Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 108C (2017) 907–916

Procedia Computer Science

International Conference on Computational Science, ICCS 2017, 12-14 June 2017, Zurich, Switzerland

Agent-based Evolutionary and Memetic Black-box Discrete Optimization

Michal Kowol, Kamil Pietak, Marek Kisiel-Dorohinicki, and Aleksander Byrski

AGH University of Science and Technology, Al. Mickiewicza 30, 30-059 Krakow, Poland
michal.kowol@gmail.com,{kpietak,doroh,olekb}@agh.edu.pl

Abstract

Hybridizing agent-based paradigm with evolutionary or memetic computation can enhance the field of meta-heuristics in a significant way, giving to usually passive individuals autonomy and capabilities of perception and interaction with other ones. In the article, an evolutionary multi-agent system (EMAS) is applied to solve difficult discrete benchmark problems without any domain-specific knowledge—thus they may be called "black-box" ones. As a means for comparison, a parallel evolutionary algorithm (constructed along with Michalewicz model) versus evolutionary and memetic versions of EMAS are used. The obtained results point out that EMAS is significantly more efficient than classical evolutionary algorithms and also finds better results in the examined problem instances.

Peer-review under responsibility of the scientific committee of the International Conference on Computational Science

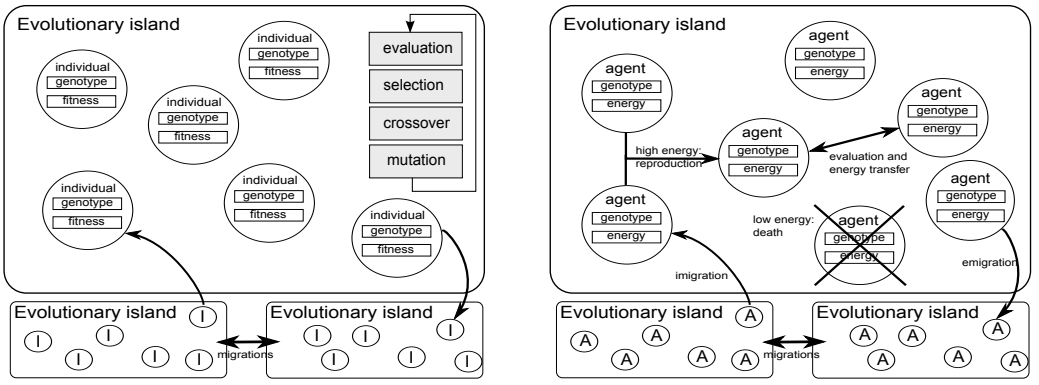
Keywords: Agent-based computing, metaheuristics, discrete global optimization, memetic algorithms

1 Introduction

Michalewicz and Fogel in [21] have proposed several reasons why a certain optimization problem may be considered *difficult*. Firstly, the number of possible solutions may be too large to perform an exhaustive search for the best answer. Or the problem may be so complex that in order to provide any feasible answer, a simplified model must be used. It also may happen that the evaluation function describing the quality of the solutions is noisy or varies with time and therefore many solutions are sought. Certain search problems, which fall into one of these categories, are perceived to be difficult *per se*, because their domains are very hard or even impossible to be described and explored, using conventional analytical methods (see, e.g. combinatorial optimization problems [24]). The setting of such problems is sometimes called "black-box scenario" [10].

In the cases of such problems, it is important to have ready one, or better more general-purpose optimization algorithms. Obviously, keeping in mind the famous *no free lunch theorem* [26], one can be sure that a certain, even evidently reliable solution, applied to all possible problems, yields only average results. Therefore having general-purpose optimization algorithms is a good idea, but this often becomes a starting point for further research, e.g. tuning them

1877-0509
Peer-review under responsibility of the scientific committee of the International Conference on Computational Science
10.1016/j.procs.2017.05.173



(a) Parallel evolutionary algorithm (PEA) (b) Evol. multi-agent system (EMAS)

Figure 1: Schematic presentation of the algorithms discussed in the paper [18]

to solve particular problems, utilizing dedicated operators, data transformations etc. In the domain of evolutionary computing, this means that one has to search for particular operators and their parameters, keeping in mind intrinsic characteristics of the problem tackled.

In this contribution, a hybrid evolutionary-agent [16] approach to solving optimization problems, namely an *Evolutionary Multi-Agent System* (EMAS), is studied. For over 15 years, it proved to be an efficient and effective technique for solving a variety of difficult optimization problems [6]. Here we focus on applying its classical (purely evolutionary) and memetic variants to difficult discrete problems that can be treated as black-box ones.

The paper is a follow-up of the paper [18], adding the memetic versions of the tested computing systems to the comparison and presents a more detailed study of the computing results. After introduction and descriptions of the systems, the problems considered are briefly presented and the study of experimental results along with the discussion are given. Finally the paper is concluded.

2 Evolutionary and memetic agent-based optimization

Evolutionary algorithms have already proved to be effective universal techniques for solving optimization problems [2].

EMAS (*evolutionary multi-agent system*), may perceived as "proactive" alternative to classical evolutionary computation techniques [17], hoped by the authors to relieve the evolutionary metaheuristics from several inconsistencies with the real-life evolution, such as e.g. lack of global control, and asynchronous reproduction. In this system, solutions (genotypes) are entrusted to agents, handling and improving their solution during realization of several types of actions available to them. In this way agents can reproduce, die or migrate among the islands. The selection mechanism is implemented using resources (agents compete for the resources, only a rich agent can reproduce, the poor agent will die) [8]. During meetings, agent exchange the resources (the worse one gives a part of its resource to the better one). For the schematic view on EMAS one can refer to the Fig. 1b. It is to note, that correctness of the EMAS as global universal optimizer has been formally proven using Markov Chain based models, inspired by the theoretical works of Michael Vose [4, 5]. EMAS has also many extensions, e.g. immunological