Chapter 6

EVOLUTIONARY ALGORITHMS AND MULTIPLE OBJECTIVE OPTIMIZATION

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Abstract This chapter presents a review of the most important evolutionary multiobjective optimization techniques developed to date. Using as a basis a simple taxonomy of approaches, we briefly describe and analyze the advantages and disadvantages of each of them, together with some of their applications reported in the literature. Other important issues such as diversity and some of the main techniques developed to preserve it, as well as the need of suitable test functions and metrics that can properly evaluate the performance of these multiobjective optimization techniques are also addressed. We conclude this chapter with a brief outline of some potential paths of future research in this area.

Keywords: Evolutionary algorithms, evolutionary multiobjective optimization, genetic algorithms, multiobjective optimization, vector optimization.
1. Introduction

The idea of using techniques based on the emulation of the mechanism of natural selection to solve problems can be traced as long back as the 1930s [12]. However, it was not until the 1960s that the three main techniques based on this notion were developed: genetic algorithms [75], evolution strategies [142] and evolutionary programming [50]. These approaches, which are now collectively denominated “evolutionary algorithms”, have been very effective for single-objective optimization [58, 144, 51].

Evolutionary algorithms seem also particularly desirable for solving multiobjective optimization problems because they deal simultaneously with a set of possible solutions (the so-called population) which allows us to find several members of the Pareto optimal set in a single run of the algorithm, instead of having to perform a series of separate runs as in the case of the traditional mathematical programming techniques. Additionally, evolutionary algorithms are less susceptible to the shape or continuity of the Pareto front (e.g., they can easily deal with discontinuous and concave Pareto fronts), whereas these two issues are a real concern for mathematical programming techniques.

The potential of evolutionary algorithms in this field was indicated in the late 1960s by Rosenberg [132], but the first implementation was not produced until the mid-1980s [137, 138]. Since then, a considerable amount of research has been done in this area, now known as evolutionary multi-objective optimization (EMOO for short). The growing importance of this field is reflected by a significant increment (mainly during the last five years) of technical papers in international conferences and peer-reviewed journals, special sessions in international conferences and interest groups on the Internet\(^1\).

The content of this chapter is organized as follows: first, we will define the terminology that we will adopt and we will describe the general multiobjective optimization problem. Then, we will give some basic notions of evolutionary algorithms. After that, we will analyze the main evolutionary multiobjective optimization techniques that have been proposed in the specialized literature. Each technique will be briefly described and criticized. We will also provide some sample applications of each. Then, we will describe some of the main approaches proposed to maintain diversity, emphasizing the importance that this process has in multiob-

\(^1\)The first author maintains an EMOO repository with over 850 bibliographical entries at: http://delta.cs.cinvestav.mx/~ccoello/EMOO, with mirrors at http://www.lania.mx/~ccoello/EMOO/ and http://www.jeo.org/emo/