A new population-based nature-inspired algorithm every month: Is the current era coming to the end?

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ABSTRACT

Every month at least one new population-based nature-inspired algorithm has been released in literature. Until recently, there were probably more than 200 algorithms of this kind in books, papers and proceedings. Many researchers discuss that this research area is becoming flooded with new algorithms that are in fact the old algorithms in a new disguise. Potentially, such behavior could be leading into the emergence of pseudoscience. In this paper, we try to find some answers to the questions what lead authors to propose and develop the new nature-inspired algorithms and what their benefits in doing so are. We propose ways in which to stop the emergence of new algorithms. In line with this, we have found that proposing the new population-based nature-inspired algorithms is actually similar to the swarm intelligence behavior in nature, where the role of population members is acted by authors of the new algorithm with the goal to publish a paper, thus promoting its algorithm and spreading it all over the world.

Keywords

metaphors, nature-inspired algorithms, swarm intelligence

1. INTRODUCTION

Approximately 50 years ago, the time emerged when scientists began applying algorithms solving the problems on digital computers by mimicking the human brain widely. These methods were called **Artificial neural networks** [13]. Artificial neural networks were proposed in the 40s in the previous century, but it took some time before the community began to use them widely for scientific and first practical usage. These networks were really interesting methods and many scientists claimed that artificial neural networks would power the world in the near future. Artificial neural networks were counted into pure artificial intelligence and now there are many various types of these networks for solving particular tasks in theory and practice. That historical time was also the time where people were limited with hardware and software. Thus, people were unable to test and develop their methods widely. However, some years after the creation of artificial neural networks, another discipline (or alternative to artificial neural networks) was developed actively by the scientific community. The name of this discipline, that was coined later, was **Evolutionary computation**. Evolutionary computation was based on the natural evolution of species and respected the theory of Charles Darwin. Initially, the Evolutionary Algorithms (EAs) simulated the operators of mutation and crossover, where the individuals to survive were selected according to their fitness values. The fitness value was determined according to the evaluation of the fitness function that corresponded to the problem to be solved. Nevertheless, over the years the EAs were divided into the following kind of algorithms: Genetic algorithms [18], evolution strategies [1], genetic programming [16] and evolutionary programming [26]. The main differences between these sub-families were basically in the representation of individuals, e.g., binary representation was used by genetic algorithms, floating point representation by evolution strategies, finite state automata by evolutionary programming and programs in Lisp by genetic programming. Additionally, it is important to mention that in the 80s other metaheuristics were also designed [23, 8, 9, 10, 15]. The period when these methods appeared in the literature was a little bit calmer compared with nowadays. It was a time without the Internet and also access to the papers was limited. Additionally, in these times people did not yet know the term **Publish or perish** [19, 2]. Scientists should not have to be forced to publish for any price in order to their hold position at the university or scientific institute. But things were changed quickly. The years of 90s came rapidly. In this scientific area a new paradigm was proposed that incorporated the social behavior of many agents that guided them into complex behavior. The roots of this method, which is named **Swarm intelligence**, can be found in the dissertation of Marco Dorigo [4]. His method proposed the colonies of ants for solving discrete optimization problems. A little bit later, in 1995, Kennedy and Eberhart [14] applied the behavior of bird swarms and fish schools into an algorithm with the name **Particle swarm optimization**. These two methods were the beginners of the new community movement, i.e. the so-called swarm intelligence community. However, in the 90s and early 2000s the community did not think that these two powerful algorithms were the stepping stones for the development of uncountable nature-inspired algorithms and, potentially, the flood of algorithms that led into pseudoscience. In this paper, we

try to get answers to the following questions:

- What is actually considered as a new nature-inspired algorithm?
- What motivates researchers to propose new algorithms?
- What they have if they propose a new algorithm?
- What is a generic recipe for proposing a new algorithm?
- What are the implications of new algorithms?
- How to stop the invasion of new algorithms?
- Is proposing new algorithms basically swarm intelligence behavior itself?

Insights on these questions will be highlighted in the remainder of the paper.

2. NATURE-INSPIRED ALGORITHMS

At the start, it is very hard to define exactly what the population-based nature-inspired algorithms actually are. However, there are many definitions and most of these definitions say that population-based nature-inspired algorithms are a kind of algorithms that are inspired by natural, biological and even social systems, and are intended to solve problems in a similar way to what nature does. Even today, there are a few taxonomies that try to deal algorithms in different groups. One of the taxonomies is a taxonomy published in 2013 by Fister et al. [5] where algorithms were split into 4 groups [5]:

- Swarm intelligence based algorithms,
- Bio-inspired that are not swarm intelligence based,
- Physics and chemistry based and
- Other algorithms.

Algorithm 1 Generic pseudo-code of most of the population-based nature-inspired algorithms

```
initialize individuals within bounds using a particular randomization generator
evaluate all individuals
while termination criteria not met do
    move all individuals according to proposed formulas
    evaluate all individuals
    find the best individuals
end while
return the best individual and vizualize
```

Generic pseudo-code for most of the algorithms in this taxonomy, especially for the first and second group, is presented in Algorithm 1.

3. THE NEW POPULATION-BASED NATURE-INSPIRED ALGORITHMS

The previous section gave readers a short overview of the population-based nature-inspired algorithms, while this section will be concentrated on the implications of the new population-based nature-inspired algorithms.

3.1 Current publishing era

Without doubt we can say that this era, after the year 2000, led to the hard race between scientists and even institutions. People that work in universities and institutes are forced to publish works that will achieve a lot of citations, since good works with many citations help universities in global rankings. Better universities have attracted more, better students. In line with this, they could obtain the government and industrial projects more easily. Projects mean money, while more students mean more tuition fees. Fortunately, this is not true for each country. For example, there are no tuition fees for students of Government Institutions in Slovenia. Only, doctoral studies require students to pay a tuition fee that is actually not as high as it is abroad. In order to meet these goals universities could make pressure on researchers to publish more and better works. This manner is also connected with the term **Publish or perish**. However, to satisfy these goals is a little bit easier for mature and well-known researchers, while newbies have mostly enormous problems. For example, some students in China are even prepared to give a kidney for having a paper accepted in a journal with impact factor. Is not publishing becoming similar to any fight sport (win at any price)? Let us leave politics and go back to our population-based nature-inspired algorithms. So, after the year 2000 when Ant colonies and Particle Swarms became popular, interesting and widely used algorithms, some researchers began thinking whether there was a possibility to develop or just propose a new algorithm that should be based on any other inspiration from nature. If we look into our bioshpere, we can easily find a lot of animal species, different trees, natural processes, social behaviors for developing the optimization algorithms. When researchers found an inspiration, they then needed to coin some operators that mimic the behavior of their inspiration and, later, put this magic into the universal recipe that was presented in the previous chapter. Most of the algorithms only used a different formula for moving individuals and that was all the magic behind an algorithm. Paradigm was the same, but only some minor changes were incorporated in the developing of the brand new population-based nature-inspired algorithm. After developing, the time has started for publishing the new algorithm. Usually, all researchers need to validate their new algorithms on some well-known benchmark functions or on some engineering problems. Of course, all algorithms have beaten other well-known algorithms without any problem, although nobody cared if researchers used special benchmarks and tested on special dimensions and compared with basic well-known algorithms and not with their improved versions. At the beginning, they were successful and achieved good publications in journals with nice impact factors and even at good conferences. Until 2010, almost nobody had yet cared about new algorithms but, after 2010, many scientists began to doubt about the originality of works. However, it was too late. Nowadays, we are in 2016. According to the list on Github (**www.github.com/fcampelo/EC-Bestiary**), we counted (as of 5 August 2016) that there are 101 nature-inspired algorithms (Fig. 1). Anyway, there are many others that are not on this list.

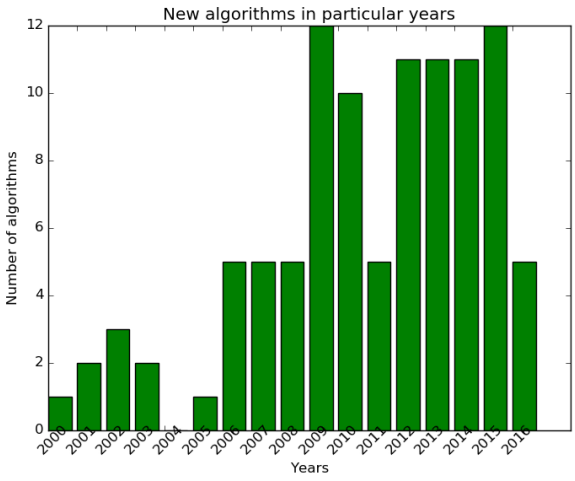

Figure 1: The emergence of new algorithms (according to Github repository EC-Bestiary.)

4. MOTIVATION FOR THE DEVELOPMENT OF THE NEW POPULATION-BASED NATURE-INSPIRED ALGORITHMS

In order to find what is actually the motivation behind the development of a new algorithm, we should take a more global view. As many papers have already shown [21, 22, 25, 24], that the new algorithms are actually old algorithms in new disguises (similar as Spy character in Team Fortress 2 game) we should discover why researchers created a new algorithm artificially and masked it within the new inspiration. We believe that motivation is connected with publishing and citations. This research area is really wide and offers excellent opportunities for publication. Along with this statement, publication also opens a pool for citations. Thus, one of the main motivations behind new algorithms is more or less the current publishing situation.

5. GENERIC RECIPE FOR PROPOSING THE NEW POPULATION-BASED NATURE-INSPIRED ALGORITHM

After studying some of the new population-based nature-inspired algorithms, we can simply propose a generic recipe that captures all the ingredients of the successful creation of a new nature-inspired algorithm. The generic recipe is presented in Algorithm 2. At the beginning, researchers are looking for an idea. While searching is in progress, when they get an idea, they need to reconcile the name of the new algorithm. If the name is still free, then the researchers need to develop formulas, choose test functions, run experiments and publish a paper. At the end, they also need to spread the word about the algorithm. This could be done easily by various social networks.

6. IMPLICATIONS OF THE NEW NATURE-INSPIRED ALGORITHMS

Mostly, the new population-based nature-inspired algorithms do not affect older researchers (however, there are some exceptions), while new algorithms of this kind are excellent bait for younger researchers, especially students. Students do not have a global view on a particular research area and, thus, they simply succumb to new algorithms. Many papers that propose new algorithms are written in tempting style and it really attracts students. Moreover, even various researchers from other totally different research areas (geology, space exploration, leisure studies, etc.) sometimes use new algorithms for research. They do not care about roots, they just want to solve their problems (no matter what method solves the problem). At the end, industry is the last thing here. People from industry need a solution for their problem. If they see that one algorithm is good for their problem they take it.

Algorithm 2 Generic recipe for the new nature-inspired algorithm proposal

```
Watch TV, browse internet, go for a walk in nature in order to get inspiration for your new algorithm
while searching in progress do
 if you get an idea about a new algorithm:
  check if your proposed name is still free (browse via major search engines and databasess)
   if name is free:
    develop formulas
    choose benchmark functions
    run experiments
    write and publish a paper
    spread the word about your algorithm
   else repeat until you find another inspiration
```

7. HOW TO STOP THE INVASION OF THE POPULATION-BASED NATURE-INSPIRED ALGORITHMS?

We believe that the invasion of the new population-based nature-inspired algorithms could be stopped within the next five years. All trends in evolution are the same. At the beginning there is a high rise, when it comes to the top then it goes down slowly. At the moment the trend is not rising any more and many Editors and Reviewers are informed about this problem. Recently, many papers that show the problems of this area have been released [22, 7, 6, 21, 5]. Some Journal Editorial Boards have even revised their rules and they do not accept papers where questionable metaphors are presented [11]. By the same token, the Matthew effect [20, 17] that depicts "the rich tend to be richer" almost always works. Hence, old and famous algorithms will always be more powerful than artificially created algorithms.

7.1 Swarm intelligence behavior in the population-based nature-inspired algorithm development

The definition of the swarm intelligence based algorithms were outlined in the previous sections. The swarm intelligence based algorithms family are, these days, more popular and there are also many journals that are devoted to these kinds of algorithms. As a matter of fact, swarm intelligence based algorithms propose **many individuals** that execute **simple actions** and their **behavioral actions** leads into a **complex** and **decentralized** system. Can we find any parallel points with the process of new nature-inspired al-

Table 1: Parallel points between the definition of swarm intelligence and the process of creation of new nature-inspired algorithms.

Definition of swarm intelligence	New nature-inspired algorithm creation
many individuals	many authors
simple actions	watching the inspiration in nature, giving a new name for the algorithm, developing a formula
behavioral actions	publishing a paper
complex	name motivates other individuals, new hybrid and adaptive variants
decentralized	algorithm is spread all over the world, impossible to stop spreading this algorithm – the same as viruses for example

gorithm creation? The Table 1 shows point to point comparison among these two processes. What is the most interesting is that the process of new algorithm creation possesses the behavior of swarm intelligence. Swarm intelligence based algorithms consist of many individuals. On the other hand, the process of population-based nature-inspired algorithms is guided by many authors. Simple actions (for example foraging in bees or pheromone tracking in ants or even home building by termites) are, in the process of new algorithm creation, defined as simple actions where authors try to find an inspiration in nature, give their algorithm a bombastic name and even develop a formula that will mostly guide an evolutionary process. Behavioral actions are, basically, connected with publishing a paper in a journal or at a conference, while complex behavior is connected with spreading the algorithm all over the world with the help of social media [12, 3] (Twitter, Facebook, Researchgate, Academia, Google groups, etc.), search engines (Google, Yahoo), emails (many authors send emails to others attached with the source code and pdfs), mouth sharing (via conferences and social meetings) and so on. Decentralized behavior is expressed as an algorithm that is spread all over the world and it is also impossible to stop it spreading. Especially, new researchers take a new algorithm and create new variants (mostly hybrid variants or apply this algorithm on industrial problems) and then, again, we obtain complex behavior.

8. CONCLUSION

In this paper we took a view on the new population-based nature-inspired algorithms‘ development. The new population-based nature-inspired algorithms are released every month and, basically, they have nothing special and no novel features for science. Thus, the development of the new population-based nature-inspired algorithms may be becoming very dangerous for science. We found that there are many social tensions that lead authors towards the new population-based nature-inspired algorithm creation, especially the wish for quick paper publishing and citations on published papers. Additionally, our research revealed that the process of the new population-based nature-inspired algorithm possesses the behavior of the swarm intelligence paradigm. Thus, it would not be easy to stop the invasions of the new population-based nature-inspired algorithms in the near future (only a systematic approach can help). However, awareness of the research community will help drastically in preventing the emergence of new population-based nature-inspired algorithms on new proposal attempts and make this research area clean again. Finally, the evolution of everything has not been finished in one night, but it took a lot of time. Eventually, it could also be the same for population-based nature-inspired algorithms.

9. REFERENCES

[1] H.-G. Beyer and H.-P. Schwefel. Evolution strategies–a comprehensive introduction. *Natural computing*, 1(1):3–52, 2002.

[2] P. Clapham. Publish or perish. *BioScience*, 55(5):390–391, 2005.

[3] T. D. Cosco. Medical journals, impact and social media: an ecological study of the twittersphere. *Canadian Medical Association Journal*, 187(18):1353–1357, 2015.

[4] M. Dorigo and T. Stützle. Ant colony optimization: overview and recent advances. *Techreport, IRIDIA, Universite Libre de Bruxelles*, 2009.

[5] I. Fister Jr., X.-S. Yang, I. Fister, J. Brest, and D. Fister. A brief review of nature-inspired algorithms for optimization. *Elektrotehniški vestnik*, 80(3):116–122, 2013.

[6] S. Fong, X. Wang, Q. Xu, R. Wong, J. Fiaidhi, and S. Mohammed. Recent advances in metaheuristic algorithms: Does the makara dragon exist? *The Journal of Supercomputing*, pages 1–23, 2015.

[7] S. Fong, R. Wong, and P. Pichappan. Debunking the designs of contemporary nature-inspired computing algorithms: from moving particles to roaming elephants. In *2015 Fourth International Conference on Future Generation Communication Technology (FGCT)*, pages 1–11. IEEE, 2015.

[8] F. Glover. Future paths for integer programming and links to artificial intelligence. *Computers & operations research*, 13(5):533–549, 1986.

[9] F. Glover. Tabu search–part i. *ORSA Journal on computing*, 1(3):190–206, 1989.

[10] F. Glover. Tabu search–part ii. *ORSA Journal on computing*, 2(1):4–32, 1990.

[11] F. Glover and K. Sörensen. Metaheuristics. *Scholarpedia*, 10(4), 2015.

[12] N. Hall. The kardashian index: a measure of discrepant social media profile for scientists. *Genome Biology*, 15(7):1–3, 2014.

[13] A. K. Jain, J. Mao, and K. M. Mohiuddin. Artificial neural networks: A tutorial. *IEEE computer*, 29(3):31–44, 1996.

[14] J. Kennedy and R. Eberhart. Particle swarm optimization. In *Neural Networks, 1995. Proceedings., IEEE International Conference on*, volume 4, pages 1942–1948. IEEE, 1995.

[15] S. Kirkpatrick, C. D. Gelatt, and M. P. Vecchi. Optimization by simmulated annealing. *Science*, 220(4598):671–680, 1983.

[16] J. R. Koza. *Genetic programming: on the programming of computers by means of natural selection*, volume 1. MIT press, 1992.

[17] R. K. Merton et al. The matthew effect in science. *Science*, 159(3810):56–63, 1968.

[18] M. Mitchell. *An introduction to genetic algorithms*. MIT press, 1998.

[19] G. Parchomovsky. Publish or perish. *Michigan Law Review*, 98(4):926–952, 2000.

[20] M. Perc. The matthew effect in empirical data. *Journal of The Royal Society Interface*, 11(98):20140378, 2014.

[21] A. P. Piotrowski, J. J. Napiorkowski, and P. M. Rowinski. How novel is the "novel" black hole optimization approach? *Information Sciences*, 267:191–200, 2014.

[22] K. Sörensen. Metaheuristics–the metaphor exposed. *International Transactions in Operational Research*, 22(1):3–18, 2015.

[23] K. Sörensen, M. Sevaux, and F. Glover. A history of metaheuristics. In *ORBEL29–29th Belgian conference on Operations Research*, 2015.

[24] D. Weyland. A rigorous analysis of the harmony search algorithm: how the research community can be misled by a "novel" methodology. *International Journal of Applied Metaheuristic Computing*, 1(2):50–60, 2010.

[25] D. Weyland. A critical analysis of the harmony search algorithm–how not to solve sudoku. *Operations Research Perspectives*, 2:97–105, 2015.

[26] X. Yao, Y. Liu, and G. Lin. Evolutionary programming made faster. *IEEE Transactions on Evolutionary computation*, 3(2):82–102, 1999.