

## Final Remarks

Solving difficult search and optimization problems (e.g. “black-box”) requires non-deterministic approaches, in particular metaheuristics. It may be said that these methods trade-off precision, quality, accuracy and execution time in favor of computational effort. Such methods usually referred to as the *methods of last resort* are necessary for dealing with difficult problems.

Following *no free lunch theorem* mentioned earlier, it turns out that looking for novel metaheuristics for particular problems will always be necessary. Therefore, the existing metaheuristics are proposed to be enhanced with agency, constituting EMAS (proposed by Cetnarowicz) and its modifications (memetic and immunological), which yielded original results presented in this monograph. Moreover, it should be noted that developing novel computing methods calls for the development of a detailed formal model that will ease the understanding of the method, and provide a base for further analytical deliberations, helpful in getting a deeper insight into the features of the system. Accurate testing of the proposed metaheuristics is also necessary, in particular tuning the system parameters may be fruitful for further application of this metaheuristics to other problems.

Significant attention should also be devoted to the fact of appropriate modeling, design and development of dedicated software platforms, capable of efficiently and flexibly supporting the process of construction and using of the computational agent-based systems. Thus, one of the starting point for this monograph was the idea of connecting the possibilities given by the agent-based approach and component techniques in the field of population-based techniques of computational intelligence. The so-far constructed platforms were leveraging different technologies (like e.g. Java, Python, C#.NET), and allowed for verification of many technological methods, showing that efficient realization of such systems requires dedicated tools, which are flexible and extensible both on the configuration level and particular implementation parts of single agents.

Summing up, this monograph gives a guidance in the field of agent-based computing, in particular connected with design, evaluate and development of agent-based general-purpose metaheuristics for optimization problems. Besides presentation of the computing paradigm, references to the state-of-the-art and technological deliber-

ations and an extensive set of experiments, a full formal model proving the ergodicity of a dedicated Markov chain is presented, in order to justify the reason for tackling such complex computing systems. Moreover, EMAS is treated as a starting point for further hybridization and extensions, so in this way memetic EMAS hybrids and immunological EMAS are discussed, which have already proved to be general-purpose search algorithms.

The authors continue with the research related to agent-based computing, focusing on novel optimization algorithms, exploring possibilities of using of heterogeneous hardware and new implementation technologies (like functional programming) in order to develop parallel and distributed versions of the computing platforms, capable of running on supercomputer machines.

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