A Study of Insect Based Optimization Algorithms: Ant Lion Optimizer and Firefly Algorithm

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Abstract:

This paper presents brief impression and analysis of two emerging insect based optimization techniques namely Ant Lion Optimizer (ALO) and Firefly Algorithm (FA). Hunting ants and flashing behavior are the inspirational factors behind the working of Ant Lion and Firefly algorithms. ALO and FA have been employed in different domain like healthcare, process planning, feature selection, agriculture, economics, cloud computing, IoT, wireless sensor and image processing. As per Google Scholar's analysis 423 and 11634 articles related to ALO and FA have been published. The maximum use of ALO has been found for feature selection and economics based applications. However, ALO is least used in developing healthcare and Internet of Things (IoT) based applications. Therefore, an attention is needed to employ these techniques in developing disease diagnosis and drug analysis based applications. On the other hand, the maximum use of FA has been found in economic and image processing based applications. Whereas, process planning and IoT based application were of least interest for the researchers who used FA. Moreover, the existing studies witnessed that the results obtained using FA and ALO are better than traditional optimization techniques like exhaustive enumeration, dynamic programming, genetic algorithm, ant colony optimization and particle swarm optimization. The researcher may use and analyze the effect of the hybridization of ALO and FA in designing smart IoT based healthcare applications.

Keywords: Genetic Algorithm, Firefly Algorithm, Healthcare Industry, Classification, Clustering.

1. Introduction

There are different types of real life and research oriented problems. However, optimization problem was and remain in focus of researchers from different domains like disease diagnosis, text processing, query optimization, task scheduling, assignment problem, resource utilization, load balancing etc. The nature and complexity of the optimization problems depends upon several factors like number and type of constraints, design parameters, types of equations involved, nature and number of objective function. Figure 1 represents some of the major types of optimization problems based upon above mentioned factors. An optimization problem has a special function called objective function which describes the motive of the problem like maximize the profit, minimize the loss, maximize throughput, minimize turnaround time etc. In general, one has to

either maximize or minimize the objective function subject to different constraints. There exist several techniques that deals with optimization problems.

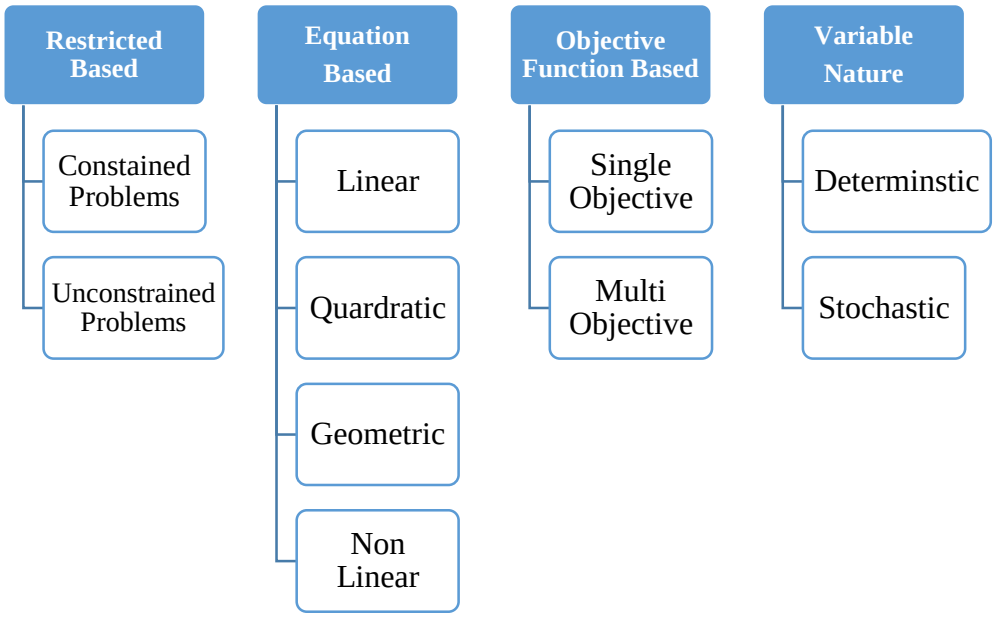

Figure 1: Classification of Optimization Problems

In general, the optimization techniques can be categorized as deterministic and stochastic techniques. Deterministic techniques are purely mathematical techniques that give 100% precise results. However, these are not fit for problem where the complexity rate is too high as the time required to generate solution will be tremendously high in that case[1]. The stochastic techniques like Nature Inspired Computing (NIC) have been effectively used to decipher different types of optimization problems. NIC algorithms are the emerging computing optimization techniques that have been imitated from nature. These algorithms have been stimulated from the behaviours of human, animals, birds, insects, water, music, flowers etc. [2]. There exist several NIC techniques and it is difficult to analyze all these techniques in a single manuscript. Therefore, in this manuscript effort is made to represent and analyze the role of two emerging insect based algorithm viz. Ant Lion and Firefly. The major objectives of this study are:-

- To briefly state and classify optimization problems.
- To momentarily highlight the effective and emerging nature inspired computing algorithms.
- To describe the working of ALO and FA.
- To analyse the ALO and FA based publications details.
- To highlight the future directions for the use of FA and ALO.

2. Review of Nature Inspired Procedures used in Optimization Process

A grand design of nature provides variety of efficient procedures to solve complex problems. Table 1 represents some of the NIC algorithms along with their developers and their inspirational factors.

Table 1: Summary of NIC Algorithms

Algorithm	Abbreviation	Developer	Year	Inspirational Factor	Actor
Genetic Algorithm [3]	GA	John Holland	1979	Human genetics	Human beings
Ant Colony Optimization [4]	ACO	M. Dorigo	1992	Food searching by ants	Ants
Fish Swarm Algorithm [5]	FSA	L. X. Lei	2002	Intelligent behavior	Fishes
Artificial Bee Colony [6]	ABC	Karboga	2005	Foraging behavior	Honey bee
Firefly Algorithm [7]	FA	X. S Yang	2007	Flashing behaviour	Fireflies
Cuckoo Algorithm [8]	CA	X. S. Yang, S. Deb	2009	Brood Parasitism	Cuckoo
Bat Algorithm [9]	BA	X. S. Yang	2010	Echolocation behavior	Microbat
Grey Wolf Optimization [10]	GWO	Mirjalili et. al. ,	2014	hunting mechanism	Grey Wolves
Dragonfly Algorithm [11]	DA	S. .Mirjalili	2015	Static and dynamic swarming behaviour	Dragonfly
Moth-flame optimization[12]	MFO	S. Mirjalili	2015	Moths navigation methods	Moth
Ant Lion Optimizer [13]	ALO	S. Mirjalili	2015	Hunting behavoiur	Ant Lions
Whale Optimization Algorithm[14]	WOA	S. Mirjalili, A. Lewis	2016	bubble-net hunting	Whales

As mentioned earlier, in this manuscript, two different insect based optimization algorithms i.e. ALO and FA are discussed. Section 2.1 and 2.2 briefly discuss the working of these two algorithms.

2.1 Ant Lion Optimization

Ant Lion optimizer was proposed by S. Mirjalili in 2015. The inspiration behind ALO lies in the hunting nature of antlions. The antlions are from insect family and fall in the category of Myrmeleontidae. Ants are victimized by this family of insect therefore; these insects are named as antlion. Sandy regions, sheltered, wooded dunes, under hedges and opens forest floors are the

common places for antlions. The general size of Ant lions lies in the range of 2 to 15 cm (0.8 to 5.9 in) i.e. ant lions can be fairly small to very large neuropterans. They have predatory natured larva that normally trapped ants [13]. Figure 2 and 3 represents the two different types of ant lions and their larva.

Figure 2: Ant lions

Figure 3: Pit trapped larva

The complete working of ALO moves around the decision variable, solution, old solution, new solution, best solution, fitness function, initial solution, selection and processing of new generation. The algorithm starts with parameters definition. Initially, the position for ants and ant lions are randomly set. The fitness of both ants and ant lions are computed. In each iteration, there will be an elite ant lion who will be considered as the fittest of that generation. The new position of ants will be updated by computing the fitness values of each ant. If the fitness of ant becomes larger than fitness of ant lion then the position of ant will be updated as an ant lions position [13].

Step 1:	Define parameters
Step 2:	Initialize Ants position.
Step 3:	Initialize Ant-lions positions

Step 4:	Compute fitness function for both Ant and Ant-lions

Step 5:	For I=1 to Max_Iterations
	Compute elite Ant-lion
	Based upon selected Ant, update Ant-Lion position
	Compute Ant fitness and update its position.
	If fitness(Ant)>fitness(Ant-lion) Then
	Update Ant position as an Ant-lion's position
	End if
	End For

Step 6:	Report optimal Ant-lion position.

As stated, ALO has been used in several domains. Some of the different applications of ALO have been mentioned below:

Kaur and Mahajan (2017) have employed ALO for community detection. Authors performed the experimentation on four different data sets viz. Bottlenose Dolphins, Books about US politics, Zachary's Karate Club and American college football network benchmarks. Authors compared their results with Ant Colony Optimization and Firefly algorithm and found that the use of ALO gives better results [15]. Sam'on et al., (2017) have employed ALO to solve unit commitment electricity problem. Authors compared the performance of ALO with dynamic programming and found that the operating cost and the computation time obtained using ALO are better than the dynamic programming [16]. Zawbaa et al., (2016) have used chaotic version of ALO in selecting optimal markers from the long list of available bio markers. Authors manipulate the random ants walk to control the exploration rate. The objective of this work was to make balance between exploration and exploitation of search space. Authors found the performance and classification rate achieved using ALO is better than as achieved with genetic algorithm and particle swarm optimization [17]. Petrovic (2015) has employed ALO to determine an optimal process plan. Authors compared the performance of ALO with GA, GASA and PSO and found that the convergence rate of ALO is better that other NIC technique [18]. Talattahari (2016) has used ALO in civil engineering. Authors tried to use ALO in designing optimum skeletal structure. Authors optimized the design of three distinct truss i.e. 71 bars space, 200 bar planer and 10 storey space and frame structure. The results produced using ALO are better than as obtained using other meta-heuristic techniques like GA, ACO, PSO, TSO etc.[19]. Mostafa et al., (2017) have designed an ALO based segmentation technique for MRI liver images. The segmentation process was performed using clustering technique. Authors found their techniques as more promising than region growing, K-means, grey wolf, ABC and level set. The rate of accuracy achieved using proposed ALO based approach was 94.49%[20].

2.2 Firefly Algorithm (FA)

FA is one of the prevailing optimization techniques. It has been inspired from the flashing behaviors of fireflies. There exist more than 2000 species of fireflies. Figure 4 represents the some of the different types of fireflies.

Figure 4: Fireflies

The flashing pattern of fireflies is different for different species of the fireflies. However, all firefly produces similar type of flashes in a species. Flashing assists in attracting other fireflies. The attraction is affected by the flash rate, time gap between two flashes and the recurring flash. It is well known that inverse square law is followed when the light intensity "I" is measured from the light object located at a distance 'd'. the law states that light intensity will increased when the distance 'd' is decreased and vice versa[7]. Mathematically,

$$I \alpha 1/(d)^2 \quad (1.1)$$

Here I is intensity.

'd' is distance.

The fireflies communicate with each other by generating a signal in terms of flashing light. In FA, the objective function is represented in the form of flashing light and the effort is made to optimize this light function. The working of firefly algorithm is based upon following assumptions [7]:

- The fireflies are assumed to be of unisex i.e. gender of firefly does not have any impact.
- The fireflies with lower brightness are fascinated towards the fireflies that are brighter.
- The distance between two fireflies will affect the brightness.

Psuedocode for FA

Step 1:	Set objective function F(x).
Step 2:	Generate initial population of n fireflies.
Step 3:	Set light intensity $I_i = F(x_i)$
Step 4:	Set light absorption factor γ
Step 5:	While (!Max_Generations)
	For k=1 to n

	For l=1 to n
	If (I_k<I_l)
	Move firefly (k) toward firefly (l)
	End if
	Evaluate new solution and update intensity
	End for
	End for
	Rank fireflies and determine current global best g.
	End While

Step 6:	Post-process result and visualization

FA can be categorized based upon different parameters like firefly's representation, population scheme and the randomization process. Figure 5 represents the different classifications of firefly algorithms.

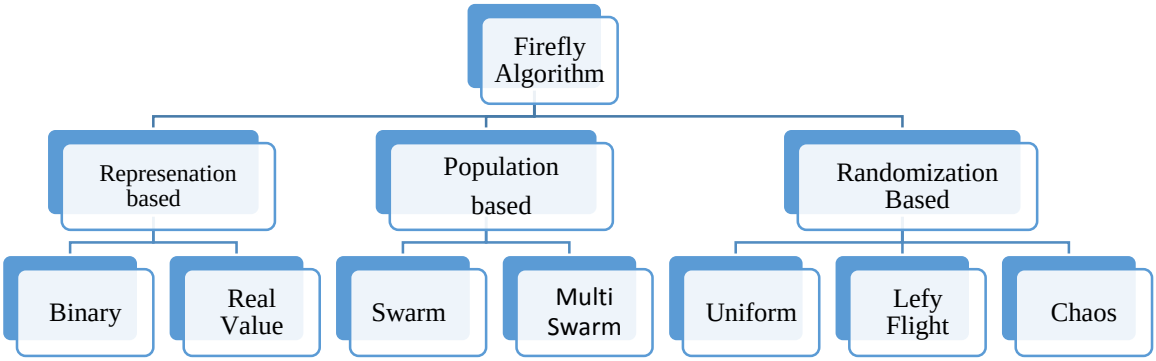

Figure 5: FA Classifications

Since 2007, FA has been employed by different researchers to solve various optimization problems like disease diagnosis, feature selection, clustering etc. Some of the applications of FA has been briefly mentioned below:

Nguyen et al. (2015) have used FA for heart disease forecasting. Authors tried to reduce attributes or dimension using rough set based approach. This approach seems to be computationally expensive. However, the hybrid use of rough set with FA found to be more suitable for optimal data reduction for high-dimensional data sets. It was experimentally proved that accuracy, specific and sensitivity achieved using hybrid combination of FA, rough sets and fuzzy logic is significantly improved. Hemabanati (2013) et al., have examined the role of FA in making data clusters. Authors have compared the performance of FClust algorithm (based upon FA) with the outcomes of PSO and DE (Differential Equation). Authors found that the convergence of FClust is outstanding as compared to PSO and DE. The experimentation was performed over six data sets. Out of six, two data sets were generated from simulation and four real world data sets (Fisher Iris, Wine, Thyroid and Wisconsin breast cancer) have been considered

[22]. Senthilnath et al. (2011) have tried to analyze the performance of FA in clustering. Authors compared the performance of twelve different clustering algorithms for thirteen different datasets. Based upon different metrics, authors found that FA is more reliable, efficient and robust as compared to other clustering techniques including PSO and ABC [23].V. Rajinikanth (2017) et al., has used FA to diagnose brain tumor using 2D-MRI. FA is used at preprocessing stage. Authors found better results as compared to other techniques [24]. V. Agarwal and S. Bhanot(2015) have employed FA for feature extraction in face recognition. Authors experimented with ORL and YALE databases. By using FA, authors were able to reduce dimensionality of ORL and YALE databases by 43.10% and 36.6% respectively. However, the rate of accuracy achieved after feature extraction was 94.37 and 99.16% for ORL and YALE respectively [25]. Reddy and Khare have hybridized three NIC algorithm viz. FA, BAT and ANN for breast cancer diagnosis. Authors compared the performance of their hybridized approach (FFBAT-ANN) with the individual performance of these computing techniques and found that hybridization produced better results as compared to their individual use [26].

3. Results

This study is carried out to analyze the publication analysis of both Firefly and ALO based articles.

3.1 Publication Analysis of Firefly Algorithm

The queries were fired to analyzed the use of FA in different applications like healthcare, process planning, feature selection, agriculture, economics, cloud computing, IoT, wireless sensors and image processing. To analyze the publications status of FA based articles, several queries have been fired to Google Scholar. Figure 4 represents the bifurcated publication details of use of FA. It is observed that maximum use of FA has been done in economics and image processing applications.

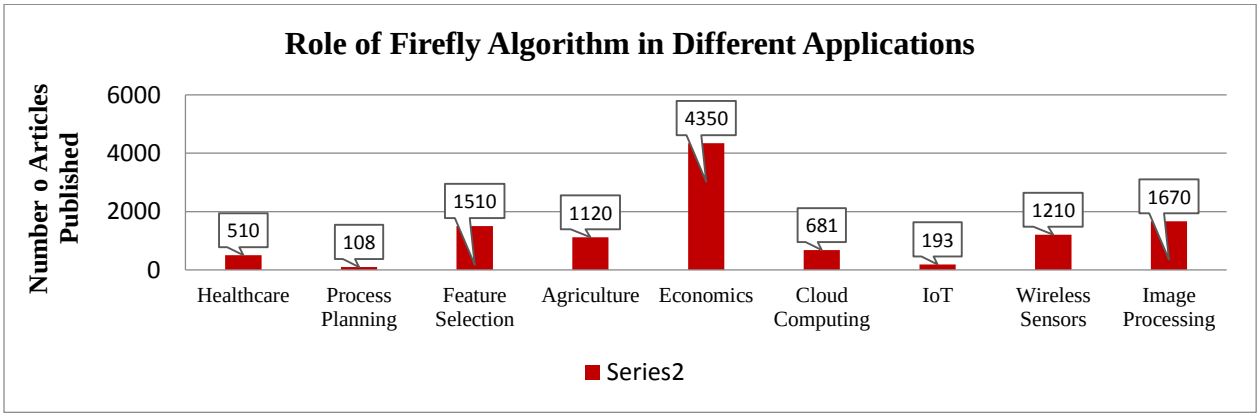

Figure 6 (a): Application based Publication Analysis of FA

As per Google Scholar's record, it is observed that since 2007, 11634 articles have been published using FA. The maximum articles have been published in 2017. Figure 6(b) represents the year wise publication details of FA based articles for the last ten years.

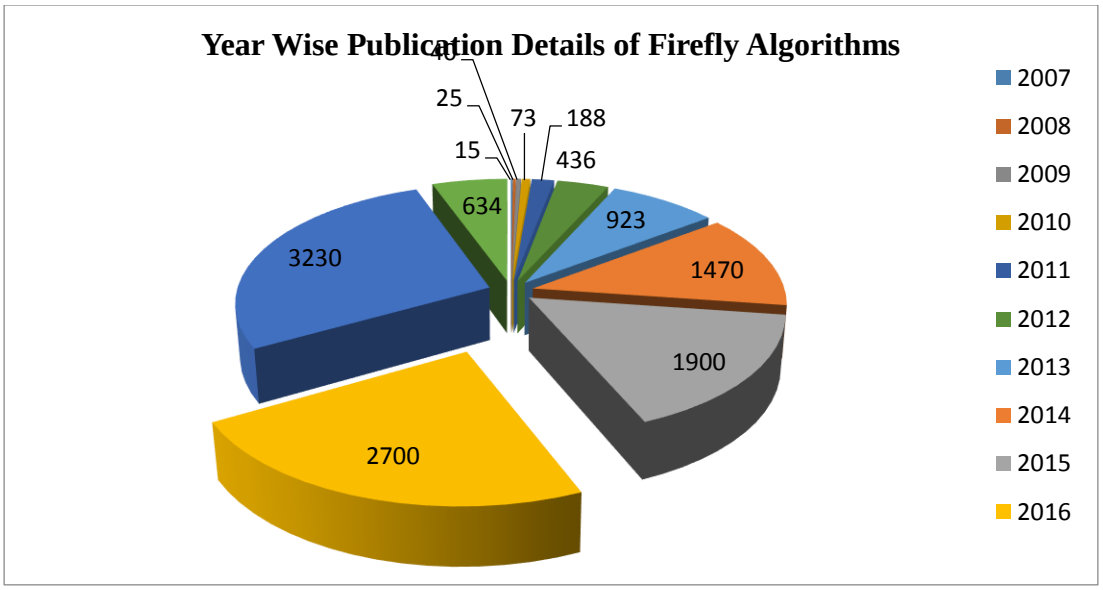

Figure 6(b): Year Wise Publication Analysis of FA

3.2 Publication Analysis of ALO

Like FA, the publication analysis for ALO has also been done. Google Scholar's witnessed that since 2015, 423 articles have been published using ALO. Maximum number of articles have been published in 2017. Figure 7(a) represents the last five year wise details of articles publication.

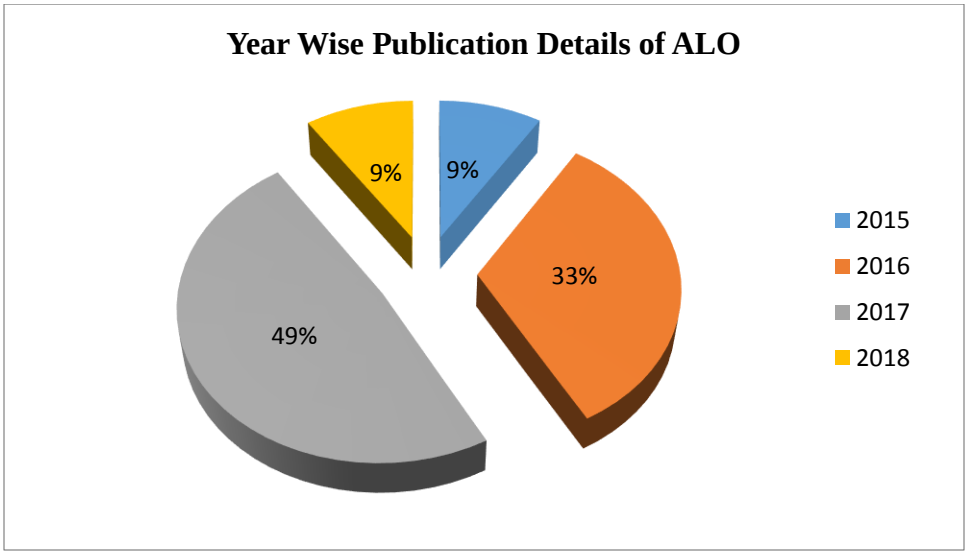

Figure 7 (a) :Year Wise Publication Analysis of ALO

Figure 7(b) represents the number of ALO based articles published in different areas viz. healthcare, process planning, feature selection, agriculture, economics, cloud computing, IoT, wireless sensor and image processing. It is found that maximum use of ALO has been done for

feature selection. However, healthcare and IoT are the areas where ALO has been least used and need to more explored.

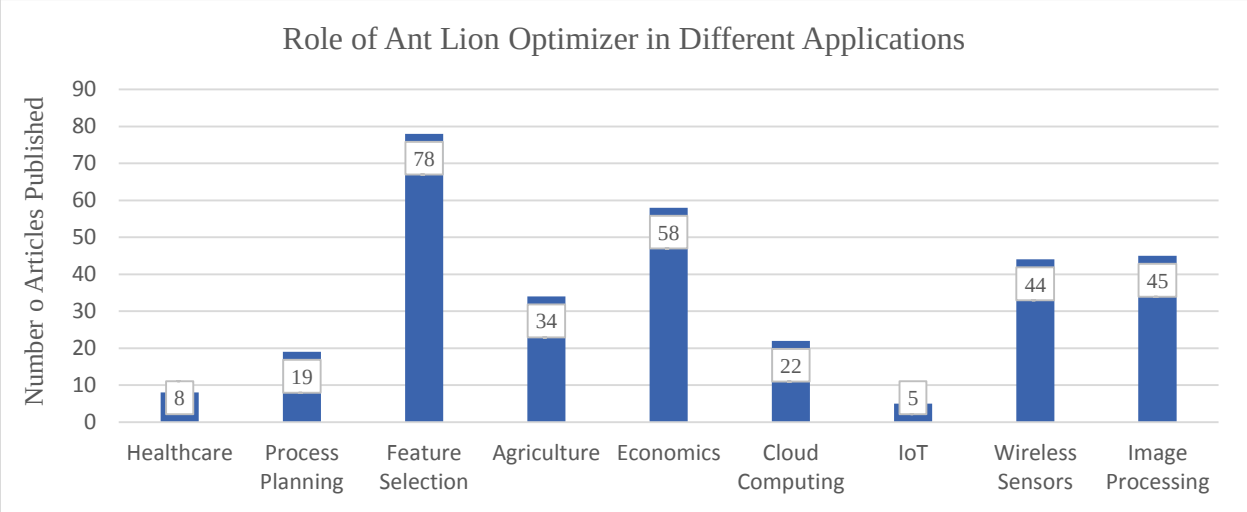

Figure 7 (b) :Application based Publication Analysis of ALO

4. Conclusion

Several NIC techniques have been evolved in last few years. This paper briefly introduces two emerging insect based optimization algorithms called Ant Lion Optimizer and Firefly. ALO and FA are based upon the ideas of hunting nature and the flashing behavior of the insects. It has been found 423 and 11634 ALO and FA based article have been published and indexed in Google Scholar. Since 2007, FA has been widely used in different applications. Whereas, ALO is an emerging optimization technique that is getting an attention of different researchers from different domains. Most of the authors have employed ALO to solve feature selection and economic based applications. Both FA and ALO has been least preferred in solving the healthcare, processing planning and economic based applications. Therefore, there is a need to design and analyze a hybrid ALO and FA based smart healthcare solution that can collect patient's data using IoT, monitor it regularly and give more precise results in disease diagnosis.

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