Chapter XXXII
Evolutionary Optimization in Production Research

Christos Dimopoulos
Cyprus College, Cyprus

ABSTRACT

This chapter provides a short guide on the use of evolutionary computation methods in the field of production research. The application of evolutionary computation methods is explained using a number of typical examples taken from the areas of production scheduling, assembly lines, and cellular manufacturing. A detailed case study on the solution of the cell-formation problem illustrates the benefits of the proposed approach. The chapter also provides a critical review on the up-to-date use of evolutionary computation methods in the field of production research and indicates potential enhancements as well as promising application areas. The aim of the chapter is to present researchers, practitioners, and managers with a basic understanding of the current use of evolutionary computation techniques and allow them to either initiate further research or employ the existing algorithms in order to optimize their production lines.

INTRODUCTION

Modern manufacturing companies strive to stay competitive by producing high-quality customized items at the lowest possible cost. In addition, modern companies need to react quickly (be 'agile') to sudden changes in the economic environment. These characteristics can only be achieved through the continuous optimization of all stages of the production process.

The use of exact optimization methodologies in production research is significantly constrained by the computational complexity of a considerable number of problems in this area (Garey & Johnson, 1979). For this reason, the solution of many optimization problems is handled

through the use of non-analytical techniques (heuristics) that are able to find at least sub-optimal solutions in acceptable computational times. An obvious drawback of these methodologies is their inability to escape local optima that are frequently encountered in multimodal solutions' spaces. Meta-heuristic techniques provide mechanisms that enable an algorithm to escape local optima under certain conditions. *Simulated annealing* (Kirkpatrick, Gelatt, & Vecchi, 1985) and *tabu search* (Glover, 1985) are some notable meta-heuristic techniques that have been used widely in the past; however, the most renowned technique is *evolutionary algorithms* (EAs) (Eiben & Smith, 2004).

The aim of this chapter is to provide an introduction on the use of evolutionary computation methods in the area of production research. Initially, a number of EA-based solutions that can be utilized in a number of critical manufacturing optimization areas are presented. A case study application of an evolutionary algorithm for the solution of the well-known cell-formation problem is described in the following section. The chapter continues with a review of the potential benefits, the practical considerations, and the potential hazards of using evolutionary algorithms for the solution of production research problems. The final section of the chapter summarizes the conclusions and highlights areas of future research.

APPLYING EVOLUTIONARY ALGORITHMS IN THE AREA OF PRODUCTION RESEARCH

The scientific field of production research is concerned with the solution of problems encountered in a manufacturing environment. In practice, many of these problems are handled sub-optimally through purpose-based heuristics or rules-of-thumb (e.g., dispatching rules for scheduling problems). Initial applications of evolutionary computation in the area of production research appeared in the beginning of the 1990s. The motivation behind their use was their ease to express a solution in the form of a permutation or a string of parameter values. This is especially useful for the solution of problems in certain optimization areas such as scheduling and design. From that point onwards, the number of EA applications has been rising constantly. More importantly, these applications expanded in all areas of production research and provided the framework for the development of efficient hybrid optimization techniques, as well as multi-objective optimization techniques.

The following paragraphs provide simple examples on how EA-based solutions can be constructed in some critical areas of production research, based on typical applications that have been published in the literature. The list of solution encodings presented in this chapter is used for illustrative purposes only and is by no means exhaustive. In addition, there is no suggestion that these solution encodings perform better than alternative ones that have been proposed in the literature. A discussion on the relative competence of EAs in this area of research is provided in a following section of this chapter. The interested reader can find comprehensive reviews of evolutionary computation applications in the area of production research in the works of Dimopoulos and Zalzala (2000) and Aytug, Khouja, and Vergara (2003).

Production Scheduling

Description

Scheduling is an optimization area with applications in various scientific fields. In the context of production research, scheduling is the part of