Memetic Evolutionary Algorithms

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1 Summary

Memetic Evolutionary Algorithms (MAs) are a class of stochastic heuristics for global optimization which combine the parallel global search nature of Evolutionary Algorithms with Local Search to improve individual solutions. These techniques are being applied to an increasing range of application domains with successful results, and the aim of this book is both to highlight some of these applications, and to shed light on some of the design issues and considerations necessary to a successful implementation. In this chapter we provide a background for the rest of the volume by introducing Evolutionary Algorithms (EAs) and Local Search. We then move on to describe the synergy that arises when these two are combined in Memetic Algorithms, and to discuss some of the most salient design issues for a successful implementation. We conclude by describing various other ways in which EAs and MAs can be hybridized with domain-specific knowledge and other search techniques.

2 Introduction

Memetic Algorithms (MAs) are a class of stochastic global search heuristics in which Evolutionary Algorithms-based approaches are combined with local search techniques to improve the quality of the solutions created by evolution. MAs have proven very successful across a wide range of problem domains such
as combinatorial optimization [27], optimization of non-stationary functions [42], and multi-objective optimization [20] (see [29] for an extensive bibliography).

Methods for hybridizing EAs with local search have been given various names in research papers such as: hybrid GAs, Baldwinian EAs, Lamarckian EAs, genetic local search algorithms, and others. Moscato [3] coined the name memetic algorithm to cover a wide range of techniques where evolutionary-based search is augmented by the addition of one or more phases of local search.

The natural analogies between human evolution and learning, and EAs and artificial neural networks (ANNs) prompted a great deal of research into the use of MAs to evolve the structure of ANNs. ANNs were trained using back-propagation or similar means during the 1980s and early 1990s. However, research applying MAs to ANNs gave a great deal of insight into the role of learning, Lamarckianism, and the Baldwin effect to guide evolution (e.g. [8, 7, 8, 9, 10, 11, 12] amongst many others). This research reinforced the experience of "real-world" practitioners as to the usefulness of incorporating local search and domain-based heuristics within an EA framework.

Since then a number of PhD theses [14, 25, 15, 27, 16] have developed algorithmic analyses of MAs. These analyses and related empirical results demonstrate the potential impact of MAs, and in practice, many state-of-the-art EAs employ some element of hybridization using local search. Research in MAs is now sufficiently mature and distinct to have its own annual international workshop, and an extensive on-line bibliography of MA research is maintained at [29].

In this chapter we set the scene for the rest of this book by providing brief introductions to Evolutionary Algorithms (EAs) and Local Search (LS). We also discuss some of the issues which arise when hybridizing the two to create MAs. As our aim is to provide an overview, we cannot hope to give a detailed description of either EAs or the many LS methods available. There are wide variety of books discussing these methods that the user can read for further detail (e.g., see [17, 18]). The rest of this chapter is organized as follows:

- In Section 3 we provide a brief overview and historical background to the field of Evolutionary Algorithms, focusing particularly on their use as search and optimization techniques.
- In Section 4 we provide a brief introduction to local search and some related techniques.
- In Section 5 we discuss some of the motives and rationale underpinning the hybridization of EAs with other search technologies and motivate this book's focus on Memetic Algorithms. Our focus is on EA hybrids in which LS acts on the output of evolutionary operators, that is to say in which some form of "lifetime learning" or "plasticity" is incorporated into the "standard" evolutionary cycle..