



# A Brief Survey on Cuckoo Search Applications

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**ABSTRACT:** Cuckoo Search (CS) is heuristic search algorithm which is inspired by the reproduction strategy of cuckoos. This paper investigates the applications of Cuckoo algorithm in various domains. The applications of Cuckoo includes optimizing weights of neural networks, parameters of Support vector machines and Radial basis function, job scheduling, finding optimal cluster head in wireless sensor networks, finding shortest path and clustering. The paper also describes the improved version of CS algorithm namely: Binary CS, Modified CS and Improved CS.

**KEYWORDS:** Cuckoo Search, Levy flights, Modified Cuckoo Search, K-means, Classification, Feature Selection.

## I. INTRODUCTION

Nature inspired computation techniques are those computing techniques that are derived from the study of natural system. Candidate solutions to the optimization problem play the role of individuals in a population, and the fitness function determines the quality of the solutions [1]. The commonly used nature inspired algorithms are Genetic algorithm, Firefly, Artificial bee colony, Ant colony optimization, CS, Particle swarm optimization, Bat, Cat, Dolphins, Elephant and many more. This paper briefs about the CS algorithm and its applications in the various domains. Section II describes the working of original cuckoo algorithm and variations of Cuckoo algorithm. Section III briefs about the applications of Cuckoo algorithm in various domain followed by conclusion in Section IV.

## II. CUCKOO SEARCH ALGORITHM

CS algorithm is based on the obligate brood parasitic behaviour of some cuckoo species in combination with the Levy flight behaviour of some birds and fruit flies. Some species of Cuckoo birds lay their eggs in communal nests. If a host bird discovers the eggs are not their own, they will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. CS, can be described using following three idealized rules:

- Each cuckoo lays one egg at a time, and dump its egg in randomly chosen nest;
- The best nests with high quality of eggs will carry over to the next generations;
- The number of available host nests is fixed, and the egg laid by a cuckoo is discovered by the host birth a probability  $p_a \in [0, 1]$ .

Generalized Pseudo code of the Cuckoo Search (CS):

**begin**

Objective function  $f(X)$ ,  $X = (x_1, \dots, x_d)^T$

Generate initial population of

$n$  host nests  $X_i$  ( $i = 1, 2, \dots, n$ )

**while** ( $t < \text{MaxGeneration}$ ) or (stop criterion)

Get a cuckoo randomly by Levy flights

evaluate its quality/fitness  $F_i$

Choose a nest among  $n$  (say,  $j$ ) randomly

**if** ( $F_i > F_j$ ),

replace  $j$  by the new solution;

**end**

A fraction ( $p_a$ ) of worse nests

are abandoned and new ones are built;

Keep the best solutions



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(or nests with quality solutions);  
Rank the solutions and find the current best  
end while  
Postprocess results and visualization  
end
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Variations of Cuckoo Search:

Three variation of CS are briefed below:

A. *Modified Cuckoo Search (MCS)* [16]:

The modifications were made, with the goal of speeding up the convergence and hence, reducing the number of objective function evaluations required to find the global minimum. In the CS,  $\alpha$  is constant and typically the value  $\alpha = 1$  is employed. In MCS, the value of  $\alpha$  was made to decrease as the number of generations increased. An initial value of the Levy flight coefficient  $\alpha = A = 1$  was selected and, at each generation, a new value is calculated using  $\alpha = A / \sqrt{G}$ , where  $G$  is the generation number. This exploratory search is only performed on those nests that are to be abandoned. The unmodified CS algorithm could be considered as a series of independent Levy flights, where the ineffective flights are reset each generation. The missing ingredient was crossover between the solutions. The second modification included the crossover concept.

B. *Binary Cuckoo Search (BCS)* [17]:

A binary version of the CS for feature selection purposes called BCS, in which the search space is modeled as a d-cube, where d stands for the number of features. The main idea is to associate for each nest a set of binary coordinates that denote whether a feature will belong to the final set of features or not, and the function to be maximized is the one given by a supervised classifier's accuracy.

C. *Improved Cuckoo Search (ICS)* [15]:

The traditional CS algorithm uses fixed value for both  $p_a$  and  $\alpha$ . These values are set in the initialization step and cannot be altered during new generations. The main drawback of this method appears in the number of iterations to find an optimal solution. If the value of  $p_a$  is small and the value of  $\alpha$  is large, the performance of the algorithm will be poor and leads to significant augment in number of iterations. If the value of  $p_a$  is large and the value of  $\alpha$  is small, the speed of convergence is high but it may be unable to find the best solutions. The key difference between the ICS and CS is in the way of adjusting  $p_a$  and  $\alpha$ . To improve the performance of the CS algorithm and eradicate the drawbacks lies with fixed values of  $p_a$  and  $\alpha$ , the ICS algorithm uses variables  $p_a$  and  $\alpha$ . In the early generations, the values of  $p_a$  and  $\alpha$  must be big enough to enforce the algorithm to increase the diversity of solution vectors. However, these values should be decreased in final generations to result in a better fine-tuning of solution vectors. The values of  $p_a$  and  $\alpha$  are dynamically changed with the number of generation.

### III. APPLICATIONS OF CUCKOO SEARCH

CS has been applied as optimization algorithm for various tasks including finding optimal features, optimizing the parameters of various classifiers including Neural Network, RBF, SVM parameters, finding optimizing cluster centers, job scheduling, find optimal path and many more in the different domains including industry, health sector, wireless sensor network, image processing. The applications of Cuckoo in the various domains are briefed below.

Davar et.al [2] have modified cuckoo to optimize two parameters namely  $C$  and  $\gamma$  for SVM and have applied it for diabetic data set. They have used Feature Weighted Support Vector Machines (FW-SVMs) and Modified CS (MCS). First the Diabetes data is collected and Principal Component Analysis (PCA) is applied as a feature selection strategy. PCA reduces the dimension of Diabetes disease dataset from 8 to 4 features. Consequently, only 4 features in training and testing is used. Choosing two parameters  $C$  (Cost of the Penalty) and  $\gamma$  (Gamma) is very important in using SVMs. In this model a three-stage method for classification of the Diabetes diseases. At first, PCA is applied to scrap the redundant and irrelevant features. Then, Mutual Information (MI) is used to calculate the consequent weight for each feature. Finally, MCS finds the best values for SVM parameters to classify the Diabetes diseases. Finally SVM is used



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with Radial Basis Function (RBF) kernel function to detect diabetes disease. They have adopted 10-fold cross validation on UCI Diabetes diseases dataset. The MI-MCS-SVM is able to achieve higher classification rate when compared to popular models like LS-SVM, PCA-LS-SVM, PCA-MI-LS-SVM and it obtains 93.58% accuracy along with significantly speeding up the classification procedure.

Diabetic Retinopathy (DR) is a severe disease involving damage to the small blood vessels in the retina; results from chronically high blood glucose levels in people with poorly controlled diabetes. Exudates is a mass of cells and fluid that has seeped out of blood vessel. So Srishti et.al [3] proposed a method detect exudates in diabetic retinopathy using multilevel thresholding. DR damages small blood vessels in the retina which may cause loss of vision. Images can be segmented by means of threshold selection as exudates and non exudates. Here CS is applied for edge detection and the steps are: Initialization of population, Generate solution via Levy's flight and when average fitness is obtained CS stops and gives output in the form of threshold values. The accuracy results of Otsu's, Kapur's and CS method are found to be 96.4%, 3% and 98.4% respectively.

Laser cutting is one of the most extensively used non-conventional material removal process for contour cutting of wide variety of materials. Miloš MADIĆ et.al [4] found that neural network can be used effectively to model the process parameters relationships and hence make accurate predictions of surface roughness obtained in laser cutting. Integrating neural networks and CS algorithm offers a simple and effective method for searching of the optimal process parameter settings in laser cutting. As an experimental set up, CO<sub>2</sub> laser cutting of AISI 304 stainless steel by considering laser power, cutting speed, assist gas pressure, and focus position as input model parameter was developed. And it is identified that CS was successful in giving optimal parameters and got an accuracy of 90.44%.

Thresholding is one of the simplest techniques for performing image segmentation that has many applications in image processing, including segmentation, classification, clustering and object discrimination. The drawback of the conventional multilevel thresholding methods is high computational cost since they do exhaustive search among exponentially growing number of possible thresholds to optimize the objective functions. Ivona et.al [5] have proposed CS algorithm for multilevel thresholds selection using the maximum entropy criterion. The optimal thresholds provided by CS Algorithm are compared with those of PSO and Kapur's thresholding function. Experiments have been conducted for four types of image datasets: House, Barbara, Boats and Living room. CS outperforms PSO in terms of both time and multilevel thresholding solution.

A computational Grid is a hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities. Grid computing is effective only when we schedule the resources optimally. The problems in grid scheduling are difficult to find the completion time of the job, resource allocation and job scheduling, resource management and fault tolerance, load balancing, considering both user and application requirement. Resources can be computers, storage space, instruments, software applications, and data, all connected through the Internet. M. Prakash et.al [6] have proposed a method to schedule the resources optimally using CS. Cuckoo optimization approach selects the optimal resource from the set of available resources. This system allocates the job optimally by considering the deadline requirement of the users and also the minimal execution time using CS Algorithm.

Sensor node in Wireless Sensor Networks (WSNs) is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. Energy is the major issue for these nodes as these nodes usually deployed in the remote areas. Manian Dhivya et.al [7] have applied CS for finding the energy efficient cluster head selection and formation of clusters among the Sensor nodes. This paper proposes a new optimization based data collection scheme incorporating CS and Generalized Particle Model Algorithm (GPMA) and is stated as Cuckoo Based Particle Approach (CBPA). Nodes are deployed randomly and organized as static clusters by CS. Once the cluster heads are selected, the information is collected, aggregated and forwarded to the base station using generalized particle approach algorithm. The GPMA transforms the network energy consumption problem into dynamics and kinematics of numerous particles in a force-field. The proposed approach can significantly lengthen



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the network lifetime when compared to traditional methods namely: Low Energy Adaptive Clustering Hierarchy (LEACH) and Hybrid Energy Efficient Distributed clustering (HEED).

There is little empirical evidence of the influence of design and workstation aesthetics on employees and the distance between health and safety (HS), psychological factors, and the architectural design process can be considerable. HS complaints have also been found to be associated with psychosocial factors at work. For big sized companies with a lot of office workstations it is difficult to study all of the employees. There is a need of an approach for systematic HS employee risk assessment of whole companies and identification of employees with extreme HS risk for immediate attention. Koffka Khan et.al [8] collected data for HS risk on employees at their workplaces, analyzed the data and proposed corrective measures applying this methodology. For the calculation of an HS risk index employed a neural-swarm CS (NSCS) algorithm. The calculation of individual employee HS risk indices HSs based of these weights enables the classification of employees into four categories: low, medium, high and extreme HS risk levels. Employees with extreme and high indices are immediately attended to by the purchasing of re-arrangement of equipment at their workstation.

Automatic clustering of unstructured documents has become an essentially indispensable task, especially when dealing with the increasing electronic documents is a serious issue. K-means is one of the most popular unsupervised clustering algorithms, though the quality of its results relies heavily on the number of clusters chosen and the right selection of the initial cluster centroids. Walid Mohamed Aly et.al [9] have adapted CS so that it can be applied efficiently to documents clustering problem. In this model two phases are presented. Experiments have been carried out on standard unstructured documents: Corpus of Contemporary Arabic (CCA) and results are compared with the K-means (with k value = 3,4,5). CS uses dynamic nests so that different values for the number of clusters can be explored; these nests are initialized with different corresponding Forgry selection of initial centroids. K-means clustering algorithm gave a purity of 0.810 when compared to CS which resulted in purity of 0.874. The obtained results revealed that the proposed approach has a good performance and reached higher value of clustering purity when compared with classical k-means clustering algorithm. In addition Moe Moe Zaw et.al [10] have applied CS Optimization algorithm in web document clustering area to locate the optimal centroids of the cluster and to find global solution of the clustering algorithm. The algorithm is tested on 7 sector benchmark data set by using Cosine Similarity as distance similarity measure of the two documents. Performance is measured using Precision, Recall and F – measure.

A method to forecast flood accurately and timely is important. Here a method based on Radial Basis Function (RBF) neural network has been applied for flood water level forecasting. The traditional way of training of the neural network may drive the network to converge in local minima instead of global minimum. So Kullawat Chaowanawatee et.al [11] have applied CS to train parameters of RBF neural network instead of a normal back propagation. The problem lies on that training with the back propagation sometimes drive the network to converge in local minima instead of global minimum. In RBF neural network, the parameters, centers ( $c_i$ ) and weights ( $w_i$ ), are trained using CS via Levy flights. Experiments are conducted on the dataset of Little Wabash River of United States. This new method with Polyharmonic function outperformed the normal method. The experimental results also showed that the errors between the forecast and the actual values are acceptable for the application that requires an initial approximation to support a decision making.

Biometrics is used to identify an individual as per their some special characteristics as finger print, voice, iris, handwriting, typing speed. Monica Sood et.al [12] have applied CS for Speaker Recognition systems and voice. The process of Speaker Recognition is optimized by a fitness function by matching of voices being done on only the extracted optimized features produced by the CS algorithm. Here voices are classified to recognize the particular voice belongs to the person by short listening the feature from voice. Initially Speaker speaks and his voice is recorded for either feature matching or feature selection. Then CS works on only the best feature to extract the feature from the voice. Now these extracted features will be matched with the inputted voice's features. For matching purpose, Correlation has been used. The extracted features closest to the stored features will be the one that will be matched.



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Based on this the decision is taken, if the features are matched then the speaker will be authenticated else will be rejected.

K-means clustering algorithm performance depends to a great extent on the initial values of the starting centroids randomly generated each time the algorithm is run. It is known that K-means can easily fall into local optima that do not produce the best clustering results. A number of bio-inspired optimization methods have recently emerged with designs imitating swarm behaviour among groups. Intuitively, bio-inspired optimization algorithms should overcome the limitations of K-means clustering algorithm in finding globally optimum clusters. This integration is significant, because it will serve as a successful pioneer exemplar for the future development of hybrid bio-inspired data mining algorithms. Rui Tang et.al [13] have optimized K-means algorithm using CS algorithm. Performance of the CS with K-means it is applied on the popular datasets namely Iris, Wine, Libras, Haberman's, Synthetic and mouse. The results of K-means clustering are compared with Ant, Firefly, Bat, Wolf and Cuckoo. CS outperformed K-means with an average time of 18.75 seconds compared to the K-mean's 75.73 seconds.

In distributed system, user give some task to the server and the server processes and give it back to the user. But the problem is that there will be many servers and it will be difficult to locate the best possible server. So the concept of mobile agent comes into the picture. Whereas, mobile agent will act as an intermediary system between user and server. Mobile agent will carry job of user and then move around the network of servers to find a suitable location to process the job. While mobile agent migrates from one server to another, user's job is paused and will be then resumed the process upon the next server. Here path finding for the mobile agent is the difficult job. Akajit Saelim et.al [14] have applied Modified CS for solving mobile agent migration problem. Mobile agent migration planning problem is the finding path problem of graph theory same as the Travelling Salesman Problem. Hence, data sets from travelling salesman problem are used rather than actual network data namely: 7 data sets p01 (15 nodes), gr17 (17 nodes), fri26 (26 nodes), dantzig42 (42 nodes), eil51 (51 nodes), eil76 (76 nodes), and rat99 (99 nodes). They have compared MCS method with the former proposed method (FOR), original CS Algorithm (CS) and Ant Colony System (ACS). Performance was measured using path length and accuracy. Experimental results prove that shorter path length and improved accuracy when compared to the above methods for most of the data sets.

Ehsan et.al [15] have proposed the Improved Cuckoo Search (ICS) for optimizing the network weights to enhance accuracy and convergence rate of the CS. ICS is described in section I. To test the improvement of ICS over CS, experiments are conducted using Iris and breast cancer data sets. The average classification accuracy for CS and ICS for Iris data set is found to be 92.14% and 94.10% respectively. For breast cancer dataset the average classification accuracy of CS and ICS is found to be 96.91% and 96.98% respectively.

Sean P. Walton [16] proposed Modified Cuckoo Search (MCS), which is a powerful gradient free optimization algorithm. MCS is a fast optimization algorithm in terms of number of objective function evaluations required to reach a solution. It is also able to handle functions which are non-smooth, multimodal and have many dimensions. MCS is described in section I. This new modified version is tested on two applications namely aerodynamic shape optimization and mesh optimization. This method showed good results as well as the reduced CPU time required to find the solution. In particular the modified CS shows a high convergence rate to the true global minimum even at high numbers of dimensions.

D.Rodrigues et.al [17] have proposed new feature selection called Binary CS Feature selection(BCS) to find the most discriminative set of features. BSC is described in section I. The experiments were carried out in the context of theft detection in power distribution systems in two datasets commercial and industrial obtained from a Brazilian electrical power company, and have demonstrated the robustness of the proposed technique against with several others nature-inspired optimization techniques like Binary Bat Algorithm, Binary Firefly Algorithm , Binary Gravitational Search Algorithm and the Binary Particle Swarm Optimization. Performance is measured in terms of Time and accuracy. The BCS resulted in the same classification accuracy when compared to other methods but in reduced time.



### III. CONCLUSION

CS is a powerful search algorithm that it inspired by the breeding behaviour of cuckoos. This paper gives the brief description of the applications of one of nature inspired algorithm – CS algorithm in the various domains including Industry, Image processing, wireless sensor networks, flood forecasting, document clustering, speaker recognition, shortest path in distributed system, classification task in health sector, job scheduling. The survey reveals that Cuckoo algorithm outperforms various nature inspired algorithm in terms of improved performance and less computational time.

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TABLE I  
APPLICATIONS OF CUCKOO SEARCH IN VARIOUS DOMAINS

Authors	Method	Comparison	Task of Cuckoo Search	Applications of Cuckoo Search
Davar Giveki et.al [2]	Modified Cuckoo Search With SVM	-	Optimizing SVM Parameters $C$ (Cost Of The Penalty) And $\Gamma$ (Gamma)	Classification of diabetic data sets
Srishti [3]	Cuckoo Search	Otsu And Kapur's Method	Edge Detection	Exudate detection in diabetic retinopathy
Miloš MADIĆ et.al [4]	Cuckoo Search With Artificial Neural Networks	-	Surface Roughness Optimization In $CO_2$ Laser Cutting	Laser cutting AISI 304 stainless steel
Ivona et.al [5]	Cuckoo Search	Particle Swarm Optimization	Multilevel Image Thresholding Selection	Segmentation of images: House , Barbara, Boats and Living room
M. Prakash et.al [6]	Cuckoo Search	-	Optimizing Job Scheduling	Job Scheduling for Grid Computing
Manian Dhivya et.al [7]	Cuckoo Search And PSO – CBPA	LEACH And HEED	Optimizing Sensor Node Energy	Searching cluster head and formation of clusters in WSN
Koffka Khan et.al [8]	Cuckoo Search With Neural Network – NSCS	-	Optimizing Neural Network Weights	Compute Health and Safety risk index for employees using NSCS
Walid Mohamed Aly et.al [9]	Cuckoo Search With Varying Size Of Nests	K-Means	Selection Of Optimal Initial Cluster Centroids	Clustering Documents: Corpus of Contemporary Arabic (CCA) document
Moe Moe Zaw et.al [10]	Cuckoo Search	-	Document Clustering	Web Document Clustering: 7 sector benchmark data set
Kullawat Chaowanawatee et.al [11]	Cuckoo Search And Radial Basis Function NN	-	Optimize RBF Parameters Centers ( $C_i$ ) And Weights ( $W_i$ )	Flood forecasting on Little Wabash River of United States data sets
Monica Sood et.al [12]	Cuckoo Search	-	Feature Selection	Speaker recognition using significant features
Rui Tang et.al [13]	K-Means And Cuckoo Search	K-Means	Optimize K-Means	Clustering
Akajit Saelim et.al[14]	Modified Cuckoo Search	Cuckoo Search Algorithm, Former Proposed Method (FOR) And Ant Colony System (ACS).	Optimizing Path	To locate the best possible server in distributed systems
Ehsan et.al [15]	Improved Cuckoo Search With Feed Forward Neural Network	Cuckoo Search	Optimize Network Weights And Convergence Rate Of Cuckoo Search	Classification of Iris and breast cancer data sets
Sean P. Walton [16]	Modified Cuckoo Search	-	Optimization Of Functions	Applied to aerodynamic shape optimization and mesh optimization
D. Rodrigues et.al [17]	Binary Cuckoo Search	Binary Bat Alg., Binary Firefly Alg., Binary Gravitational Search Alg. And The Binary Particle Swarm Optimization	Feature Selection	Theft detection in power distribution systems for two datasets commercial and industrial obtained from a Brazilian electrical power company



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**BIOGRAPHY**



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