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An Analytical Review on The Recent Performances of Firefly Algorithm (Fa)

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ABSTRACT
It was noted that the problem of optimization gained tremendous attention from many researchers and offered better ways to solve real-life problems. Actually, the firefly algorithm (FA), which is meta-heuristic swarm intelligence (SI). It is similar to optimizing ant colony, optimizing bacterial foraging, bee-inspired algorithm, optimizing fish swarm and many others.It is based on a firefly's reaction to the light of other fireflies, the gene exchange of firefly, its pheromone and the effect that wind has on the dispersion of pheromones. In this way, they collected and examined scientific documents from respected publishers; among others, Elsevier, Springer. This analysis focuses on recent performances by firefly; taking into account its brief biological past, initial algorithm. A description, Authors ' review, variants, essence of optimization, and taxonomy were also provided. The firefly algorithm, also discovered, is a modern, nature-inspired algorithm worthy of solving complex optimization problems where other techniques failed or did not perform or did not find suitable. The examination may be extended to both inexperienced and expert practitioners for reference purposes.
KEYWORDS: Swarm Intelligence, Review, Firefly Algorithm

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I. INTRODUCTION

Swarm Intelligence (SI) is an important optimisation system category. SI is the property of a system where agents ' collective behaviors that interact locally with their environments cause the emergence of coherent global functional patterns (Mavrovouniotis, Li, & Yang, 2017). Optimization tends to find values for variables that give the objective function the optimal functionalvalue(s). Firefly algorithm (FA) is an intelligence swarm-based algorithm close to other biologically inspired algorithms such as ant colony optimization ACO), bacterial foraging optimization (BFO), artificial bee-inspired algorithm (ABC), fish swarm optimization (FSO), worms, and many others, have proved to be a very good method to solve difficult optimization problems as found useful above. Firefly algorithms (FA) are stochastic (check for a fixed solution), nature-inspired (by flashing light) and heuristics (search solution through trial & error) useful for solving the toughest optimization problem–a meta-heuristic; high-level search where algorithms use trade-offs between randomization and local search. Reviews are important for dissertations and journal articles (Mudavanhu, 2017) Reviews in dissertations and in journal articles are significant. It helps candidates are expected to demonstrate a formal understanding of their field of literature, intellectual independence, fluency in information, and ability to continually re-evaluate ideas and practices. The purpose of the researchers to present a literature review is also to demonstrate that he / she has read and understood the key published work concentrated Different subject. Critics then accepted that most analyses of literature are insufficient but disagreed on why that was the case. However, they accept that without a sufficient understanding of literature on the topic of interest, researchers can not perform successful studies.Therefore, a review is a structured assessment of something with the intention of instituting improvement if appropriate. Whereas Collins Dictionary.com sees it as a systematic review on the part of people in authority; usually done to see if it can be modified or revised or if it can be carefully studied to see what's wrong with it or how it can be enhanced or if someone offers it how they think of something like a new book or

film.While recently; several reviews of firefly algorithms have been performed and published; (Fister, Yang, &Fister, 2014) a comprehensive review of the firefly algorithm, (Ariyaratne&Pemarathne, 2015) a summary of recent advances in the firefly algorithm, which is currently used as a benchmark for its logical structure. Others are studying not only the firefly algorithm but also general swarm agents (Tilahun&Ngnotchouye, 2017), and (Mavrovouniotis et al., 2017). The latest review's innovation focused on detailed description, taxonomy, and scholarly source analyzes. It also presented research basics on the current performance of the firefly algorithm for inexperienced readers and may be useful as a guide Information to technical trainees. The current review's logical structure has five (5) parts in it: I. Introduction, II Algorithm for firefly, III. Latest Firefly Algorithm developments, IV. The firefly algorithm variants and description, V. Reason(s) make the firefly algorithm different from other swarm agents and Section VI Conclusion.

II. FIREFLY ALGORITHM

A) Firefly?

(Fister et al., 2014) summarized the firefly is a "Lampyridae" lightning bug It is the wing beetles insect family of approximately 2,100 species found in both temperate and tropical climates. At dusk, fireflies use chemical reactions called "bioluminescence" for the attraction of mates at sex reaction or prey. This chemical light is "cold" since it does not have one in. In addition, the larvae of male and female fireflies emit light (glowworms) and are able to fly with elytra or font wings, leatherier than those of other beetles. A few days after mating, females lay fertilized eggs with a hatch period of 3 to 4 weeks below the surface of the ground and the larvae feed until summer. During the larval stage they hibernate during winter, some years while others burrow underground or later emerge in the spring under the backs of trees. They feed and emerge as adults in other insects, snails, larvae, pupate from 1.0-2.5 weeks and. The larvae are a specialist predator by directly supplying digestive fluids to the intended prey while adults feed on larvae, pollen from plants, and nectar. We have a variety of ways to interact in courtships with mates; steady light, blinking and using chemical signals, etc. They often mimic the mating flashing of other lightning-bugs for the sole purpose of predation, attracting targeting mates as a suitable mat and are then eaten; whereas non-bioluminescent fireflies use a chemical pheromone to signal mates.The taxonomy of fireflies is seen on the basis of shared characteristics as the science for identifying and naming classes of biological organisms. Organisms are grouped into taxa (singular) and these groups are assigned a taxonomic rank; groups of a given rank may be aggregated to form a super-group of a higher rank, thus forming a taxonomic hierarchy in Table 1:

Table 1: *Photurislucicrescens:* **Scientific classification of firefly**

Kigdom	Clade	Class	Order	Superfamily	Family
Animalia	Euarthropoda	Insecta	Coleoptera	Elateroidea	Lampyridae

In a nutshell, fireflies are charismatic, easily spotted by non-experts, thus providing good flashing species which attract the attention of researchers due to the sensitivity of the fireflies and the rapid response to changes in the environment, among others, good bio-indicators for artificial lightning.

a) What is the original firefly algorithm (FA)?

i. Both were considered (Ritthipakdee, Thammano, Premasathian, &Uyyanonvara, 2014), and (Ariyaratne&Pemarathne, 2015). They supported that Yang created the original Firefly algorithm in 2009, inspired by fireflies ' flickering behavior and the algorithm relies on the following three (3) rules:

ii. Fireflies are unisex as they are sexually neutral of their attraction to each other.

iii. Attractiveness is proportional to the brightness; the less (dimmer) light shifts towards the brighter one for every two (2) fireflies. Brightness, however, decreases as distances increase; if there is no brighter than a single firefly, it flies at random.

IV. One firefly's brightness is determined

In addition (Tilahun&Ngnotchouye, 2017) given an original firefly algorithm which translates the three (3) idealized rules in Algorithm 1 above: original firefly algorithm below:Set algorithm parameters (α,γ)

Set simulation set-up (Maximum number of iteration (Maxitr), Number of initial solutions (N))

Randomly generate N feasible solutions (x1, x2,….xN)

Computer light intensity I, for each x, based on the objective function f(x)

Rank or sort fireflies based on their light intensity
i.e $I \geq_{1i-1}$, for all i
for iteration = I :MaxItr
for i=I:N-1
for j=i+I:N
if(I_i>I)
move firefly I toward firefly j
attractiveness varies via exp(γ^r)
updatethesolution and compute light intensity
endif
end for
end for
move X_N randomly rank fireflies
end for
Report the best solution

B) How is this firefly algorithm working?
Once again, (Fister et al., 2014) and (Ariyaratne&Pemarathne, 2015) outlined the problem-specific objective function of FA based on the above algorithm 1. That the initial population will identify the problems at random with a selection of feasible solutions. Then the light intensity of each firefly is determined mathematically, where each firefly in the population begins to move towards brighter fireflies according to the following equations:

Assume x(i) and x(j) are two fireflies
$x(i) = (x(i)+\beta(x(j) - x(i)) + \alpha(rand-0.5)$
.... eq 1.
Where $\beta = \beta_o e^{-\lambda r}$
.....eq 2
Here, λ denote light absorption coefficient, r is the distance between two fireflies and β_o *is attraction @ r=0.*

Therefore, there are three words that are vividly noted; the first term is the attraction of fireflies and randomness, the second is an attraction between two fireflies, while the third term is a randomization parameter where α is a random factor. These have already been proved in Yang's Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) comparison. This made other researchers follow suit by testing the firefly algorithm over difficult mathematics, engineering, and physics optimization problems, yet the FA algorithm proved successful.

III. RECENT ADVANCEMENTS OF FIREFLY ALGORITHM

Multi-objective / models / variables, Remote sensing, Precision, Comparative analysis, Cloud resource use, VANET, Image processing & classification and work scheduling among others. In general, swarm intelligence (SI), and particularly FA, is an important tool capable of solving complex problems in both scientific and engineering practice. Despite numerous works available in the literature at different online repositories, a handful of important research works are reviewed here**:**

A Nicking Higher-Order Evolutionary Strategy (NHOES) has been implemented in a multi-model, multi-objective research (Alb et al., 2015) to detect local solutions on their way to the best solution for a given scalar objective function. FA has yet been applied to Restricting the test function and shielding an electromagnetic problem with two and three targets respectively, and FA proved to be the most effective compared to NHOES. A variable selection technique coupled with three separate multivariate validation models was proposed in another multi-model research (Attia, Nassar, El-Zeiny, &Serag, 2017); residual concentration augmented classical minus squares, artificial neural network and support vector UV-spectral analysis. FA and GA conducted a comparative study. Results indicated that FA is superior to GA. Statistical tests, however, did not reveal any significant difference in predictability between the models. (Balachennaiah&Suryakalavathi, 2015) suggested identifying optimum variables such as transformer taps, UPFC position and its variables in a power transmission system network. These multi-variables were simultaneously designed as a multi-objective method for optimal power flow problem to optimize the actual power loss (RPL) and then decrease the RPL and maximize the voltage stability limit (VSL).The research took place on England 39 and outperformed the methods of Interior Point successive linear programming (IPSLP) and Bacteria foraging algorithm (BFA). These have proved the FA's effectiveness over others. Again, (Balachennaiah, Suryakalavathi, &Nagendra, 2016) suggested firefly Optimizing a large transmission network's real power loss and voltage stability limit using the firefly algorithm. This was formulated mathematically as a problem of optimization constrained by nonlinear equality and inequality, with an objective function integrating both real power loss and voltage stability limit.Simulation tests from England also showed 39 bus systems that transformers taps, single power flow controller and its parameters were all effectively configured as control variables. (Bendjeghaba, 2014) implemented a Continuous Firefly Algorithm (CFA) dependent tuning approach. This was purposefully done to obtain the parameters for the proportional-integral-derivative (PID) controller in the Automatic Voltage Regulator (AVR) system. The tuning process was able to reach optimal / near-optimal parameters for the PID controller and improved the characteristics of the AVR phase response.This proved the

approach's efficacy and success over PSO. Systematically proposed FA control parameters such as randomization, attractiveness, absorption coefficient and a number of fireflies (Sekhar, Sahu, Baliarsingh, & Panda, 2016); Using an optimized hybrid fuzzy PID controller with a derivative Filter (PIDF), they tuned out multiple runs of algorithms for each control parameter variation. These are used within a deregulated environment for Load Frequency Control (LFC) of multi-area multi-source systems. They found nonlinearity to physical constraints like the Generation Rate Constraint (GRC) and the Governor Dead Band (GDB).Simulation of the time domain and an analysis of sensitivity indicated the effectiveness of the proposed scheme over others. (Ibrahim &Khatib, 2017) suggested a random forest technique; the best number of trees and leaves per tree contained in the forest. They used three (3) statistical error values; square root-means error, mean bias error and mean absolute error percentage. Such statistical inferences showed the best number of trees in the wood, leaves per tree and one leaf per tree. The FA random forest model better performed over the traditional random forest model, artificial neural network and optimized artificial neural network in terms of prediction accuracy / prediction speed.Remote sensing (Kaur&Sachdeva, 2017) lets users land space information without necessarily having interaction with the experimental field. They suggested FA and explored a number of procedures with the construction of landscape elements where grouping exists, which increases the importance of kappa. After the work features were implemented the error matrixes were calculated. Water, vegetation, urban, rocky, and barren are among these. For the method of validation, the amount of pixels measured in firefly; 73 for water pixels, 161 for vegetation pixels, 158 for urban pixels, 101 for rocky pixels and 57 for Barren pixels.Over other methods the Firefly algorithm proved to be efficient. Gaussian Disturbance, local search and Firefly Algorithms (GDLSFA) were proposed (Lv& Zhao, 2018). This method not only enhances population diversity but also increases precision optimization under the same parameters as compared with 12 benchmark functions. Nevertheless, the SIA work is only at a preliminary stage, rather than solving many of the swarm intelligence algorithm (SIA) issues. In other veins, a comparative study between prey-predator and firefly algorithms was proposed (Ong, Tilahun, Lee, &Ngnotchouye, 2017).The findings of both theoretical and simulation revealed that the prey-predator algorithm is a more generic search algorithm, whereas the firefly algorithm fell as a special case of a prey-predator algorithm by setting some of the prey-predator algorithm parameters to certain values. It proved FA's superiority over the prey-predator algorithm. In addition, (Florence &Shanthi, 2014) introduced a new FA dependent parameter load index; memory use, processing time, and shared access rate are computed on a virtual cloud server computer. The essence of this is optimizing resource utilization and providing a well-balanced load across cloud server resources. FA has been proven effective with an average time of 0.934ms ahead of GA and Revised GA. However, the remaining challenge is to do the same on a higher configuration system. (Sachdev, Mehta, & Malik, 2016) suggested FA for internet distribution in Ad Hoc Vehicle (VANET) networks. This allows to group vehicles driving along highways into cluster-based routing just to facilitate good communication. The architecture recognized the scale and geographical range of the clusters, which has significant impacts on the quality of communication. In VANET real-time communication enables distributed applications in infrastructure-less areas among vehicle nodes.In addition, it allows location-based clustering techniques that improve routing performance under various mobility structures. The NS2-based experimental result showed that FA proved to be the most effective in route discovery, optimal route finding, route maintenance, delay, resources, packet delivery. Certain SIA have not been tested however. Also proposed for band selection is the FA (H. Su, Cai, & Du, 2016) and an optimized extreme learning machine (ELM).Essentially, hyper-spectral image classification is performed to reduce complexity and optimized parameters (regularization coefficient C, Gaussian kernel π, and secret number of neurons L). Two hyper-spectral databases of photographs obtained by HYDICE and HYMAP. The results indicated that, compared with PSO and other similar band selection algorithms, FA offers better efficiency. (Udaiyakumar&Chandrasekaran, 2014) proposed to take advantage of FA because of its inspiration and find a makepanminimisation. They used 1-25 Lawrance problems from a classical OR library as a benchmarking.They interpreted and compared the results to fuzzy logic and simulated annealing. Subsequently again contrasted with the Genetic Algorithm (GA), Selective Breeding Algorithm (SBA), Taboo Search Algorithm and Ant Colony Optimization ACO. FA outperformed and proved to be the best way to view problems related to Job Shop Scheduling for all comparisons made. (Wang, Wang et al., 2017) proposed a method for the multi-step forward forecasting of electricity prices. They used a hybrid model that was based on the methodology of two-layer decomposition and neural BP network.They used a technique of two layers of decomposition and then developed a hybrid model based on the neural network of rapid ensemble

empirical mode decomposition (FEEMD), variation mode decomposition (VMD), and back propagation (BP). The model is unique as VMD is specifically applied to further decompose the intrinsic high frequency mode functions (IMFs) into a number of FEEMD-generated modes, thus improving the predictive accuracy. Furthermore, three electricity price series obtained from Australia and France's real-world energy markets are adopted for empirical study. The results showed that the FA model outperforms and has proven superior over one, two, four and even six-step forward forecasting. (Wońniak, Gabryel, Nowicki, & Nowak, 2016) suggested a firefly algorithm to solve device positioning, based on an independent 2-order hyper-exponential packet input stream and an exponential time distribution of operation. Various scenarios that examined the operation of the system were presented, evaluated and suggested that FA proved successful. (Zhao et al., 2017) suggested the firefly algorithm as a multi-objective optimisation model based on probabilism.In an effort to configure Radio Frequency Identification (RFID), they addressed the challenges of number of readers, interference frequency, and tag coverage. A firefly algorithm based on decomposition is conceived for the problem. Digital force is embedded in a random walk to direct readers on their path to increase exploitation. The proposed approach is being illustrated and tested by numerical simulations.A comparison was made with the Non-dominated Genetic Sorting Algorithm-II and Multi-Objective Particle Swarm Optimization (PSO). Ironically, under the same computational framework, the FA-based approach achieved better performance in terms of both efficiency and generational distance.

Table II: Summary of the Recent Advancements of Firefly Algorithm

Objective(s) Optimized	Author(s)
Multi-objective/models/variables	(Alb et al., 2015), (Attia et al., 2017)etc
Real power loss & Voltage stability	(Balachennaiah et al., 2016), (Bendjeghaba, 2014)etc
Remote sensing	(Kaur & Sachdeva, 2017)
Precision	(Kaur & Sachdeva, 2017)
Comparative analysis	(Ong, Tilahun, Lee, & Ngnotchouye, 2017)
Resource utilization in the Cloud	(Ong, Tilahun, Lee, & Ngnotchouye, 2017)
VANET	(Ong, Tilahun, Lee, & Ngnotchouye, 2017)
Image processing & classification	(Ong, Tilahun, Lee, & Ngnotchouye, 2017)
Prince forcasting	(Ong, Tilahun, Lee, & Ngnotchouye, 2017)
Job scheduling	(Udaiyakumar & Chandrasekaran, 2014)

IV. VARIANTS OF FIREFLY ALGORITHMS

Each segment is presented in two folds; the firefly altered/adjusted version is regarded as being improved or modified. The second fold is a hybridized firefly, where a offspring is obtained through the cross-breeding of two or more SI algorithm species.

a) *Improved/ Modified*

The literature revealed that an enhanced FA plays, among others, significant roles in estimation, forecasting, power monitoring, resource utilization, distribution and image processing:

Ritthipakdee et al., (2014)suggested an improvement on the original firefly algorithm (IFA) and took into account not only light attracted but other contributing factors as well. Such considerations include the sharing of genes for firefly, its pheromone and the effect that wind has on the dispersion of pheromones. Our algorithm has been tested and is the fastest in optimum global convergence compared with the original FA and Genetic Algorithm that IFA is. An improved Artificial Firefly Algorithm (IAFA) was also introduced (Miao, 2014).Then a chaos algorithm was introduced, using luciferin updates to improve the AFA. The simulation used the CloudSim and MatLab2012 on Corei3 CPU. The results indicated an improvement in the AFA which greatly enhanced the accuracy and efficiency in task processing / rational resource allocation. Nonetheless, further studies are needed. The Opposition and Dimensional Approaches (OD-FA) were established (Verma, Aggarwal&Patodi 2016). The purpose of the strategy was tackling traditional FA's sluggish convergence.The new approach performed in terms of accuracy, convergence speed and several complex multi-dimensional criteria for higher dimensionality problems. Experiments conducted have shown that the OD-FA performed better. (Singh, Sinha, Goswami, &Sinha, 2017) suggested the least square-based firefly algorithm (FA-LS) for power system estimation. FA estimates the stages, and LS estimates harmonic signal amplitudes. The simulation result demonstrated the effectiveness of the FA-LS estimation and computational time as the best over PSO, ABC and passive congregation. Research was conducted on power efficiency and the use of resources in a cloud service (S. Su, Su,

Shao, &Guo, 2015). They had developed a meta-scheduler (PAFA) novel. This makes use of the discrete multi-objective FA, which has obtained a set of non-dominated solutions. The aim is to detect and monitor the evolving, optimal target servers for the provisioning of virtual machine (VM). We found resource dynamics and server power consumption in different sleeping states, with different loads. The experimental research was performed by CloudSim & Java programming, and found it superior over multi-objective genetic algorithm (MGGA) and PSO grouping.The task is to research the algorithm scalability and architecture swarm intelligence (SI)/deep learning-based mapper of meta-heuristic VMs for adaptive service / power consumption in data centres. Again, (Singh, Sinha, Goswami, &Sinha, 2016) suggested FA and recursive least square (FA-RLS) for the sole purpose of harmonic estimation of the power system; harmonics, inter-harmonics and sub-harmonics from a distorted / noise corrupted signal of power. The integration allowed FA to obtain optimal initial weight for RLS for parameter update. The study using the real-time data is used for testing and compared to ABC-LS, optimization foraging bacteria (BFO-RLS), but FA-RLS is the best in terms of accuracy, convergence and computational time. (Teshome, Lee, Lin, &Lian, 2016) suggested a Modified Firefly Algorithm (MFA) to fix inherent firefly algorithm (FA) problems. The new technique of MFA has solved different maximum power point tracking (MPPT), reduced number of computing operations and convergence time. Experimental results suggested that MFA performed better than standard FA performance.(Wang, Zhou et al., 2017) implemented FA with parameters for adaptive control (ApFA). The experiments showed that the ApFA outperforms the regular FA and five other newly proposed variants of FA. Designing more efficient parameter strategies as further research, though, required. (Garousi-Nejad, Bozorg-Haddad, &Loáiciga, 2016) used the Modified Firefly Algorithm (MFA) methodology for optimum tank operations. Many mathematical programming methods contrasted the results; linear programming (LP), differential dynamic programming (DDP) and discrete differential dynamic programming (DDDP).There were also similarities between the Genetic Algorithm (GA), Multi-Colony Ant Algorithm (MCAA), Honey Bee Mating Optimization (HBMO), Water Cycle Algorithm (WCA), Bat Algorithm (BA), and Biogeography-Based Optimization (BBO). The MFA was found to be effective and therefore advantageous over alternative methods of optimisation. (Wang, Cui, Sun, Rahnamayan, & Yang, 2017) proposed a new FA (RaFA), attracted randomly. As the name implies, instead of the fully-attracted one, it employs a randomly attracted model. Each firefly in this model is attracted by another randomly chosen firefly. A system of Cauchy hops is employed to improve the FA's global search capability.A Cauchy mutation is performed on the world's best firefly found so far, per generation. Experiments conducted on 11 well-known benchmark functions and tests showed that RaFA is better than the outperformed regular FA and two others in terms of solution accuracy and robustness. Nevertheless, the impact of measurements, such as the scalability test, on RaFA's efficiency remains its future research. (Kar& Swain, 2016) suggested a Firefly Search Algorithm (HS-FA) for harmony. It was used for a study of a transmission system's power oscillation. The study used an integral square error (ISE) to evaluate the output of the controller under different conditions of perturbation. HS-FA was discovered to dump out-power oscillation for better stability of the system. (Gokhale& Kale, 2016) suggested a chaotic firefly algorithm (CFA) to organize overcurrent relays in an electrical distribution network in an optimum time. The CFA was implemented in MATLAB, and tests in terms of time synchronization superseded the traditional FA. (Lei, Wang, Wu, Zhang, &Pedrycz, 2016) proposed the Markov clustering FA (MCL-FA) to classify protein complexities and supplement the bioinformatics limitations of MCL. The findings of the experiments were compared with PSO and standard FA but MCL-FA outperformed with respect to the precision of the detection of protein complexities. (Osaba et al., 2017) designed a vehicle routing problem-solving strategy for real-world recycling newspaper delivery. We suggested an asymmetric and clustered vehicle routing problem called (AC-VRR-SPDVCFP) with simultaneous pickup and distribution, vehicle costs and prohibited routes.The work utilized specific geographical positions as benchmarks located in Bizkaia province, Spain. Discrete firefly algorithm (DFA) was proposed, and performance was compared with algorithms for differential evolution (DE) and evolutionary simultaneous annealing (ESA). The results obtained showed that DFA surpassed DE and ESA, respectively. (Wang, Cui, et al., 2017; Wang, Wang, Sun, &Rahnamayan, 2016) proposed a Neighbor Strategy Random Attraction FA (NSRa-FA) model to create a trade-off between production and exploration capacities. They also employed a complex parameter change system for automated parameter monitoring.The experiment revealed that NSRa-FA has found a better solution than five other newly proposed versions of FA. Again (Wang et al., 2016) suggested neighborhood attraction FA (Na-FA) to overcome the problem of too many attractions; resulting in complications of oscillation and a lot of computing time. The strategy allowed

fireflies attract other brighter ones rather than the population from predefined neighbours. This increased the efficiency of the solutions and the difficulties in computational time. In addition, a New Dynamic FA (ND-FA) was implemented (Wang, Wang, Cui, Zhou et al., 2018).The model was aimed at estimating the demand in the City of China for water resources. Again they suggested avoiding manual stop vector change. Furthermore, linear, exponential, and hybrid models are designed to eliminate the effect of various data units. The tested model (ND-FA) achieved efficacy over others by 97.7 per cent in water demand prediction. (Xiao, Shao, Liang, & Wang, 2016) proposed Short-Term Load Forecasting FA (STLF-FA) to optimize the combined model weight coefficients based on the theory of non-passive constrains. They used semi-hour electric power data in Australia from New South Wales, Victoria and Queensland.The numerical experiment showed that six other state-of - the-art discrete models outperformed the proposed model. (Saleh, 2017) suggested an enhanced firefly algorithm (IFA) to tackle the challenges of higher fuel, storage, spare parts and maintenance costs in the Microgrid electric network. All characteristics of levy flights and IFA were employed in solving the problems in mind; daily power balance and generation cap as parameters. The work was carried out in MATLAb and proved better than standard FA, Differential Evolution (DE), PSO, and Cuckoo Search Algorithm (CSA) in optimal cost, convergence, and robustness.(He & Huang, 2017) proposed a Modified Firefly Algorithm (MFA) to evaluate the optimum multi-level color picture threshold values. Kapur'ds entropy approaches, minimum cross-entropy, and the objective functions between class variance are. Compared to basic FA, Brownian Search Based firefly algorithm (BFA) and Levy Search based Firefly Algorithm (LFA), the MFA was tested. The experimental results showed an outperformance of the proposed MFA. A Support Vector Machine FA (SVM-FA) was introduced (Ghorbani et al., 2017). The aim was to forecast parameters of soil field potential (SFC) and Permanent Witting Point (PWT) due to their important in biophysical and agricultural models.Certain parameters were also considered; silt, sand, clay, bulk density and organic matter as inputs remained as outputs, and SFC and PWP. SVM-FA have outperformed models of the Neural Network (NN) in predicting better results.

Table IV: Few among Authors, Variants and objectives achieved using an improved or Modified FA

Authors/ Year	Variants	Objective(s) Optimized
(Ritthipakdee et al., 2014)	IFA	Pheromone dispersion
(Miao, 2014)	IAFA	Luciferin update
(Verma et al., 2016)	OD-FA	Slow convergence
(Singh et al., 2017)	FA-LS	Estimation of power system
(S. Su et al., 2015)	PAFA	VM provisioning/Resource utilization
(Singh et al., 2016)	FA-RLS	Power system harmonic estimation
(Wang, Cui, et al., 2017; Wang et al., 2016)	NSRa-FA	Automatic parameter control
(Xiao et al., 2016)	STLF-FA	Short-term load forecasting in electrical system
(Saleh, 2017)	IFA	high cost of fuels, maintenance, logistics, spare parts & maintenance
(Wang, Wang, Cui, Zhou, et al., 2018)	NDFA	Demand estimation of water resources

b) *Hybridized*

Records showed that FA was hybridized with DE, GA, PSO among others, and optimized various problems; task classification efficiency and accuracy, irregular cardiac identification / detection, avoidance of local minima, improved accuracy and increased convergence rates. Certain areas dealt with by the FA included optimisation of data clustering, differential optimisation and energy efficiency:

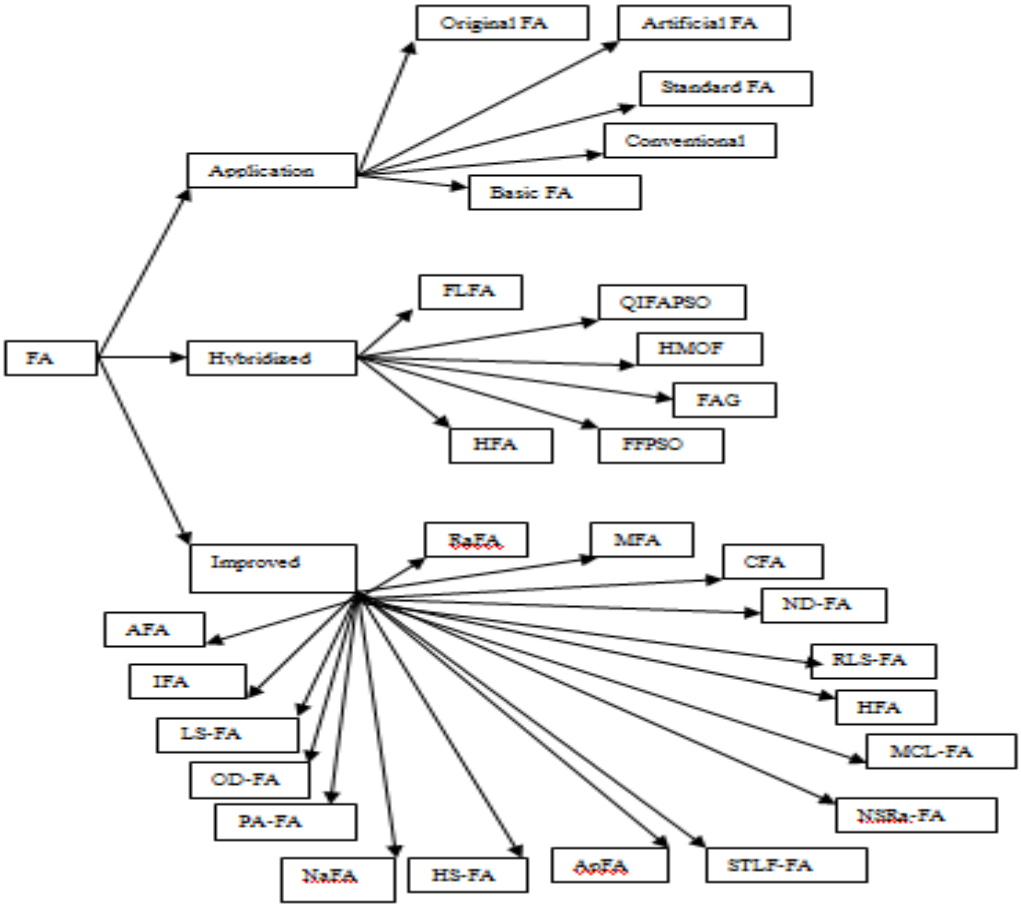
(Pouyan, Yousefi, Ostadabbas&Nourani, 2014) proposed a novel hybrid method using;fuzzy logic and FA to improve classification tasks performance and accuracy. They had used nine (9) different sets of data. The results showed that the classification's accuracy and efficiency are far better than other strategies mentioned in their literature and are very competitive. The irregular cardiac detection model (Kora& Krishna, 2016) was developed solely to identify heart ailments. We used Bundle Branch Block (BBB), FA, and PSO (FFPSO), respectively.Additionally, they merged classifier Leivenberg Marquardt Neural Network (LMNN). The FFPSO was made to perform local searching by stepping with the PSO operator via the adjusted light intensity attraction. Comparison of the FFPSO features was rendered with classical FA and PSO. The findings were provided as input to the

classifier Levenberg Marquardt Neural Network (LM NN). The processes enhanced classifier efficiency. A hybrid metaheuristic optimisation algorithm (Aydilek, 2018) was proposed. This algorithm merged FA and PSO algorithms with strong points, respectively. They employed a local search strategy that managed the best fitness interest of the previous regional.Also proposed in their limited function evaluations is HFPSO, which was compared with the original FA, other hybrid, and Memetic Algorithm (MA). In addition, the 2015 and 2017 CEC standards, engineering, mechanical architecture, and statistical Holm-Bonferroni measures were all used. (Pei, Huayu, Zheqi, &Meibo, 2019; Zhang, Liu, Yang, & Dai, 2016) proposed a novel population-based hybrid FA (HFA) which combines the same DE.The statistical analysis showed better avoidance of local minima, precision, convergence rate, robustness and overall HFA efficiency over the remainder. However, it does not explore different ways of mixing; regrouping population for enhanced performance, or performing a comprehensive parametric analysis to analyze iteration sub-stage. (Kaushik&Arora, 2015) suggested the Firefly Based Genetic Algorithm (FAG), which would pick the initial population from the population pool using FA. The FAG is then applied to available data sets from the UCI repository, the results obtained were satisfactory and highly competitive, respectively over both standard FA and GA(Sundaram, Kumar, Krishnakumar&Sugavanam, 2016) suggest a hybrid FA and Fuzzy logic method for energy-efficient induction motor operation. The technique improved the performance of the A / C voltage controller that fed motor drives with three-phase induction; manufacturing, propulsion, and transport. The simulation result on MatLab showed that the disadvantages of the modern search approach have been overcome to achieve the best efficiency level. The technique thus improved motor efficiency, the power factor, and the engine operates very wonderfully in the energy-efficient region.An Hybrid Multi-Objective Firefly Algorithm for Big Data Optimization (HMOFA) was developed (Wang, Wang, Cui, Sun et al., 2018). The methodology suggested six problems with single objectives and six problems with multi-objectives. The results of the calculation showed that HMOFA achieved good performance over all test problems. Quantum-inspired Firefly Algorithm with Particle Swarm Optimization (QIFAPSO) was proposed (Zouache, Nouioua, & Moussaoui, 2016) The method adapts the firefly approach to solve the problems of discrete optimization. The QIFAPSO applies the basic concepts of quantum computing; Q-bit and quantum measure superposition states to ensure better control of diversity of solutions.In addition, the Hamming distance method was used in computing the attractiveness and merged the two approaches in exploring the search space; first, pushing less bright fireflies towards the brighter ones and second, the PSO movement in which a firefly moves by taking into account its best position as well as the best position of its neighbourhood. Later, the use of multidimensional knapsack problem in validating the findings showed that QIFAPSO was competitive and stronger than the initial FA & PSO approaches, respectively.

Table III: Few Authors, Variants and objectives achieved in a hybridized FA

Authors/Year	**Variants**	**Objectives**
(Pouyan et al., 2014)	FLFA	Performance and accuracy of classification task
(Zouache et al., 2016)	QIFAPSO	Discrete optimization problems
(Kora & Krishna, 2016)	FFPSO	Abnormal cardiac identification
(Pei et al., 2019; Zhang et al., 2016)	HFA	Avoidance of local minima, precision, rate of convergence
(Wang, Wang, Cui, Sun, et al., 2018)	HMOFA	Multi-Objective

Fig. I: Depicting the taxonomy of the variants of firefly algorithm



V. WHY FIREFLY ALGORITHM IS SO SPECIAL

Considering two major parts of equation 1, FA is so special, as derived from various research efforts; information-based movement x(i)+β(x(j)-x(i) and random movement α(rand-0.5):

- The first element of compar. 1Exploits the current firefly to construct a new firefly taking into account the brightness of a given firefly and its distance from another brighter firefly while changing its solution, whereas the random component produces a random solution which may lead to a good or bad situation.
- The (rand) and (α) optimize output in the random process as α controls randomness and is scaled using (Ub-Lb), indicating both upper and lower boundaries respectively.
- Exploitation conducts local search during the search process when exploration reveals a random or global quest. As such, at every stage of problem-solving, FA maintains a balance between exploitation and discovery. Therefore, in local search β is important where the brightness of a firefly is associated with eq.2 influenced by the coefficient of distance (r) and light absorption (ÿ). Also, the value of γ is critical for the solution's convergence.
- As the value of π increases, β goes to zero (0) eliminating the algorithm's cheating capacity and making it possible to walk a simple random path. If ÿ tends to zero (0), the β brightness shifts towards its initial value, meaning that the gap is no longer in use and that fireflies clearly identify each other.
- Exploitation does more work in these situations than spontaneous movement leading to a solution to be stuck in the optimal locale. As such, balancing the importance of π in many optimization tasks contributes to the performance of the firefly algorithm and these make FA special.

VI. CONCLUSION

Around fifty-three (53) reviews of scholarly articles were reviewed as follows; implementation of standard FA 17 (32.09%), improved FA has 21 (39.62%), hybridized FA 7 (13.21%), similar FA reviews have 4 (7.54%) and other sources have 4 (7.54%) posts. The purpose of this consultation was to review the firefly algorithm's results, understand its short history, and contribute to the field of optimization amongst others. Therefore, the firefly algorithm was considered exceptional and continues to maintain dominance in all ways compared to other meta-heuristics due to its fewer parameters, use of manipulation techniques and exploration.Such scientific references were from respected publishers in the same vein; IEEE, Springer, Grid Distribution Computing, Information Science, Soft Computing, Swarm Evolutionary, and International Conferences, etc. These papers are regular database products; Google Scholar, Science Direct to name but a few. As such, without any iota of doubt, this paper may conclude that FA is a modern, nature-inspired algorithm worth solving complex optimization issues where other techniques have failed, performed less, or found unfit.

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