (Ham, Hitomi, & Yoshida, 2012; Goldengorin, Krushinsky, & Pardalos, 2013).

This technique consists in dividing a manufacturing plant into a set of machine-part cells or manufacturing units by following the idea "*similar things should be made in the same way*" (Kusiak, 1987). The content of a cell is characterized by having some similarities, *e.g.*, materials, manufacturing processes, functions, and/or tools. The idea is to group machines and parts into cells with the purpose of minimizing the flow between them (Selim, Askin, & Vakharia,1998).

The independence of cells is difficult in practice. The reason is that it is usual that some parts need to be processed in more than one machine and these machines could be assigned to different cells. The identification and formation of cells is known as the Manufacturing Cell Design Problem (MCDP), which is an NP-hard optimization problem (Garey & Johnson, 1979).

Because of the relevance of this manufacturing technique, many techniques were applied for solving the problem (Papaioannou & Wilson, 2010; Chattopadhyay, Sengupta, Ghosh, Dan, & Mazumdar, 2013). Some authors addressed the MCDP by assuming exact techniques, such as branch-and-cut and branch-and-bound algorithms. However, this type of solving methods is not recommended for addressing NP-hard problems, because computational times rise exponentially with the problem dimension. Instead, approximate methods should be assumed, such as metaheuristics, which were successfully considered in the literature for solving NP-hard problems from different fields (Dasgupta & Michalewicz, 2013).

In this paper, the authors solve the MCDP by assuming a swarm intelligence metaheuristic, concretely the ElectroMagnetism-like (EM-like) algorithm, which was proposed by Birbil and Fang (2003). This population-based algorithm is inspired by the attraction-repulsion mechanism of particles in the context of the electromagnetic theory. The original EM-like algorithm was designed for solving continuous optimization problems. However, the MCDP is usually formulated by assuming a discrete scope. Hence, the authors propose a binarization approach of the EM-like algorithm for solving the problem. The metaheuristic is applied for solving a set of 50 known MCDP instances getting competitive results compared to recent techniques.

The remainder of this work is structured as follows. In the second section, the related work is discussed. In the third section, the MCDP is described, including a problem example. In the fourth section, the EM-like algorithm is introduced. In the fifth section, the experimental results are discussed. Finally, conclusions and future works are left for the last section.

BACKGROUND

There are two principal lines of research for papers addressing the MCDP. On the one hand, works considering exact techniques and on the other hand, authors assuming approximate techniques.

Beginning with the first line, there are authors considering different types of exact algorithms. Linear programming approaches were assumed by Purcheck (1975), Oliva-Lopez and Purcheck (1979), and Elbenani and Ferland (2012). Linear quadratic models were considered by Kusiak and Chow (1987) and Boctor (1991). Dynamic programming was assumed by Steudel and Ballakur (1987). Goal programming