Chapter 4
Hybrid Evolutionary Optimization Algorithms:
A Case Study in Manufacturing Industry

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ABSTRACT

The novel industrial manufacturing sector inevitably faces problems of uncertainty in various aspects such as raw material availability, human resource availability, processing capability and constraints and limitations imposed by the marketing department. These problems have to be solved by a methodology which takes care of such unexpected information. As the analyst faces this man made chaotic and due to natural disaster problems, the decision maker and the implementer have to work collaboratively with the analyst for taking up a decision on an innovative strategy for implementation. Such complex problems of vagueness and uncertainty can be handled by the hybrid evolutionary intelligence algorithms. In this chapter, a new hybrid evolutionary optimization based methodology using a specific non-linear membership function, named as modified S-curve membership function, is proposed. The modified S-curve membership function is first formulated and its flexibility in taking up vagueness in parameters is established by an analytical approach. This membership function is applied for its useful performance through industrial production problems by employing hybrid evolutionary optimization algorithms. The novelty and the originality of this non-linear S-curve membership function are further established using a real life industrial production planning of an industrial manufacturing sector. The unit produces 8 products using 8 raw materials, mixed in various proportions by 9 different processes under 29 constraints. This complex problem has a cubic non-linear objective function. Comprehensive solutions to a non-linear real world objective function are achieved thus establishing the usefulness of the realistic membership function for decision making in industrial production planning.

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INTRODUCTION

In the literature, there are several techniques and heuristic/metaheuristic have been used to improve the general efficiency of the evolutionary algorithms. Some of the most commonly used hybrid approaches are summarized as below:

1. Hybridization among several techniques of evolutionary algorithm and another evolutionary algorithm (example: an evolutionary strategy is used to improve the performance of a genetic algorithm)
2. Neural network and evolutionary algorithms
3. Fuzzy logic and evolutionary algorithm
4. Particle swarm optimization (PSO) and evolutionary algorithm
5. Ant colony optimization (ACO) and evolutionary algorithm
6. Bacterial foraging optimization and evolutionary algorithm
7. Evolutionary algorithms incorporating prior knowledge
8. Hybridization between evolutionary algorithm and other heuristic approaches (such as local search, general pattern search, mesh adaptive direct search, tabu search, simulated annealing, hill climbing, dynamic programming, greedy random adaptive search procedure and others).

The combination of different learning and adaptation techniques, to overcome individual limitations and achieve synergetic effects through hybridization or fusion of these techniques, has in recent years contributed to a large number of new hybrid evolutionary systems. Most of these approaches, however, follow an ad hoc design methodology, further justified by success in certain application domains. Due to the lack of a common framework it remains often difficult to compare the various hybrid systems conceptually and evaluate their performance comparatively. There are number of ways to hybridize a conventional evolutionary algorithm for solving optimization problems. Some of them are summarized below (Swain & Morris, 2000).

- The solutions of the initial population of evolutionary algorithm may be created by problem-specific heuristics.
- Some or all the solutions obtained by the evolutionary algorithm may be improved by local search. This kind of algorithms is known as memetic algorithms (Hart, 1998; Moscato, 1999).
- Solutions may be represented in an indirect way and a decoding algorithm maps any genotype to a corresponding phenotypic solution. In this mapping, the decoder can exploit problem-specific characteristics and apply heuristics approaches.
- Variation operators may exploit problem knowledge. For example, in recombination more promising properties of one parent solution may be inherited with higher probabilities than the corresponding properties of the other parent(s). Also mutation may be biased to include in solutions promising properties with higher probabilities than others.

Fuzzy logic controller (FLC) is composed by a knowledge base, that includes the information given by the expert in the form of linguistic control rules, a fuzzification interface, which has the effect of transforming crisp date into fuzzy sets, an inference system, that uses them together with the knowledge base to make inference by means of a reasoning method, and a defuzzification interface, that translates the fuzzy control action thus obtained to a real control action using defuzzification method. Fuzzy logic controllers have been used to design adaptive evolutionary algorithms. The main idea is to use a fuzzy logic controller whose inputs are any combination of evolutionary algorithms performance measures and current control parameter values and whose

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