A Survey on Flower pollination algorithm

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Abstract

Flower pollination algorithm (FPA) is a metaheuristic algorithm that proceeds its representation from flowers' proliferation role in plants. The optimal plant reproduction strategy involves the survival of the fittest as well as the optimal reproduction of plants in terms of numbers. These factors represent the fundamentals of the FPA and are optimization-oriented. Yang developed the FPA in 2012, which has since shown superiority to other metaheuristic algorithms in solving various real-world problems, such as power and energy, signal and image processing, communications, structural design, clustering and feature selection, global function optimization, computer gaming, and wireless sensor networking. Recently, many variants of FPA have been developed by modification, hybridization, and parameter-tuning to cope with the complex nature of optimization problems this paper provides a survey of FPA and its applications.

Keywords: FPA, metaheuristic, optimization, global optimization; Optimal

1. Introduction

Many phenomena in nature have single features that can be utilized and converted into a mathematical model or even an algorithm to solve real-world problems. Over the last few decades, researchers have established many metaheuristic algorithms to attempt to catch the best solutions for many optimization problems. Cases are genetic algorithm (GA), artificial bee colony (ABC), particle swarm optimization (PSO), gray wolf algorithm (GWA), firefly algorithm (FA), bat algorithm (BA), and cuckoo search (CS) [1]. These algorithms have been successfully applied to an extensive range of optimization problems and are widely used in the literature of metaheuristics for the last two decades [1]. On the other hand, nature still has many other phenomena that can be utilized to solve different types of problems. One phenomenon is the flowering plant reproduction strategy through pollination, which inspired Yang in 2012 to propose a new algorithm called the flower pollination algorithm (FPA)[1-5].

DOI: 10.5281/zenodo.4049330

FPA is a swarm-based optimization technique that has attracted the attention of many researchers in several optimization fields due to its impressive characteristics[2]. FPA has very fewer parameters and has shown a robust performance when applied in various optimization problems. Besides, FPA is a flexible, adaptable, scalable, and simple optimization method. Therefore, FPA, compared with other metaheuristic algorithms, shows good results for solving various real-life optimization problems from different domains such as electrical and power system, signal and image processing, wireless sensor networking clustering and classification, global function optimization, structural and mechanical engineering optimization, and many others [3-4].

The structure of the rest of the paper is as follows: the biological inspiration of the algorithm is discussed n Section 2. different applications of FPA are presented in Section 3. In Section 4, the main FPA variants and hybrids are introduced. Finally, conclusion and future works in Section 5.

2. Flower Pollination Algorithm

Flower Pollination Algorithm (FPA) was founded by Yang in the year 2012 [2]. Inspired by the flow pollination process of flowering plants are the following rules:

Rule 1: Biotic and cross-pollination can be considered as a process of global pollination process, and pollen-carrying pollinators move in a way that obeys Le'vy flights.

Rule 2: For local pollination, abiotic and self-pollination are used.

Rule 3: Pollinators such as insects can develop flower constancy, which is equivalent to a reproduction probability that is proportional to the similarity of two flowers involved.

Rule 4: The interaction or switching of local pollination and global pollination can be controlled by a switch probability p∈[0,1], with a slight bias toward local pollination.

To formulate updating formulas, we have to convert the aforementioned rules into updating equations. For example, in the global pollination step, flower pollen gametes are carried by pollinators such as insects, and pollen can travel over a long distance because insects can often fly and move in a much longer range. Therefore, Rule 1 and flower constancy can be represented mathematically as:

$$x_i^{t+1} = x_i^t + \gamma L(\lambda)(x_i^t - B) \qquad (1)$$

Where x_i^t is the pollen i or solution vector xi at iteration t and B is the current best solution found among all solutions at the current generation/iteration. Here γ is a scaling factor to control the step size. Also, L(λ) is the parameter that corresponds to the strength of the pollination, which essentially is also the step size. Since insects may move over a long distance with various distance steps, we can use a Le'vy flight to imitate this characteristic efficiently. That is, we draw $L > 0$ from a Levy distribution:

$$L \sim \frac{\lambda \Gamma(\lambda) \sin(\pi\lambda/2)}{\pi} \frac{1}{S^{1+\lambda}}, (S >> S_0 > 0) \qquad (2)$$

Here, Γ(λ) is the standard gamma function, and this distribution is valid for large steps $s > 0$.

Then, to model the local pollination, both Rule 2 and Rule 3 can be represented as

DOI: 10.5281/zenodo.4049330

$$x_i^{t+1} = x_i^t + U(x_j^t - x_k^t) \quad (3)$$

Where x_j^t and x_k^t are pollen from different flowers of the same plant species. This essentially imitates the flower constancy in a limited neighborhood. Mathematically, if x_j^t and x_k^t comes from the same species or selected from the same population, this equivalently becomes a local random walk if we draw U from a uniform distribution in [0, 1]. Though Flower pollination activities can occur at all scales, both local and global, adjacent flower patches or flowers in the not-so-far-away neighborhood are more likely to be pollinated by local flower pollen than those far away. To imitate this, we can effectively use the switching probability like in Rule 4 or the proximity probability p to switch between common global pollination to intensive local pollination. To begin with, we can use a naive value of p = 0.5 as an initial value. A preliminary parametric showed that p = 0.8 might work better for most applications. The basic steps of FP can be summarized as the following algorithm [4–12]:

Algorithm1: Flower Pollination Algorithm FPA
Define Objective function f (x), x = (x1, x2, ..., xd)
Initialize a population of n flowers/pollen gametes with random solutions
Find the best solution Bin the initial population
Define a switch probability p ∈ [0, 1]
Define a stopping criterion (either a fixed number of generations/iterations or accuracy)
while (t <MaxGeneration)
for i = 1 : n (all n flowers in the population)
if rand <p,
Draw a (d-dimensional) step vector L which obeys a L´evy distribution
Global pollination via $x_i^{t+1} = x_i^t + L(B - x_i^t)$
else
Draw U from a uniform distribution in [0,1]
Do local pollination via $x_i^{t+1} = x_i^t + U(x_j^t - x_k^t)$
end if
Evaluate new solutions
If new solutions are better, update them in the population
end for
Find the current best solution B
end while
Output the best solution found

3. Applications of FPA

Due to the FPA efficiency and flexibility, it was applied for solving many optimization problems in various real-life fields. The FPA is successfully tailored for several domains of optimization problems, including electrical and power system, vehicle path planning problem, signal and image processing, wireless sensor networking, clustering and classification, global optimization, medical image segmentation, retinal vessel localization, EEG channel selection, structural and mechanical engineering and many others [33-44]. Finally, the FPA has shown good results for solving many optimization problems in various real-life fields. . In this section, a list of the relevant applications will be exhibited in Table 1

Table 1 FPA recent applications

Problem	Reference
Fractional programming problems	[13]
Optimum design of reinforced concrete retaining walls	[14]
Optimization of P& PI controller parameters	[15]
Global optimization	[16]
EEG Channel Selection	[17]
Scheduling	[18]
Color image quantization	[19]
Linear antenna design problems	[20]
Intelligent diagnosis of natural gas pipeline defects	[21]
Classification Problems	[22]
Rectangular Packing Problem	[23]
Groundwater Management	[24]
Image fusion for medical diagnosis	[25]
Mobile Robot Path Planning	[26,27]
Task-Scheduling Heterogeneous Cloud Environment	[28]
Multi-objective knapsack problem	[29]
Vehicle delay models	[30]
Economic and Emission Dispatch Solution	[31]
Others	[32-40]

4. Variants of FPA

4.1 Improvements

Although the efficiency of FPA, it has some drawbacks such as time consuming and premature convergence for several given problems. So that, Several improvements were proposed to overcome these drawbacks [12-30]. The adjustment of the algorithm can be made to the global search or local search procedures or both.

4.2 Hybridization of FPA

The prosperity of FPA most appears in the case of hybridization with other optimization techniques (e.g. metaheuristics, machine learning, exact methods, etc.). Hybridization can be done at a low or high level according to the interference level between hybridized methods[11-25]. i.e. high-level hybridization indicates that low interference between the internal work of hybridized algorithms while low-level hybridization means that only an extracted step of metaheuristic is exported to another metaheuristic. Moreover, the execution of the hybridized algorithms can be done in a different order (sequential, interleaved, or parallel). In other words, the hybridized algorithms may collaboratively exchange information or integrated with a master one that operates the search procedure during the search process [26-30]. For more information, see ref. [1].

4.3 Multi-objective optimization

Yang et. al [2] introduced multi-objective FPA to deal with multiple conflicting objectives of a wide range of optimization problems. The authors accommodated a simple weighted sum approach to transform the

DOI: 10.5281/zenodo.4049330

multiple objectives problem into a single-objective one. In other words, these weights values determine the priority of each objective. For each set of weights, a Pareto front is generated. The generated solution becomes the Pareto optimal if the corresponding sum of weights values is positive and larger enough [2].

4.4 Binary FPA

The original FPA was proposed to solve continuous optimization problems. To deal with discrete and combinatorial optimization problems, appropriate adjustments are required [41-45].

5. Conclusions and Future Works

However, metaheuristics are not problem-specific, choosing the appropriate metaheuristic for the given problem should be considered, i.e., the more adaptation to the given problem, the more efficient metaheuristic. This is, what characterizes FPA since it owns a few parameters that need to be adjusted. As consequence, FPA has recently applied to many application areas. Whereas, it is clear that the basic FPA still needs some amendments to improve its performance and disposal from premature convergence and time-consuming. This paper gives an overview of FPA's main structure, previous studies, variants, and applications to provide interested researchers with a comprehensive overview of FPA. New modifications and improvements can enhance its performance even further.

Funding: “This research received no external funding”

Conflicts of Interest: “The authors declare no conflict of interest.”

References

1. Dokeroglu, T., Sevinc, E., Kucukyilmaz, T., & Cosar, A. (2019). A survey on new generation metaheuristic algorithms. Computers & Industrial Engineering, 137, 106040
2. Yang, Xin-She, Mehmet Karamanoglu, and Xingshi He. "Flower pollination algorithm: a novel approach for multiobjective optimization." Engineering optimization 46.9 (2014): 1222-1237.
3. Abdel-Raouf, O., El-Henawy, I., & Abdel-Baset, M. (2014). A novel hybrid flower pollination algorithm with chaotic harmony search for solving sudoku puzzles. International Journal of Modern Education and Computer Science, 6(3), 38.
4. Ram, J. P., Babu, T. S., Dragicevic, T., & Rajasekar, N. (2017). A new hybrid bee pollinator flower pollination algorithm for solar PV parameter estimation. Energy conversion and management, 135, 463-476.
5. Wang, R., & Zhou, Y. (2014). Flower pollination algorithm with dimension by dimension improvement. Mathematical Problems in Engineering, 2014.
6. Alyasseri, Z. A. A., Khader, A. T., Al-Betar, M. A., Awadallah, M. A., & Yang, X. S. (2018). Variants of the flower pollination algorithm: a review. In Nature-Inspired Algorithms and Applied Optimization (pp. 91-118). Springer, Cham.
7. Abdel-Basset, M., & Shawky, L. A. (2019). Flower pollination algorithm: a comprehensive review. Artificial Intelligence Review, 52(4), 2533-2557.

8. Hezam, I. M., Abdel-Baset, M., & Hassan, B. M. (2016). A hybrid flower pollination algorithm with tabu search for unconstrained optimization problems. Inf. Sci. Lett, 5(1), 29-34.
9. ABDEL-BASET, M. O. H. A. M. E. D., & HEZAM, I. M. (2015). An improved flower pollination algorithm based on simulated annealing for solving engineering optimization problems. Asian Journal of Mathematics and Computer Research, 149-170.
10. Abdel-Basset, M., El-Shahat, D., & El-Henawy, I. (2019). Solving 0–1 knapsack problem by binary flower pollination algorithm. Neural Computing and Applications, 31(9), 5477-5495.
11. Abdel-Raouf, O., Abdel-Baset, M., & El-henawy, I. (2014). Improved harmony search with chaos for solving linear assignment problems. International Journal of Intelligent Systems and Applications, 6(5), 55-61.
12. Abdel-Basset, M., Shawky, L. A., & Sangaiah, A. K. (2017). A comparative study of cuckoo search and flower pollination algorithm on solving global optimization problems. Library Hi Tech.
13. Abdel-Baset, M. (2015). A modified flower pollination algorithm for fractional programming problems. International Journal of Intelligent Systems and Applications in Engineering, 3(3), 116-123.
14. Mergos, P. E., & Mantoglou, F. (2020). Optimum design of reinforced concrete retaining walls with the flower pollination algorithm. Structural and Multidisciplinary Optimization, 61(2), 575-585.
15. Nadweh, S., Khaddam, O., Hayek, G., Atieh, B., & Alhelou, H. H. (2020). Optimization of P& PI controller parameters for variable speed drive systems using a flower pollination algorithm. Heliyon, 6(8), e04648.
16. Rodrigues, D., de Rosa, G. H., Passos, L. A., & Papa, J. P. (2020). Adaptive improved flower pollination algorithm for global optimization. In Nature-Inspired Computation in Data Mining and Machine Learning (pp. 1-21). Springer, Cham.
17. Alyasseri, Z. A. A., Khader, A. T., Al-Betar, M. A., & Alomari, O. A. (2020). Person Identification using EEG Channel Selection with Hybrid Flower Pollination Algorithm. Pattern Recognition, 107393.
18. Alyasseri, Z. A. A., Khader, A. T., Al-Betar, M. A., & Alomari, O. A. (2020). Person Identification using EEG Channel Selection with Hybrid Flower Pollination Algorithm. Pattern Recognition, 107393.
19. Lei, M., Zhou, Y., & Luo, Q. (2020). Color image quantization using flower pollination algorithm. Multimedia Tools and Applications, 1-18.
20. Salgotra, R., Singh, U., Saha, S., & Nagar, A. K. (2020). Improved flower pollination algorithm for linear antenna design problems. In Soft Computing for Problem Solving (pp. 79-89). Springer, Singapore.

21. Liang, X., Liang, W., & Xiong, J. (2020). Intelligent diagnosis of natural gas pipeline defects using improved flower pollination algorithm and artificial neural network. Journal of Cleaner Production, 121655.
22. Alweshah, M., Qadoura, M. A., Hammouri, A. I., Azmi, M. S., & AlKhalaileh, S. (2020). Flower Pollination Algorithm for Solving Classification Problems. Int. J. Advance Soft Compu. Appl, 12(1).
23. Virk, A. K., & Singh, K. (2020). On Performance of Binary Flower Pollination Algorithm for Rectangular Packing Problem. Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science), 13(1), 22-34.
24. Akram, S. (2020). Improved Flower Pollination Algorithm for Optimal Groundwater Management. International Journal of Computational Intelligence and Applications, 2050022.
25. Sumithra, M., & Malathi, S. (2020). Modified Global Flower Pollination Algorithm-based image fusion for medical diagnosis using computed tomography and magnetic resonance imaging. International Journal of Imaging Systems and Technology.
26. Mishra, A., & Deb, S. (2020). Mobile Robot Path Planning Using a Flower Pollination Algorithm-Based. Nature-Inspired Computation in Navigation and Routing Problems: Algorithms, Methods and Applications, 127.
27. Mehta, I., Singh, G., Gigras, Y., Dhull, A., & Rastogi, P. (2020). Robotic Path Planning Using Flower Pollination Algorithm. Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science), 13(2), 191-199.
28. Gokuldhev, M., & Singaravel, G. (2020). Local Pollination-Based Moth Search Algorithm for Task-Scheduling Heterogeneous Cloud Environment. The Computer Journal.
29. Hadachi, Y., & Fujiwara, A. (2020). Flower pollination optimization for the multi-objective knapsack problem. Bulletin of Networking, Computing, Systems, and Software, 9(1), 27-30.
30. Korkmaz, E., & Akgüngör, A. P. (2020). Comparison of artificial bee colony and flower pollination algorithms in vehicle delay models at signalized intersections. Neural Computing and Applications, 32(8), 3581-3597.
31. Sulaiman, M. H., Mustaffa, Z., Saari, M. M., & Mohamed, A. I. An Application of Barnacles Mating Optimizer Algorithm for Combined Economic and Emission Dispatch Solution. In Proceedings of the 11th National Technical Seminar on Unmanned System Technology 2019 (pp. 1115-1124). Springer, Singapore.
32. Abid, A., Malik, T. N., Abid, F., & Sajjad, I. A. (2020). Dynamic economic dispatch incorporating photovoltaic and wind generation using hybrid FPA with SQP. IETE Journal of Research, 66(2), 204-213.
33. Nayyar, A., Kumar, S., & Nguyen, N. G. (2020). Recent Innovations and Advancements in Swarm Intelligence: Algorithms, Methodologies and Applications (Part 2). Recent

Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science), 13(1), 3-4.

34. Singh, O., & Singh, M. (2020). A Comparative Analysis on Economic Load Dispatch Problem Using Soft Computing Techniques. International Journal of Software Science and Computational Intelligence (IJSSCI), 12(2), 50-73.
35. Wang, Y. X., Li, X. Z., & Wang, Z. Y. (2020, January). Parameters optimization of SVM based on the swarm intelligence. In Journal of Physics: Conference Series (Vol. 1437, No. 1, p. 012005). IOP Publishing.
36. Das, D., Pal, A. R., Das, A. K., Pratihar, D. K., & Roy, G. G. (2020). Nature-inspired optimization algorithm-tuned feed-forward and recurrent neural networks using CFD-based phenomenological model-generated data to model the EBW process. Arabian Journal for Science and Engineering, 45(4), 2779-2797.
37. Manickavasagam, J., Visalakshmi, S., & Apergis, N. (2020). A novel hybrid approach to forecast crude oil futures using intraday data. Technological Forecasting and Social Change, 158, 120126.
38. Nguyen, T. T., Pan, J. S., & Dao, T. K. (2019). An improved flower pollination algorithm for optimizing layouts of nodes in wireless sensor network. Ieee Access, 7, 75985-75998.
39. Priya, K., & Rajasekar, N. (2019). Application of flower pollination algorithm for enhanced proton exchange membrane fuel cell modelling. International Journal of Hydrogen Energy, 44(33), 18438-18449.
40. Wang, K., Li, X., & Gao, L. (2019). A multi-objective discrete flower pollination algorithm for stochastic two-sided partial disassembly line balancing problem. Computers & Industrial Engineering, 130, 634-649.
41. Rathasamuth, W., & Pasupa, K. (2019, October). A Modified Binary Flower Pollination Algorithm: A Fast and Effective Combination of Feature Selection Techniques for SNP Classification. In 2019 11th International Conference on Information Technology and Electrical Engineering (ICITEE) (pp. 1-6). IEEE.
42. Virk, A. K., & Singh, K. (2020). On Performance of Binary Flower Pollination Algorithm for Rectangular Packing Problem. Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science), 13(1), 22-34.
43. Rathasamuth, W., & Pasupa, K. (2020, July). Efficient distributed SNP selection by a Modified Binary Flower Pollination Algorithm. In Proceedings of the 11th International Conference on Advances in Information Technology (pp. 1-7).
44. Yan, C., Ma, J., Luo, H., Zhang, G., & Luo, J. (2019). A Novel Feature Selection Method for High-Dimensional Biomedical Data Based on an Improved Binary Clonal Flower Pollination Algorithm. Human heredity, 84(1), 1-13.
45. Johnson, D. S., Johnson, D. L. L., Elavarasan, P., & Karunanithi, A. (2020, March). Feature Selection Using Flower Pollination Optimization to Diagnose Lung Cancer from CT

DOI: 10.5281/zenodo.4049330

Images. In Future of Information and Communication Conference (pp. 604-620). Springer, Cham.