Chapter 12
Afterword

In the previous chapters, we presented the fundamental concepts and variants of PSO, as along with a multitude of recent research results. The reported results suggest that PSO can be a very useful tool for solving optimization problems from different scientific and technological fields, especially in cases where classical optimization methods perform poorly or their application involves formidable technical difficulties due to the problem's special structure or nature. PSO was capable of addressing continuous and integer optimization problems, handling noisy and multiobjective cases, and producing efficient hybrid schemes in combination with specialized techniques or other algorithms in order to detect multiple (local or global) minimizers or control its own parameters.

All these properties have established PSO as one of the most popular intelligent optimization algorithms, adequately simple to be usable by non-expert researchers. Thus, one may arguably question how much room is left for further improvements and developments on PSO. The answer is: a lot. Although PSO has been shown to be a very successful algorithm, we are still far from the ultimate goal of introducing an intelligent optimization algorithm with the ability to self-adapt to the structure and nature of any given optimization problem. Indeed, as exposed in the largest part of the book, user intervention in selecting among alternative variants and/or parameter settings of the algorithm has a dominant position and impact on the successful culmination of the optimization procedure. Moreover, it is evident that, despite the large number of works on PSO applications, improvements targeted on specific problem types can further enhance its performance.

The aforementioned scope for improvement provides solid ground for further research on PSO. Actually, it opens a vast research horizon, where the ascertained plasticity of the algorithm can serve as the base material for the implementation of numerous ideas targeted at enhancing PSO's performance and promoting its more intelligent and autonomous operation. We anticipate the introduction of such new developments in

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the form of novel research works and doctoral dissertations in the following years, maximally exploiting the available knowledge, of which, a large part has been presented in the previous chapters.

Of course, each research effort and achievement has a special (strong or weak) merit. Nevertheless, every effort must be recognized as a step towards the desirable direction. Unfortunately, due to the large number of researchers working on PSO worldwide, many of these efforts are inevitably uncoordinated, resulting in overlapping works and the weakening of some results that, if combined with other approaches, could be of great significance. In addition, some cases followed a wrong direction, resulting in fruitless efforts. One of the main reasons for this is the lack of an adequate number of sources where young researchers can find comprehensive presentations of the fundamental variants and the most important developments in PSO. We tried to address this problem, to the extent allowed by the limited space of a book, by writing the book at hand.

In mathematical research, we could say that, as compared to the past and present, the concept of *significance* is biased in favor of the future, with all the hopes and prospects it holds. Thus, we could not end this book without taking a glimpse at the research directions that are expected to significantly contribute in PSO in the following years, and distinguish the most promising ones:

a. Theoretical analysis.
b. Strategies and operators.
c. Self-adaptive models.
d. New variants suited to modern computation systems.
e. New and more fascinating applications.

In the following paragraphs, we briefly comment on what we believe are the most significant of these topics.

THEORETICAL ANALYSIS

As we already reported in Chapter Three, there have been some serious attempts to theoretically analyze PSO. However, the existing results do not fully describe the dynamics of the algorithm. This can be attributed to the specific approaches used, which impose the use of approximating models due to the inability of directly studying the original PSO model with the existing mathematical tools. Thus, a rigorous study of PSO's convergence properties on problems without nice mathematical properties is questionable. History reveals that although the existing theoretical studies have not completely succeeded in mathematically interpreting PSO, they have yielded significant contributions, providing a better understanding of the algorithm, as well as better control on its parameters and building blocks in general optimization problems. Our hope is that this knowledge will be enriched through similar theoretical studies in the future.

STRATEGIES AND OPERATORS

The handling of the swarms in PSO, as well as the operators applied on the particles, constitute significant choices that shall precede its application. The nature of the problem itself is the crucial factor that