IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

Cuckoo Search Optimization and its Applications: A Review

Venkata Vijaya Geeta. Pentapalli[1], Ravi Kiran Varma P[2]

CSE Department, MVGR College of Engineering, Vizianagaram, India[1]

Associate. Professor, CSE Department, MVGR College of Engineering, Vizianagaram, India[2]

Abstract: The Cuckoo Search is an optimization algorithm developed by Yang and Deb in 2009. It is used in solving optimization problems. It was inspired by a bird species named cuckoo that lays their eggs in the nest of other host birds. The cuckoo egg laying and breeding is the first basic motivation for the development of new optimization algorithm. This optimization algorithm increases the efficiency, accuracy, and convergence rate. In this paper, a brief review is given about the cuckoo search algorithm and also about the optimization and its problems. Different categories of the cuckoo search and several applications of the cuckoo search are reviewed.

Keywords: Optimization, Cuckoo Search, Levy Flight

I. INTRODUCTION

Optimization is a process of modifying a system to make some features to work more efficiently or finding alternative performance under given constraints, as possible by maximizing desired parameters and minimizing the undesired parameters which are involved in the problem. Maximizing means trying to obtain good results without the expense. If the computer or any Android phone is optimized then it runs faster or to run with fewer memory requirements. Optimization can be classified in many ways. This cuckoo search algorithm is one of the algorithms in solving optimization problems. The Cuckoo search optimization is introduced in 2009 by Yang and Deb[1]. Cuckoo Search Algorithm is inspired by the bird cuckoo species in nature. This algorithm is used for the continuous problems and NP-hard problems. This algorithm is tested by the many researchers on some benchmark functions and compared with the other algorithms like PSO (Practical Swarm Optimization) and GA(Genetic Algorithms), and the solutions obtained for cuckoo search algorithm is better than the other algorithms like PSO and GA. These algorithms are applied to Engineering optimization.

Ant Colony Optimization (ACO) is one of the popular metaheuristic, combinatorial search optimization technique, inspired from natural ant behavior. ACO was used along with Rough Sets and Fuzzy Rough Sets in feature selection in [2], [3], [4]. ACO was also used for optimization of firewall rules in [5]. Nowadays the Cuckoo search algorithm is used in every domain like scheduling planning, forecasting, image processing, feature selection and engineering optimization[6]. There are many papers on this cuckoo search; the aim of this algorithm is to solve for optimization problems. This paper makes an attempt to discuss cuckoo search algorithm, types, and applications. A case study on Travelling Salesmen Problem (TSP) is also presented.

II. CUCKOO SEARCH ALGORITHM

Cuckoo search is a meta-heuristic algorithm inspired by the bird cuckoo, these are the 'Brood parasites' birds. It never builds its own nest and lays their eggs in the nest of another host bird nest. Cuckoo is a best-known brood parasite. Some host birds can engage directly with the intruding cuckoo. If the host bird identifies the eggs that are not their egg then it will either throw that eggs away from its nest or simply rid its nest and build a new nest.
In a nest, each egg represents a solution and cuckoo egg represents a new and good solution. The obtained solution is a new solution based on the existing one and the modification of some characteristics. In the simplest form each nest has one egg of cuckoo in which each nest will have multiple eggs represents a set of solutions. CS is successfully used to solve scheduling problems and used to solve design optimization problems in structural engineering. In many applications like speech reorganization, job scheduling, global optimization.
Cuckoo search idealized such breeding behavior and can be applied to various optimization problems [7].
1. Each cuckoo lays one egg at a time and dumps it in a randomly chosen nest.
2. The best nests with the high quality of eggs will carry to the next generations.
3. The number of available host nest is fixed and if a host bird identifies the cuckoo egg with the probability of $p_a = [0,1]$ then the host bird can either throw them away or abandon them and build a new nest.

Flow Chart

Levy Flight: Levy flight is a random walk; in this, the steps aredefinedregarding the step-lengths, which have a certain probability distribution, with the directions being random. This random walk can be observed in animals and insects. The next movement is based on the current position. [7].

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

$$X_i(t+1)=X_i(t) + \alpha \oplus Levy(\lambda) \quad (1)$$

Where $\alpha > 0$ is the step size. In most of the cases assume that α is equal to one. The product $\oplus$means entry-wise multiplication i.e. Exclusive OR operation
Levy flight is a random walk with random step size following a levy distribution

$$levy \sim u = t^{-\lambda}(1 < \lambda \leq 3) \quad (2)$$

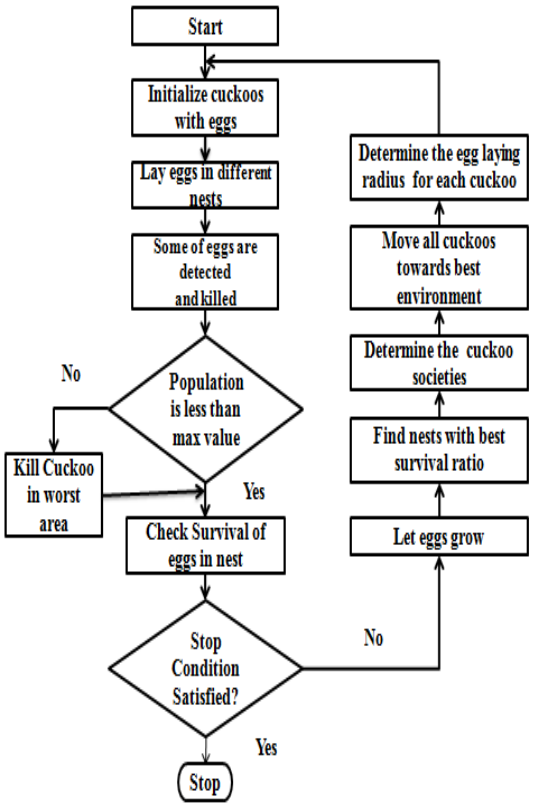

Figure 1 Flow chart of Cuckoo search

The Pseudo-code of Cuckoo Search:
Begin
Objective function f(x), $x = (x_1, x_2, \ldots, x_d)^T$;
Generate initial population of n host nests $x_i (i = 1,2, \ldots n)$
While (t< Max Generation) or (stop criterion)
Get a cuckoo randomly by Levy Flights
Evaluate its fitness F_i
Choose a nest among n (say j) randomly
If ($F_i > F_j$)
Replace j by the new solution;
End If

A fraction (p_a) of worse nests is abandoned and new ones are built;
Keep the best solutions (or nest with quality solutions)
Rank the solution and find the solution and find the current best
End while
Post process results and visualization
End Begin

III. CUCKOO SEARCH ALGORITHM TYPES

The cuckoo search algorithm is also used to test functions of optimization benchmarks. The standard benchmark functions are developed to compare this cuckoo algorithm with the other algorithms [8]

Some types of cuckoo search algorithms are
An efficient cuckoo search algorithm for numerical function optimization[9]: Cuckoo search algorithm is metaheuristic algorithm, it is the best-known brood parasitic bird, the cuckoos have explained in obtaining the global solution for numerical optimization problems. Therefore, the involvement of fixed step comes in exploration and exploitation behavior might get slow down the search process considerably.

Multimodal Optimization [10]: In this, Numerical results are to show that the cuckoo search algorithm can successfully locate multiple solutions in both non-noise and additive white Gaussian noise is the relatively high degree of accuracy.

Cuckoo Search via Levy flights[1] :It is a new meta-heuristic algorithm for solving optimization algorithm, based on the obligate brood parasitic behavior of bird cuckoo species with the combination of Levy flight behavior of some birds and fruit flies.

This algorithm is used to test functions and then it compares with the other algorithms like genetic algorithm and particle swarm optimization. Many types of cuckoo search algorithm developed by the many researchers. In that the major types of cuckoo search are

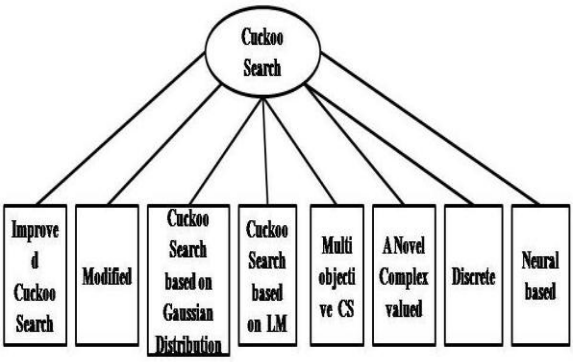

Figure 1: Types of Cuckoo Search

Hybrid Algorithms: Cuckoo search can find the better solutions and efficiently for the many continuous optimization problems. In some cases, the solutions cannot be found for some optimization problems.

So Hybridization is applied to optimization algorithms to find the solutions for a set of problems. The cuckoo search is hybridized with other optimization algorithms like heuristic, learning techniques, one rank CS are show in table 3.1

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

IV. SOLVING THE TSP WITH CS

This algorithm can be implemented in the Travelling Salesman problem. The Traveling Salesman Problem (TSP) is defined by N cities and distance matrix $D = d_{(i,j)N\times N}$ it gives distances between all cities. In TSP, the main object is to visit every city exactly once within minimum distance [20].

The tour can be as a cyclic permutation is $\pi = (\pi(1), \pi(2) \dots \pi(N))$ of cities from 1 to N if $\pi(i)$ is interpreted to the city visited in step $i, i = 1, \dots N$.
The cost of tour is defined as:

$$f(\pi) = \sum_{i}^{N-1} d_{\pi(i)\pi(i+1)} + d_{\pi(N)\pi(1)} \qquad (3)$$

Table: 3.1

Name	Author	Application	Reference
Hybrid CS	Li and Yin	For shop scheduling problems.	[11]
Improved CS for Global optimization	E.Valian et.al	To enhance the accuracy and convergence rate.	[12]
Modified-CS	Tuba,Walton et al.	For Unconstrained Optimization problems	[13][14]
Based on Levenberg-Marquardt (LM)	Nawi et al.	Helps in reducing errors and avoids local minima in an algorithm.	[15]
Multi objective CS	Yang and Deb	In Job Scheduling Problems	[16]
A Novel Complex value	Zhou and Zheng	Reducing the local convergence and Enhance the information of nests.	[17]
Discrete	Jati and Manurung	For solving traveling salesman problem.	[18]
Neural based	Khan and Sahai	Employee health and safety (HS) risk on employees at their workplaces,	[19]

If the distance satisfies $d_{i,j} = d_{j,i}$ for $1 \le i, j \le N$, it is the symmetric TSP. The vertices of the graph are cities and the graph edges are connections between cities. An optimal TSP tour is a path through an undirected graph which visits each vertex exactly once. The main aim of adapting CS to TSP is the process of applying general principles of the results obtained in special cases. The main elements in this are an egg, nest, levy flights, object function, search space. The worse nest or abandoned is the route with max length is worse route and that route is abandoned and builds a new route with min distance. This new route is replaced by the old route. In this, the fitness is the best route. CS gives good solutions by using local search in areas specified by Levy flights. Improved CS and local search constitute a single entity in finding solutions of good quality. CS and its inspiration sources can be defined in the following five terms: egg, nest, objective function, search space, and Levy flights. These key terms can have important meanings for combinatorial problems.

4.1 The Egg
An egg in a nest is a solution represented by one individual in the population, an egg of the cuckoos is a new solution for a location in the population. An egg is the equal of a Hamiltonian path. The direction of the tour is the salesman.

4.2 The Nest
The number of nests is static. A nest is an individual of the population and the number of nests is equal to the size of the population. A rid nest involves the replacement of an individual of the population by a new one.A nest can have multiple eggs, but for easy simplification, each nest contains only one egg.

4.3 Objective Function
In the traveling salesman problem, the quality of a solution is related to the distance of the Hamiltonian path. The best solution is the shortest Hamiltonian path.

4.4 Search Space
To change the location of a nest, change the actual values of its coordinates. The moving nests or locations of the nests do not impose real constraints. This is mostly in continuous optimization problems, it canbe considered as an advantage that reduces technical obstruction such as the representation of the coordinates in the solution space of TSP, for moving a solution from one neighborhood to another. The coordinates of cities are fixed coordinates of

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

the visited cities; hence the visiting order between the cities can be changed.

V. APPLICATIONS OF CUCKOO SEARCH ALGORITHM

One rank Cuckoo Search algorithm for solving Economic Load Dispatch problems:
Nguyen Thang Trung, Ngoc Dieu[21] proposed a paper on power generations to minimize the cost of flues. The problem is considered non-convex and piecewise quadratic fuel cost function of thermal units in the objective of the problem with complicated constraints such as prohibited operating zones (POZ) and power loss. CSA is used mainly for searches optimal solution based on random walks. One Rank Cuckoo Search algorithm is used i.e. Two modifications are done to the basic CSA method to enhance its search ability for an optimal solution within minimum time. The First modification is exploitation and exploration phase corresponding to the new solution via levy flight of new eggs is the replacement of egg. The second modification is the technique for handling the inequality constraints. i.e. The ORCSA was proposed by the Ahmed et.al 2013. In this, the input is in power with probability to generate in different values. This method obtains better cost with time when compared to other methods. It is a more efficient method for solving ELD.

The cost and vulnerabilities optimization in cloud using CS algorithm with Levy flights:
Cloud computing is using in various aspects. Mohamed, Zinedine proposed that when minimizing the cost and vulnerabilities resulting some risk and threats. So the set of techniques is used to minimize the number of vulnerabilities and security threats to the information system in the cloud. To minimize the risk of proxy attacks, maximizing the distance between the vulnerable node and a potential victim node is done.
h_j is host distance, n_j is network distance (distance between the node and the victim node which is outside the subnet).

$$\varepsilon = Max \sum_{j=1}^{n} (h_j + n_j) \qquad (4)$$

Cloud computing security frameworks are-Gathering information, Network mapping, vulnerabilities exploration, audits and penetration tests, vulnerabilities enumeration and categorization, technology selection for vulnerability remediation, security solutions implementation [22]. It is a non-deterministic polynomial-time hard (NP-Hard). It can be solved with a heuristic approach. Cuckoo Search algorithm with Levy flights is the best algorithm to solve the problems because CS is reliable and gives better solutions when compared to the other algorithms.
The security technology is used to decrease the vulnerability and costs are called Set covering problem (SCP). This problem is combinatorial optimization problem.

A Novel Cuckoo Search Optimization Algorithm based on Gauss Distribution:
"A meta-heuristic is a concept which is used to define heuristic methods that are applied to a wide set of different problems[23]. Levy flights are random steps.

$$X_i(t+1)=X_i(t) + \alpha \oplus \text{Levy}(\lambda) \qquad (5)$$

In this the consecutive steps of the cuckoo from a random walk process to obey a power law step length distribution. For each random variable, a probability density function is used to express its probability distribution [24]. Example, the number of phone calls per minute, and the number of users of a web server per day all obey the Poisson distribution.

$$p(n, \lambda) = \frac{\lambda^n e^{-\lambda}}{n!}, (n = 0,1,2 \ldots .) (6)$$

$\lambda > 0$it is the mean or expectation of the occurrence of the event during a unit interval.
Gaussian distribution the most popular distributions, because many physical variables including light intensity, and errors/uncertainty in measurements, and many other processes obey the normal distribution.

$$X_i(t+1)=X_i(t) + \alpha \oplus \sigma_s \qquad (7)$$
$$\sigma_s = \sigma_0 \, exp(-\mu k)$$

$\sigma_0$andμ are constants, k is current generation, $\alpha > 0$. Replace the equation 3 with equation 5. It is used to solve the standard test functions and engineering design optimization problems.

Adaptive Cuckoo Search for Optimal Network Reconfiguration and Distributed generation:
To optimize the network topology and placement of distribution generation (DG) in Distribution networks to reduce the power loss and energy loss voltage stability enhancement. Duong Quoc Hunga, N. Mithulananthana, R.C. Bansa proposed [25] that is the Distribution systems will have more power loss and poor voltage regulation and voltage stability;
This is the main problem in distribution systems. Some researchers have proposed both Distribution network reconfiguration (DNR) and DG to improve the distribution network[26]. Adaptive cuckoo search is used for the DN Rconsiderations of DG. It is normally from small scaleto the large scale distribution networks. Teaching-learning-based CS algorithm in Structure designing and machining processes: Huang and Gao proposed Optimization in Structural designing and machining process [27]. In the designing process, the quality of the product is very important. To get the highly quality of the product the optimization process is used. In this, 'Teaching-learning-based optimization (TLBO) is used. It is a hybrid

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

algorithm. The TLBO is proposed by (Rao et al. 2011a; Rao et al. 2012), for continuous optimization problems. The main use of this algorithm is to improve the local search ability. The TLBO is used to searches for an optimum by each learner trying to achieve the experience of the teacher, which is treated as the most learned person in the society. The Teaching-Learning process is like the teacher and learner process in the classroom. It consists teaching phase and learning phase. The "Teacher phase" means learning from the teacher and the "Learner phase" in this, the learners learns through the interaction among them [28]·The important parameters are a number of design variables (D_n), discovering probability(p_a), and size(P_n). The solutions should be updated for better results. The worse solutions are replaced by the new updated solutions. This algorithm is used in the design of vehicles (eg: size of car), milling process etc.

Cuckoo Search for Secured Vehicular Adhoc Network (VANET)

The number of protocols is used to achieve the secure information broadcasting in VANET. VANET is an intelligent transport system (ITS). It provides communication between the vehicles to vehicle or vehicle to infrastructure. Dr. B. Ramakrishna et.al[29] proposed an Adaptive Routing Protocol based on Cuckoo Search (ARPCS) i.e. the combination of topology based routing protocol and geographic based routing protocol. If the network density is high then the topology routing based approach is applied, if the network dense is low then the geographically based routing approach is applied. It can overcome the drawbacks of topology based routing protocol and geographic routing protocol. ARPCS provides reliable and reduces the congestion in the network and improves the delivery of the packet. The drawback of geographic routing protocols is created loops in maintaining routes and discovering routes due to vehicle mobility. Therefore it loses its memory of past traffic history, so it cannot discover the new routes. The drawback of topology based routing protocols is route instability because of high vehicle mobility it brakes route frequently between the source and destination. To reduce the overhead in routing, the ARPCS diffuses the transmitted packets in a stochastic manner. At the same time, to send the packets in multiple paths to reduce the delay time and overhead in routing between the source and destination. In VANETS, the node position, topology details and the route between the source and destination are stored in the routing table and it updated dynamically when the route changed.

Cuckoo Search Algorithm for Antenna Arrays:

Cuckoo search is also used in electromagnetic and antenna arrays. Khairu lNajmy Abdul Rani[30] proposed to obtain the desire beam pattern by suppression of side lobes in the pattern by applying cuckoo search algorithm. The conical antenna array is useful in satellite communications, submarine and point-to-point communications etc. CS can be used to reduce the parameters or elements in the antenna array like relative current and phase of elements and interspacing elements. The main aim is to suppress the side lobes and the null control in certain directions in the radiation pattern (Radiation pattern of the antenna is the distribution of power outflow of power from the antenna and in the flow of power to the antenna). In the wireless application the antenna pattern is designed as a strong beam towards the arrive signal and to rescind the interfering signals, these antennas are called as smart antennas. There are many techniques applied to suppress the sidelobe but null control is to lessen the effect of undesired interference in the signal. When the 2N isotropic radiators are placed along the x-axis then array factor in the azimuth plane is,

$$AF(\emptyset) = 2\sum_{n=1}^{N} I_n \cos\left[kx_n \cos(\emptyset + \varphi_n)\right] \quad (8)$$

Where $k = 2\,{}^{\pi}/_{\lambda}$ is wave number

$I_n, \varphi_n, \text{and} x_n$, are excitation amplitude, phase, location of n^{th} element respectively.

Cuckoo search algorithm for feature selection:

A Feature or variable or attribute refers to elements of data. Feature selection is data pre-processing technique used in the classification of IDS[25]. It is used to remove the unnecessary, redundant attributes from the given datasets. It improves accuracy and decreases training time.

The main aim is maximizing the classification performance and minimizes the number of features. The feature selection can be done with BCS (Binary Cuckoo Search Algorithm), the problem is which features to select, or which features are not to select in a given problem, to solve this the binary vector is used i.e. where 1 is either to select the feature for a given data and 0 is nor to select. To employ this binary, vector the equation (10) provides binary values.

$$S\left(x_i^j(t)\right) = \frac{1}{1 + e^{-x_i^j(t)}} \quad (9)$$

$$x_i^j(t+1) = \begin{cases} 1 & \text{If } S\left(x_i^j(t)\right) > \sigma \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

Where $\sigma \sim U(0,1)$ and $x_i^j(t)$ denotes the new egg's value at step t.

Now the feature selection is using in IDS (Intrusion Detection System) by using cuckoo search algorithm. The intrusion detection is a type of security management system for computer or networks. ID collects the information from various areas in the computer to accredit security contravention which attack may be from outside of the organization and misuse attack i.e. from the inside of the organization. ID uses vulnerability assessment i.e. detecting the confidential resource and attacks the

computer or network. For example, the car can be protected from theft by lock system if the theft tries to break the lock and steal the car it is burglar alarm that detects the car lock is broken and alerts the owner by an alarm.

So here the firewall protects the organization from malicious attacks from the internet and IDS detects that someone is trying to break through the firewall then it alerts the system organization if there is vulnerability in security.

They are different attacks like DoS attack (Denial of Service Attack), Scanning attack, and also protocol attacks or network attacks. In this the feature selection is based on Cuckoo search algorithm, the KDD-NSL dataset is employed for implementing this approach.

CONCLUSION

CS is the best search algorithm that it inspired by the breeding behavior of cuckoos. It gives the brief description of the applications of the nature-inspired algorithm. CS algorithm is in various domains including Industry, Image processing, wireless sensor networks, flood forecasting, document clustering, speaker recognition, shortest path in distributed system, in the health sector, job scheduling.

The Cuckoo algorithm performs various nature-inspired algorithms in terms of improved performance and less computational time.

REFERENCES

[1] Xin She Yang and Sush Deb, "Nature & Biologically Inspired Computing," in IEEE, University of Cambridge, Trumpinton Street, CB2 1PZ, UK, 2010.
[2] Ravi Kiran Varma P, Valli Kumari V, and Srinivas Kumar S, "A novel intelligent attribute reduction technique based on Ant Colony Optimization," International Journal of Intelligent Systems Technologies and Applicaitons, vol. 1, no. 1, pp. 23-45, 2015.
[3] Ravi Kiran Varma P, Valli Kumari V, and Srinivas Kumar S, "Feature selection using relative fuzzy entropy and ant colony optimization applied to real-time intrusion detection system," Procedia Computer Science, vol. 85, no. 2016, pp. 503-510, 2016.
[4] Ravi Kiran Varma P, Valli Kumari V, and Srinivas Kumar S, "Application of Rough Sets and Ant Colony Optimization in feature selection for Network Intrusion Detection," International Journal of Applied Engineering Research, vol. 10, no. 22, pp. 43156-43163, 2015.
[5] Ravi Kiran Varma P, Valli Kumari V, and Srinivas Kumar S, "Ant Colony Optimization Based Anomaly Mitigation Engine," Springerplus, vol. 5, no. 1, pp. 1-32, 2016.
[6] Xin-She Yang and Suash, ""Engineering optimisation by cuckoo search"," International Journal of Mathematical Modelling and Numerical Optimisation, vol. 1, no. 4, pp. 330-343, 2010.
[7] Xiin-She Yang and Deb, "Engineering Optimization By Cuckoo Search," J. Mathematical Modelling and Numerical Optimisation, vol. 1, no. 4, 2010.
[8] Xin She Yang and Suash, "A brief literature review: Cuckoo Search and Firefly Algorithm," Studies in Computational Intelligence, vol. 516, pp. 49-62, 2014.
[9] Pauline Ong and Zaritha Zainuddin, "An efficient cuckoo search algorithm for numerical function optimization.," in AIP Conference Proceedings, vol. 1522, 2013.
[10] Dusan Fister and Iztok Fister, "A Comprehensive Review of Cuckoo Search: Variants and Hybrids ," International Journal of Mathematical Modelling and Numerical Optimisation, vol. 4, no. 4, pp. 387-409, 2013.
[11] Xiangtao Li and Minghao Yin, "A hybrid cuckoo search via levy flights for the permutation flow shop scheduling problems.," International Journal of Production Research, vol. 51, no. 16, pp. 4732-4754, 2013.
[12] Valian.E and Mohanna.s, "Improved Cuckoo Search for Global Optimization," International Journal of Communications and Information Technology, vol. 1, no. 1, pp. 31-44, 2011.
[13] T.Milan and M. Subotic, "Modified CS algorithm for unconstrained optimization problem," in Proceedings of the 5th European conference, 2011.
[14] Walton.S, Hassan.O, Morgan.K, and Brown.M.R, "Modified Cuckoo Search:A new Gradient free Optimisation Algorithm.," Science Direct:Elsevier, vol. 44, no. 9, 2011.
[15] Nazri Mohd Nawi, Abdullah Khan, and Rehman Zubai Mohammadr, "A New Cuckoo Search based Levenberg-Marquardt (CSLM) Algorithm.," Computational Science and Its applications, Springer, pp. 438-451, 2013.
[16] Xin-She.Yang and Suash, "Multiobjective Cuckoo Search for Design Optimization.," Computers & Operations Research, vol. 40, no. 6, 2013.
[17] Z Zheng Zhou Yongquan and Hongqing, "A novel complex valued cuckoo search algorithm.," The Scientific World Journal, 2013.
[18] PreetamDasgupta and SwagatamDa, "A DiscreteInter-SpeciesCuckooSearchfor flowshop scheduling problems," ScienceDirect, pp. 111-120, 2015.
[19] S.Sahai and K.Khaian Ashok, "Neural-based cuckoo search of employee health and safety," International Journal of Intelligent Systems and Applications, vol. 5, no. 2, 2013.
[20] Xin.Shi.Yang, A.Ouaarab, and B.Ahiod, "Discrete cuckoo search algorithm for the travelling salesman problem," 2014.
[21] Nguyen Thang Trung and Ngoc Dieu, "The application of one rank cuckoo search algorithm for solving Economic Load Dispatch," scienceDirect, 2015.
[22] Mhamed and Zineddine, "Vulnerabilities and mitigation techniques toning in the cloud," ScienceDirect-Computers and Security, vol. 48, 2014.
[23] ANDREA ROLI and BLUM CHRISTIAN, "Metaheuristics in Combinatorial Optimization: Overview and Conceptual Comparison," in ACM Computing Surveys, vol. 35, September 2003.
[24] Hongqing Zheng and Yongquan Zhou, "A Novel Cuckoo Search Optimization Algorithm based on Gauss Distribution," Journal of Computational Information Systems, vol. 8, no. 10, 2012.
[25] Quoc Hunga Duong, Mithulananthana N, and Ramesh Bansa, "An optimal investment planning framework for multiple distributedgeneration units in industrial distribution systems," UPSpace Institutional Repository-Department of Electrical, Electronic and Computer Engineering, vol. 62, no. 72, July 2014.
[26] Thuan Thanh Nguyen and Anh Viet Truong, "A Novel method basedon adaptive cuckoo search for optimal network reconfiguration and distribution generation allocation in distribution network.," Elsevier- Electrical Power and Energy Syestems, vol. 78, pp. 801-815, 2015.
[27] Jida Huang, Liang Gao, and Xinyu, "An effective teaching-learning-based cuckoo search algorithm forparameter optimization problems in structure designing andmachining processes.," Elsevier-Applied Soft Computing, vol. 36, 2015.
[28] Rao and Venkata.R, "Review of applications of TLBO algorithm and a tutorial for beginners to solve the unconstrained and constrained optimization problems.," Springer International Publishing, Switzerland., vol. 5, no. 1, pp. 1-30, 2016.
[29] Dr.B.Ramakrishnan and R.Sreedivya, "Adaptive Routing Protocol based on Cuckoo Search algorithm (ARP-CS) for secured Vehicular Ad hoc network (VANET)," International Journal of Computer Networks and Applications (IJCNA), vol. 2, no. 4, 2015.
[30] Khairul Najmy ABDUL RANI and Mohd. Fareq ABD MALEK, "Nature-inspired Cuckoo Search Algorithm for Side Lobe Suppression in a Symmetric Linear Antenna Array ," RADIOENGINEERING, vol. 21, no. 3, 2012.

[31] Milan Tuba, Milos Subotic and Nadezda Stanarevic, "Modified CS algorithm for unconstrained optimization problems," in Proceedings of the 5th European conference, 2011.
[32] Sanket Kamat and Asha Gowda Karegowda, "A Brief Survey on Cuckoo Search Applications," International Journal of Innovative Research in Computer and Communication Engineering, vol. 2, no. 2, May 2014.
[33] Kullawat Chaowanawatee and Apichat Heednacram, ""Implementation Of Cuckoo Search In RBF Neural Network For Flood Forecasting"," IEEE Computational Intelligence, Communication Systems and Networks (CICSyN), no. 978-1-4673-2640-7, pp. 22-26, July 2012.
[34] Xin-She.Yang, Naturae-Inspired Metaheuristic Algorithm. University of Cambridge, United Kingdom: LUNIVER Press, 2010.
[35] Athanasios Papadopoulos and Konstantinos Toumpas, "Exploring Optimization Strategies in Board Game Abalone for Alpha-Beta Search," in IEEE Conference on Computational Intelligence and Games, 2012.
[36] Marco Dorigo, G.D.Caro, and L.M.Gambardella, "Ant Algorithms for Discrete Optimization," Massachusetts Institute of Technology, vol. 5, 1999.
[37] Marco Dorigo and Thomas Stutzle, Ant Colony Optimization Algorithm:Introduction. London, England: Massachusetts Institute of Technology Press, 2004.
[38] H.Christos and S. Kenneth, "Combinatorial Optimization Algorithms," in Dover Publications, University of California-Berkeley, 1998.
[39] P Ravi Kiran Varma and V Valli Kumari, "Feature Optimization and Performance Improvement of a Multiclass Intrusion Detection System Using PCA and ANN," International Journal of Computer Applications, vol. 44, no. 13, pp. 4-9, 2012.