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A Brief Review of Cuckoo Search Algorithm (CSA) Research Progression from 2010 to 2013

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Abstract – *Cuckoo Search Algorithm is a new swarm intelligence algorithm which based on breeding behavior of the Cuckoo bird. This paper gives a brief insight of the advancement of the Cuckoo Search Algorithm from 2010 to 2013.*
The first half of this paper presents the publication trend of Cuckoo Search Algorithm. The remaining of this paper briefly explains the contribution of the individual publication related to Cuckoo Search Algorithm. It is believed that this paper will greatly benefit the reader who needs a bird-eyes view of the Cuckoo Search Algorithm's publications trend. ***Copyright © 2014 Praise Worthy Prize S.r.l. - All rights reserved.***

Keywords: *Cuckoo Search Algorithm, Publication Trend, Swarm Intelligence*

I. Introduction

Nowadays, Swarm Intelligence (SI) algorithms have become famous due to its simplicity. In fact, there are numerous SI algorithms that have become visible and often being applied in real world problems. Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Genetic Algorithm (GA) and Differential Evolution (DE) are few examples of the well-established SI algorithms [1].

On the other hand, Cuckoo Search Algorithm (CSA) is considered to be one of the latest SI algorithms [1]. It is based on breeding and Levy-flight based foraging behavior of the Cuckoo birds. Based on the finding of the original author, CSA is considered a superior algorithm which surpasses PSO and GA [2].

The publication papers include journals and conference proceedings are accumulated from well-established online databases like IEEE Explore, Scopus, ScienceDirect, Elsevier and Scientific.Net. The keyword "Cuckoo Search Algorithm" is used to search the papers. After collecting papers from the online databases, the process of elimination is done to get rid of unwanted and unrelated papers. Lastly, it only left with 71 papers related to CSA.

In these 71 papers, there are 27 papers brief about the modifications or hybridizations of CSA and the rest are application of original CSA. The papers are collected from 2010 to 2013.

Note that the analysis of the publications of CSA is based on the framework in [3].

Only information that tells the development of CSA that also includes the number of publications, year of publications, journal and countries' institutions are acquired through collecting and analyzing 71 papers related to CSA.

II. Format of Manuscript

II.1. Publication by Year

Fig. 1 indicates the number of publication of CSA on yearly basis from year 2010 to 2013. It is clearly seen that the number of publication increases in exponential order throughout the 4 years duration.

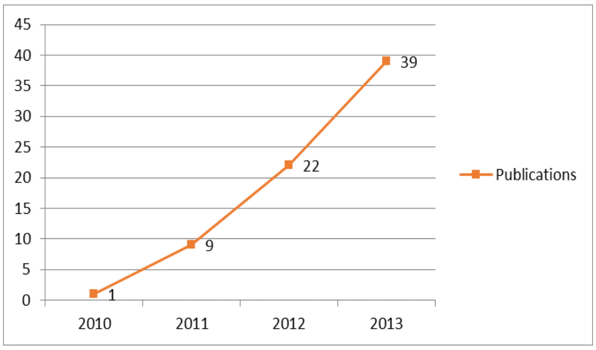

Fig. 1. Number of publications by year

II.2. Publication by Type of Publication

From the 71 papers, there are 43 journals and 28 conference proceedings. Table I shows the contribution of journals towards CSA publications. These are the few scientific journals that contributed the most; International Journal of Bio-Inspired Computation (3 papers), Journal of Applied Mathematics (3 papers), and Advances in Intelligent Systems and Computing (4 papers).

II.3. Publication by Country

Besides analysis of publications by year and type of publications, countries of publications are also recorded and the most notable publications comes from India

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which contributed 22% from the total publications of CSA. This follows by China (22.5%), Malaysia (11.2%) and United Kingdom (8.4%). Countries that contribute around 1% of the total publications are from United States, Sweden, Romania, Germany, Algeria, Mexico and Jordan. Table II shows number of publications and the percentage of publications of each country which involved.

TABLE I
JOURNALS/ PROCEEDINGS

No	Journals/ Proceedings	No of papers
1	Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology	1
2	Communications and Information Technologies:	1
3	Advances in Intelligent Systems and Computing	4
4	AIP Conference Proceedings	1
5	Applied Mathematics and Information Sciences	2
6	Journal of Beijing Jiaotong University	1
7	American Journal of Applied Sciences	1
8	Computers and Industrial Engineering	1
9	Engineering with Computers	1
10	Computers and Operations Research	1
11	Energy Education Science and Technology	1
12	Expert Systems with Applications	1
13	IET Microwaves, Antennas and Propagation	1
14	Power Engineering, Energy and Electrical Drives	1
15	Indian Journal of Science and Technology	1
16	International Journal of Advanced Manufacturing Technology	2
17	International Journal of Bio-Inspired Computation	3
18	International Review on Computers and Software	1
19	Journal of Applied Mathematics	3
20	Journal of Experimental and Theoretical Artificial Intelligence	1
21	Journal of Theoretical and Applied Information Technology	1
22	Journal of Theoretical and Applied Information Technology	2
23	Mechanism and Machine Theory	1
24	IEEE International Advance Computing Conference	1
25	International Conference on Advances	1
26	Research Journal of Applied Sciences, Engineering and Technology	1
27	Swarm and Evolutionary Computation	1
28	Structural Design of Tall and Special Buildings	2

TABLE II
COUNTRY OF ORIGINS

No.	Country	Number of Publications	Percentage
1	India	22	30.9
2	China	16	22.5
3	Malaysia	8	11.2
4	U.K	6	8.4
5	Iran	4	5.6
6	Thailand	4	5.6
7	Serbia	2	2.8
8	Turkey	2	2.8
9	USA	1	1.4
10	Sweden	1	1.4
11	Romania	1	1.4
12	Germany	1	1.4
13	Algeria	1	1.4
14	Mexico	1	1.4
15	Jordan	1	1.4

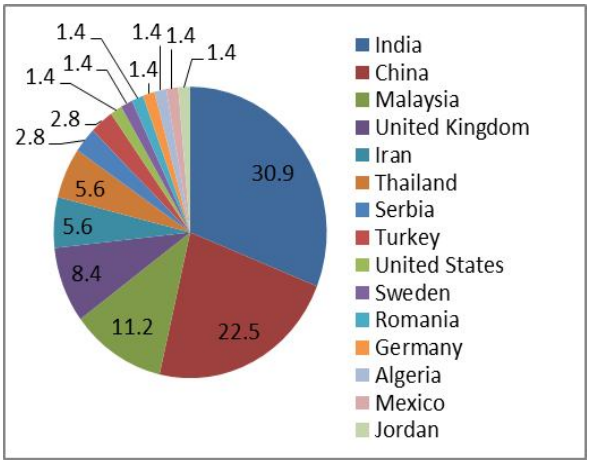

Fig. 2. Country of Publications

II.4. Publication by Type of Contribution

Most of the CSA publications can be divided into three main area of contributions: CSA modification, hybridization of CSA, and the application of the CSA.

Based on our findings, there are 14 papers related to CSA modification which majority shows improvement from the original CSA, 13 papers related to the hybridization of CSA with other optimization algorithms, and 66 papers including those of the CSA modification papers and CSA hybridization papers are related to the applications of CSA.

Modifications of CSA

The improvement of CSA has been growing from 2010. There are various enhancement done on CSA performance and Table III states the modification of CSA.

Hybridizations of CSA

There are many combinations or hybridization of CSA with other algorithms are also been introduced. These combinations have bought great advancement in term of performance: better fitness value or faster convergence rate, which outperforms CSA itself, PSO, GA, ACO and etc. The following Table IV shows the result of the combination of CSA.

Applications of CSA

The interests in exploiting CSA capabilities lead to the increase of application of CSA in various areas. The main areas are Computer Science, Mathematics, Energy, Engineering, etc. Table V shows the areas and applications of CSA.

III. Conclusion

In this paper, the development of CSA has been reviewed from 2010 to 2013. CSA is still considered as a new algorithm, but its growth is remarkable during these four year.

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TABLE III
CSA MODIFICATIONS

Author	Technique	Modification/Problem	Result	Ref.
Zhou, Y., Zheng, H., Luo, Q., Wu, J.	Improved CSA (ICSA)	Modification: Three strategies are introduced: walking one strategies, swap and inversion strategies and greedy strategies Problem: Solving planar graph coloring problem	ICS is more efficient and accurate than modified PSO towards graph coloring problem	[2]
Zheng, H., Luo, Q., Zhou, Y.	Cuckoo Search Algorithm and Simplex Method (SMCS)	Modification: Combination of excellence global finding capability of CS and excellence local finding capability and fast convergence of SM Problem: Improving converged speed and solution precision of cuckoo search algorithm	Calculation accuracy and convergence speed and performance of SMCS is better than CS	[4]
Zhang, Y., Wang, L., Wu, Q.	Modified Adaptive Cuckoo Search	Modification: MACS includes grouping, incentive, adaptive and information-sharing characteristic. Problem: Improving the strategies of formal descriptions	MACS outperforms basic CS algorithm in test problem	[5]
Zheng, H., Zhou, Y., He, S., Ouyang, X.	Discrete Cuckoo Search Algorithm	Modification: Discrete Binary Cuckoo Search (DBCS) is designed to meet the need of qualitative distinction between variables. Problem: Solving knapsack problem	DBCS perform better due to it has a better convergence speed and accuracy	[6]
Zhao, P., Li, H.	Opposition-Based Cuckoo Search Algorithm (OCS)	Modification: Combine the opposition-based learning into CS algorithm and the OCS algorithm for the benefit of best solution. Problem: Improving the searching of solution space in solving optimization problems	OCS shows its superiority in exploitation	[7]
Ouyang, X., Zhou, Y., Luo, Q., Chen, H.	Novel Discrete Cuckoo Search Algorithm	Modification: Discrete Cuckoo Search Algorithm generate a city number of every call. Problem: Solving spherical Traveling Salesman Problem which includes all points locate on the surface of the sphere		[8]
Yang, X.-S., Deb, S.	Multi-objective Cuckoo Search Algorithm (MOCS)	Modification: Cuckoo Search combines with mutation, crossover, Levy flight and selective elitism Problem: Solving multi objective optimization problems	Performance of the overall search moves of MOCS is more subtle compare to PSO	[9]
Abdul Rani, K.N., Hoon, W.F., Abd Malek, M.F., Mohd Affendi, N.A., Mohamed, L., Saudin, N., Ali, A., Neoh, S.C.	Modified Cuckoo search (MCS) algorithm	Modification: The MCS algorithm uses fitness to lead the Lévy flights in the process of finding the feasible nest (solution) in the N-dimensional space. Problem: Solving the synthesis of symmetric linear array geometry with minimum side lobe level (SLL) and nulls control	Performance of MCS algorithm excel Evolutionary Algorithm and originally Cuckoo Search Algorithm	[10]
Chaowanawatee, K., Heednacram, A.	Improved Cuckoo Search (ICS) algorithm	Modification: Gaussian distribution involves in producing a cuckoo egg Problem: Solving training network problem in the classical method	CSA via Gaussian distribution perform better in time taken and prediction error.	[11]
Saelim, A., Rasmequan, S., Kulkasem, P., Chinnasarn, K., Rodtook, A.	Modified Cuckoo search (MCS) algorithm	Modification: Cuckoo Search is altered in two ways; in finding new nest, random replacement replace Lévy fight algorithm and a context sensitive parameter replace a constant parameter Problem: Improving searching path for migration planning	MCS perform better than ACO and originally CSA	[12]
Tuba, M., Subotic, M., Stanarevic, N.	Modified Cuckoo search (MCS) algorithm	Modification: From the sorted section determines the step size, instead of permuted fitness matrix Problem: Solving unconstrained optimization problems	Performance of MCS is better compare to originally CSA	[13]
Layeb, A.	Novel Quantum Cuckoo Search	Modification: Cuckoo search Algorithm corporate with some of quantum computing principles Problem: Solving Knapsack problems	Ability of the novel quantum cuckoo search shows a good quality in obtaining solutions	[14]
Wang, L., Yang, S., Zhao, W.	Improved Cuckoo Search (ICS) Algorithm	Modification: CSA is improved by focusing on dynamic detection probability, step length and levy flight method Problem: Solving structure damage characteristics of bridge erecting machines	Improvement in convergence speed and global optimization capability and the accuracy in prediction	[15]
Walton, S., Hassan, O., Morgan, K.,Brown, M.R.	Modified Cuckoo Search (MCS) Algorithm	Modification: Modify best solution by adding addition information exchange between the top eggs Problem: Modify cuckoo search to improve its robustness	Performance of MCS is better compare CSA	[16]

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TABLE IV
CSA HYBRIDIZATIONS

Author	Technique/ Hybridization	Problem	Result	Ref.
Babukarthik, Raju, Dhavachelvan	Technique: ACO and CSA Hybridization: Combination of ACO and CSA	Solving job schedule problem	perform better in minimizing the implementation time in job schedule	[18]
Kanagaraj, Ponnambalam, Jawahar	Technique: CSA and GA Hybridization: Combination of CSA and GA	Reliability and redundancy allocation problem	Outperform PSO and ABC in searching the feasible solution	[17]
Karthikeyan & Venkatalakshmi	Technique: PSO and CSA Hybridization: PSO incorporated CSA	Solving the clustering to increase the Wireless Sensor Network's lifespan	Better performance of PSO and CSA in extending the lifespan of network by utilizing more in advanced nodes and also minimize the communication distance compare to GA	[19]
Chandrasekaran, K., Simon, S.P.	Technique: Fuzzy and CSA Hybridization: Binary coded CSA deals with economic dispatch problem (EDP) assisted by fuzzy which generates boundary variables.	Solving multi objective unit commitment problem (MOUCP)	The feasibility and performance of fuzzy and CSA outperform Hybrid GA and PSO	[20]
Srivastava, Khandelwal, Khandelwal, Kumar, Ranganatha	Technique: CSA and and Tabu mechanism Hybridization: Combination of the strength of CSA in converging and tabu mechanism in backtracking from Lévy flight.	Solving software testing to produce a feasible test cases	Perform better in producing optimal test cases compare to GA	[21]
Zheng, H., Zhou, Y., Guo, P.	Technique: CSA and GA Hybridization: CSA fine-tune the initial population with the assistance of GA	Solving Aircraft Landing Problem with runway dependent attributes	Performance of GSA and CSA is superior in searching the objective function values and computational time compare to GA and GLS	[22]
Wang, G., Guo, L., Duan, H., Liu, L., Wang, H., Wang, J.	Technique: DE and CSA Hybridization: DE optimize the process of CSA	Solving the Unmanned Combat Air Vehicle (UCAV) three-dimensional path planning problem	DE and CSA is more effective and feasible in UCAV path planning compare to basic CS	[23]
Zheng, H., Zhou, Y.	Technique: CSA and Gauss Distribution (GCS) Hybridization: Low convergence of rate of cuckoo search algorithm basing on Gauss Distribution	Solving standard test functions and engineering design optimization problems	GCS perform much better than CS in getting the feasible solution	[24]
Nawi, N.M., Khan, A., Rehman, M.Z.	Technique: CSA and Levenberg-Marquardt (CSLM) Algorithm Hybridization: The improve Levenberg-Marquardt Back Propagation (LMBP) algorithm is complete with CSA to avoid the problem of local minima	Solving the occurrence of stuck in minimum and the stagnant network	Performance of CSLM is better than other algorithms which is listed	[25]
Nawi, N.M., Khan, A., Rehman, M.Z.	Technique: CSA and Back-Propagation neural network (CSBP) Algorithm Hybridization: Back-Propagation neural network is integrated with CSA to avoid local minimum problem	Solving occurrence of stuck in local minimum and slow convergence speed	CSBP performs better compare to Artificial Bee Colony (ABC) combined with Back-Propagation Algorithm	[26]
Kavousi-Fard, A., Kavousi-Fard, F.	Technique: Autoregressive integrated moving average (ARIMA), CSA and Support Vector Regression (SVR) Hybridization: ARIMA corporate with CSA and SVR to obtain more accurate forecasting	Determining the reliability of forecasting result	The combination of algorithms improve the accuracy of forecasting result and also the search ability	[27]
Zheng, H., Zhou, Y.	Technique: Co-evolutionary Cuckoo Search (CCCS) algorithm Hybridization: Combination of co-	Solving optimization and engineering problem	The performance of CCCS is good in generating the quality of solution and it is more robust	[28]

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Author	Technique/ Hybridization	Problem	Result	Ref.
	evolutionary and cuckoo search algorithm which includes population of organization and organization of dynamic individuals			
Li, X.-T., Yin, M.-H.	Technique: CSA and Orthogonal strategy Hybridization: Combination of the stochastic exploration (CS) and the exploitation capability (orthogonal learning strategy)	Improving the estimation of parameter of Lorenz system and Chen system	The performance of this algorithm is better compare to PSO and GE in getting a quality solution	[29]

TABLE V
CSA APPLICATIONS

Area	Applications	Authors	Year	Ref
Computer Science	Solve structural optimization problems	Gandomi, A.H., Yang, X.-S., Alavi, A.H.	2013	[1]
	Solving planar graph coloring problem	Zhou, Y., Zheng, H., Luo, Q., Wu, J.	2013	[2]
	A novel hybrid Cuckoo Search algorithm based on simplex operator	Zheng, H., Luo, Q., Zhou, Y.	2012	[4]
	Formal description for global optimization	Zhang, Y., Wang, L., Wu, Q.	2012	[5]
	Solving knapsack problems	Zheng, H., Zhou, Y., He, S., Ouyang, X.	2012	[6]
	Opposition-based cuckoo search algorithm for optimization problems	Zhao, P., Li, H.	2012	[7]
	Spherical traveling salesman problem	Ouyang, X., Zhou, Y., Luo, Q., Chen, H.	2013	[8]
	Design optimization	Yang, X.-S., Deb, S.	2013	[9]
	Migration planning	Saelim, A., Rasmequan, S., Kulkasem, P., Chinnasarn, K., Rodtook, A.	2013	[12]
	Unconstrained optimization problems	Tuba, M., Subotic, M., Stanarevic, N.	2012	[13]
	Reliability-Redundancy Allocation Problems	Kanagaraj G., Ponnambalam S.G., Jawahar N	2013	[17]
	Job scheduling	Babukarthik R.G., Raju R., Dhavachelvan P.	2013	[18]
	Multi-objective scheduling problem	Chandrasekaran, K., Simon, S.P.	2012	[20]
	Automated test data generation	Srivastava, P.R., Khandelwal, R., Khandelwal, S., Kumar, S., Ranganatha, S.S.	2012	[21]
	A novel Cuckoo Search optimization algorithm base on gauss distribution	Zheng, H., Zhou, Y.	2012	[24]
	A new Cuckoo Search Based Levenberg-Marquardt (CSLM) algorithm	Nawi, N.M., Khan, A., Rehman, M.Z.	2013	[26]
	Correction method for short-term load forecasting	Kavousi-Fard, A., Kavousi-Fard, F.	2013	[27]
	Channel estimation of MIMO-OFDM	Vidya K., Shankar kumar K.R.	2013	[31]
	Edge magnitude based multilevel thresholding	Panda R., Agrawal S., Bhuyan S.	2013	[32]
	Tsallis entropy based optimal multilevel thresholding	Agrawal S., Panda R., Bhuyan S., Panigrahi B.K.	2013	[33]
	Particle filter for Non-linear state estimation	Walia G.S., Kapoor R.	2013	[34]
	Clustering	Senthilnath J., Das V., Omkar S.N., Mani V.	2013	[35]
	Supplier selection: Reliability based total cost of ownership	Kanagaraj, G., Ponnambalam, S.G., Jawahar, N.	2012	[39]
	Bloom filter optimization	Natarajan, A., Subramanian, S.	2012	[40]
	A novel strategy of biomimicry	Goel, S., Sharma, A., Bedi, P.	2011	[41]
	Energy efficient cluster formation in wireless sensor networks	Dhivya, M., Sundarambal, M., Vincent, J.O.	2011	[42]
	Path optimization for software testing	Srivastava, P.R., Chis, M., Deb, S., Yang, X.-S.	2011	[43]
	Design optimization for reliable embedded system	Kumar, A., Chakarverty, S.	2011	[44]
	Data clustering	Manikandan P., Selvarajan S.	2013	[45]
	Inverse problems and topology optimization	Yang, X.-S., Deb, S.	2013	[46]
	Business optimization applications	Yang, X.-S., Deb, S., Karamanoglu, M., He, X.	2012	[47]
	Inverse problems and simulated-driven shape optimization	Yang, X.-S.	2012	[49]
	Solving the problem of optimum synthesis of a six-bar double dwell linkage	Bulatovi, R.R., Dordevi, S.R., Dordevi, V.S.	2013	[53]
	Optimizing the semantic web service composition process	Chifu, V.R., Pop, C.B., Salomie, I., Suia, D.S., Niculici, A.N.	2011	[54]
	Multimodal function optimization	Jamil, M., Zepernick, H.-J.	2013	[55]
	Training spiking neural models	Vazquez, R.A.	2011	[57]
Engineering	Weighted sum optimization for linear antenna array synthesis	Abdul Rani, K.N., Hoon, W.F., Abd Malek, M.F., Mohd Affendi, N.A., Mohamed, L., Saudin, N., Ali, A., Neoh, S.C.	2012	[10]
	Structural damage identification of bridge erecting machine	Wang, L., Yang, S., Zhao, W.	2013	[15]
	Energy conscious clustering of Wireless Sensor Network	Karthikeyan, M., Venkatalakshmi, K.	2012	[19]
	Solving runway dependent aircraft landing problem	Zheng, H., Zhou, Y., Guo, P.	2013	[22]
	UCAV path planning	Wang, G., Guo, L., Duan, H., Liu, L., Wang, H., Wang, J.	2012	[23]
	Back-	Nawi, N.M., Khan, A., Rehman, M.Z.	2013	[25]

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Area	Applications	Authors	Year	Ref
	propagation neural network			
	Optimization of scaling factors in electrocardiogram signal watermarking	Dey N., Samanta S., Yang X.-S., Das A., Chaudhuri S.S.	2013	[30]
	Expedition of groundwater exploration	Gupta D., Das B., Panchal V.K.	2013	[36]
	Scheduling optimization of flexible manufacturing system	Burnwal S., Deb S.	2013	[37]
	An efficient algorithm for gray level image enhancement	Agrawal, S., Panda, R.	2012	[38]
	Symmetric linear antenna array geometry synthesis	Rani, K.N.A., Malek, F.	2011	[50]
	Flood forecasting	Chaowanawatee, K., Heednacram, A.	2012	[52]
	The selection of optimal machining parameters in milling operations	Yildiz, A.R.	2013	[56]
	Real-world simulation-based manufacturing optimization	Syberfeldt, A., Lidberg, S.	2012	[58]
	Design optimization of truss structures	Gandomi, A.H., Talatahari, S., Yang, X.-S., Deb, S.	2013	[59]
	Optimization of antenna arrays	Khodier, M.	2013	[60]
	Optimum design of steel frames	Kaveh, A., Bakhshpoori, T.	2013	[61]
	Side lobe suppression in a symmetric linear antenna array	Abdul Rani, K.N., Abd Malek, M.F., Siew-Chin, N.	2012	[62]
	A new approach for DG allocation in distribution network with time variable loads	Moravej, Z., Akhlaghi, A.	2012	[63]
Mathematics	RBF neural network	Chaowanawatee, K., Heednacram, A.	2013	[11]
	Knapsack problems	Layeb, A.	2011	[14]
	A new gradient free optimization algorithm	Walton, S., Hassan, O., Morgan, K., Brown, M.R.	2011	[16]
	A cooperative co-evolutionary cuckoo search algorithm for optimization problem	Zheng, H., Zhou, Y.	2013	[28]
	Engineering optimization	Yang, X.-S., Deb, S.	2010	[64]
	Determining optimal link capacity expansions in road networks	Baskan, O.	2013	[65]
	Parameter estimation of photovoltaic models	Ma, J., Ting, T.O., Man, K.L., Zhang, N., Guan, S.-U., Wong, P.W.H.	2013	[66]
Energy	Optimal DG allocation in a smart distribution grid	Buaklee, W., Hongesombut, K.	2013	[51]
	A soft computing MPPT for PV system	Ahmed, J., Salam, Z.	2013	[67]
	Parameters optimization of support vector machine	Ye, Z., Li, Q., Wang, C., Liu, W., Chen, H.	2013	[68]
	Allocation and sizing of DG	Tan, W.S., Hassan, M.Y., Majid, M.S., Rahman, H.A.	2012	[69]
Physics and Astronomy	Parameter estimation for chaotic systems	Li, X.-T., Yin, M.-H.	2012	[29]
	Numerical function optimization	Ong, P., Zainuddin, Z.	2013	[70]
Multi-disciplinary	Medical image retrieval system	Jaganathan, Y., Vennila, I.	2013	[3]
	A new approach for solving the unit commitment problem	Gharegozi, A., Jahani, R.	2013	[71]

It can be clearly seen that CSA can solve real-world problems by the number of publications in various applications in the area of Computer Science, Mathematics, Energy, and Engineering. In fact the performance of CSA still can be improved through modification and hybridization. There are many enhancements introduced in the structure of CSA, and the result are promising.

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