Improved Cuckoo Search Algorithm for Wind System Optimization

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***Abstract*—Nowadays, researchers use two different methods to solve optimization problems: exact methods which guarantee to find an optimal solution for a given problem but at the cost of computation time and/or very large memory space. And the approximate methods offering the possibility of finding a solution close to the optimal in a reasonable time. In order to optimize grid-connected wind systems, methods inspired by nature have been used. In this article, we present the method Meta heuristics Inspired by Nature Search of the Cuckoo via the Lévy Flights, their classification, as well as their advantages in contribution to the optimization by colonies of ants; and particle swarm optimization, ending with simulation results of the cuckoo method. We discuss the implication of the results and suggestion for further research**

Keywords—Cuckoo optimization; Levy flights; Optimization by ant colonies; Particle swarm optimization

I. INTRODUCTION

Optimization and artificial intelligence are bright study areas with a growing literature. For best applications, weather, argent and means are always restricted, and therefore their optimal utilize becomes more important.

In this paper, we present a demonstration of the algorithm that we have taken as a starting point towards solve the optimization problems of wind turbine systems.

The cuckoo optimization algorithm COA. It was proposed in 2011[1]. Is inspired by the behavior of cuckoos in their life, breeding and advancement. In the COA algorithm, a given solution is called "habitat". A habitat represents a current position of the cuckoo in the search space [2].

Each cuckoo's habitat produces a number of eggs, some of them develop into mature cuckoos. The creation of the eggs is founded on the present location of the cuckoo's habitat and the egg laying distance proportional to the overall number of eggs of the cuckoo itself and also two other variables limiting the range hence the values of the variables are drawn (denoted Varhi and Varmax).

The researchers tested this algorithm on some well-known benchmark functions and compared with PSO and GA, and it was found that the cuckoo search performed better than the results of PSO and GA [3].

We can see that optimization by cuckoo search (CS), is one of the most recent methods, it is more robust and more used in various fields. This is why our work is dedicated to the cuckoo optimization method.

II. A LITERATURE REVUE OF CUCKOO SEARCH ALGORITHM FOR WIND SYSTEM

Cuckoo search optimization (CSO) was applied in reference [4] and its efficacy characteristics have been obtained by comparing current approaches and projection that the CSO approach provides improves results in the form of power extraction. With control technique Cuckoo search optimization (CSO) MPPT, the DC-DC converter was used to offer the duty pulses agreed to boost the voltage at the converter and elaborate analysis was observed with present methods such as Perturb and Observe (P&O) and Particle Swarm Optimization (PSO).

In this work [5], the cuckoo search method was considered in wind energy prediction at first , secondly was compared to other folk character-inspired techniques for predicting the exit values of wind farms in Texas and Montana, both in the United States. The results were shown, with statistical significance, Cuckoo Search (CS) and self-adaptive. Cuckoo Search (SACS) not only exhibited higher prediction execution compared to PSO, ACO and a hybrid of the two but also converged much faster than the another algorithm.

In this survey [6], an approximate was proposed founded on the cuckoo search (CS) optimization algorithm. A various of CS has equally been proposed which incorporates a heuristic-founded seed resolution for top performance. The proposed CS algorithms are compared with genetic optimization and particle swarm algorithms that have been broadly painstaking in the conception of wind farm layouts

The performance revealed that the proposed CS algorithms produced higher yearly energy manufacture and improved capacity for all considered test scenarios and various numbers of wind turbines. This capability that the CS algorithm was most efficient than the GA optimization and particle swarm algorithm in traversing the research space, which resulted in right solutions by CS.

In this article [7], two optimization methods have been used, a genetic algorithm and a cuckoo search, to identify the parameters of electric conduct controllers using some quality standard and applying a locating to the maximum indicative values in the controlled installation. The results of the two optimization methods are compared. The impact of the likelihood that the guest of the brood finds the composed eggs at the rapidity of research for the optimal solution was studied.

In this work [8], the author was focused on the optimization issue of a wind farm arrangement, cuckoo search (CS), a new inhabitance-founded metaheuristic optimization algorithm was worn. The literal is to find the turbine provision and types that maximize the net offer price of the wind farm, while restraint on the turbine positions has to be met.

The test performance marked that the substructure cost has a significant impact on the optimum wind farm resolution. A genetic algorithm, commonly applied to wind farm micro-siting problems, are used to benchmark the performance of the CST he results indicate that the CS is able of consistently fabrication improve solutions than the genetic algorithm

In this work [9] author introduced a novel method to resolve economic sending (ED) issue in power system transaction with wind farm (WF) connecting. The method was cuckoo research algorithm (CSA) which can get solved efficient ED problem with WF.

In this paper [10], a wind turbine modeling was introduced with suggested controllers, in adjust to improve the system answar, with evaluatet to both pitch control and utmost output power. Cuckoo research algorithm (CSA), a meta-heuristic optimization technique, was implemented to establish the gains of a (PI) controller and fractional order proportional-integral-derivative (FOPID) controller to optimize the system, which respected three control loops: pitch , rotor-side converter, and grid-side converter control loop.

This paper [11] presents a qualified and good evolutionary-based road to procure optimal power flow (OPF) issue solution The road employs a nature inspired meta heuristic optimization algorithm called cuckoo optimization algorithm (COA) to terminate the optimal settings of control variables.

In above work [12] a Hybrid Controller adopted with a Conventional PI and ANFIS are planned for Wind Energy Systems. The realization of Hybrid controller was upgraded with a Conventional PI regulator. It has been also interpreted by enumerating ALOFOPI and CS-ALOFOPI from which we can look that the dominant of DFIG coupled WES are farther exhibiting the restoration of the powers by which we can inspect the attainment of DFIG has been amended.

In [14], A novel CS algorithm-based MPPT application has been proposed to define the MPPs in the DFIG-WECS [13]. The DFIG is controlled by the reach MPPs by using the CS algorithm to assure that the DFIG-WECS is always operated at MPPs under various wind speeds. The obtained performance of using the CS algorithm validated the proposal. Moreover, the solution with the CS algorithm is always better than the solutions with the HCS and PSO algorithms in the MPPT control strategy in the DFIG-WECS.

III. THE PRINCIPLE AND THE STAGE OF THE CUCKOO SEARCH

The cuckoo search (CS) optimization method is based on three principles [4]:

- Initially: each cuckoo lays a single egg at a given time and the eggs are placed on randomly selected nests.
- Next generation: nests containing better quality eggs (solutions) will be elected for the next generation.
- Acceptance rule: the number of valid host nests is fixed and the ability to detect the egg by the host bird is with a probability $P_a \in [0,1]$ In this case, the host bird cuts between ejecting the cuckoo out of the nest or abandoning its nest to go to a new position and build a new nest.

The probability P_a represents the fraction of N nests that will be replaced by new nests (with new random solutions in new positions in the search space). The quality of a nest or solution is measured based on the objective function, which varies from problem to problem.

In order to generate a new solution $X(t+1)$ for a cuckoo i , Yang and Deb integrated Lévy's flight as follows [23]: $X_i^{(t+1)} = X_i^{(t)} + \alpha \otimes l\acute{e}vy(\lambda)$ [15].

Where α > 0 is the step size, it is related to the problem treated.

The new solution will therefore be generated according to two essential factors:

- The current position of the cuckoo clock.
- The new direction measured by Lévy's flight.

Lévy's flight represents a random walk whose random steps are defined from the Lévy distribution. It should be noted that the Lévy distribution has a panoply of variants with an infinity of meaning.

IV. THE CUCKOO SEARCH ALGORITHM

We give on the figure1the flowchart of the cuckoo search algorithm.

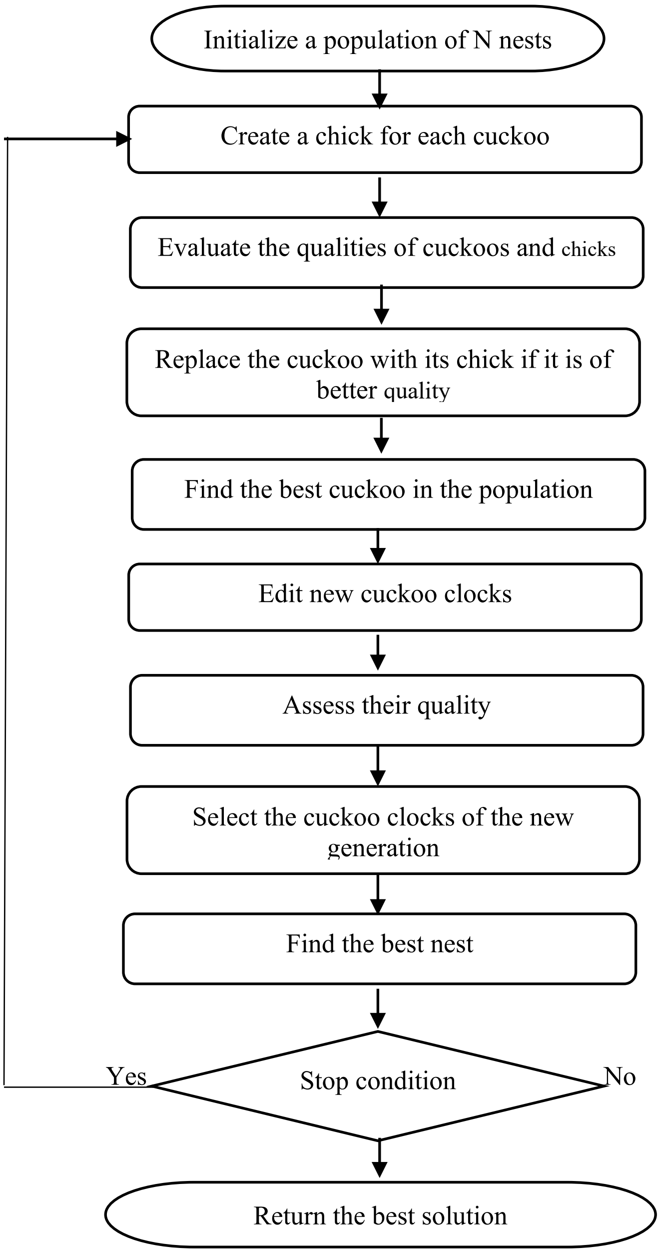

Fig. 1 Flow chart of the cuckoo search algorithm

The following algorithm summarizes the general steps of the CS algorithm:

Close observation of the steps of the CS algorithm shows that it revolves around three phases:
selection of the best solution.

The exploitation of the solution by random local search and the exploration of the search space by the random creation of new solutions using Levy's flight.
Inspired by one of the types of selection used in the genetic algorithm [23].

TABLEI. CUCKOO SEARCH ALGORITH

Beginning
initialize a population of N cuckoos (solutions);
While (the stopping criterion is not satisfied) Do
For every hello s do
Create his chick g using Lévy's flight;
Calculate the fitness of s and g;
Replace s by g if f(g) is better than f(s);
End for
Find the best cuckoo clock;
For every hello s do
Modify a fraction Pa of its content to obtain a new solution;
Evaluate the fitness of s';
Replace s by s' if f(s') is better than f(s);
End for
Find the best cuckoo clock;
End While
Return the best solution;
End

V. RESULTS OF SIMULATION

The results of the simulation show the efficiency of the cuckoo method, the following figures show the convergence diagram and the function of the algorithms in convergence towards the optimal solution in an appropriate number of iterations

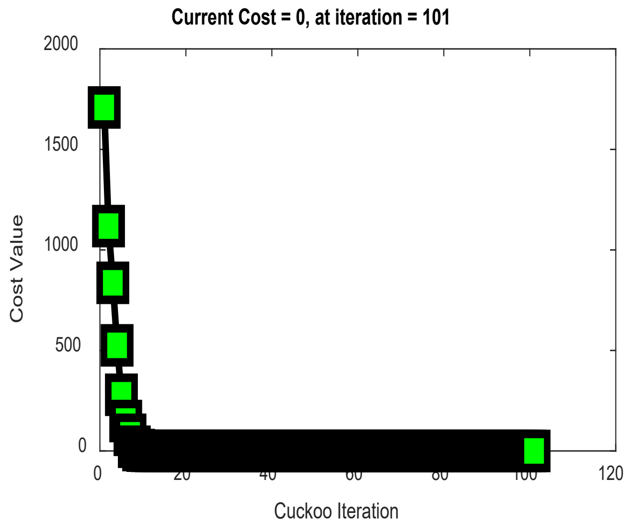

Fig. 2 The Cost Value Diagram of COA iteration 101, Current Cost 0

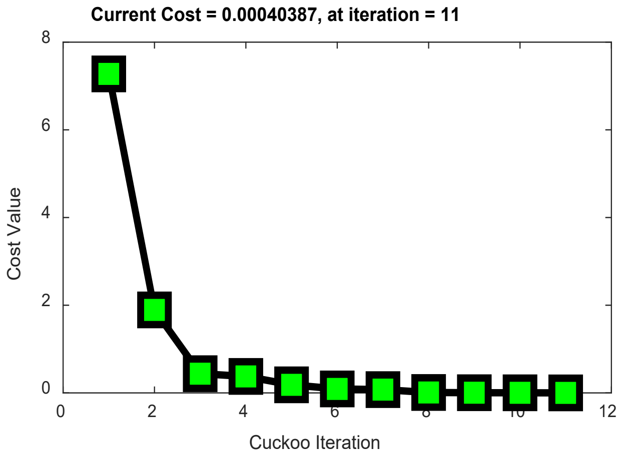

Fig. 3 The Cost Value Diagram of COA iteration 11, Current Cost 0.0004

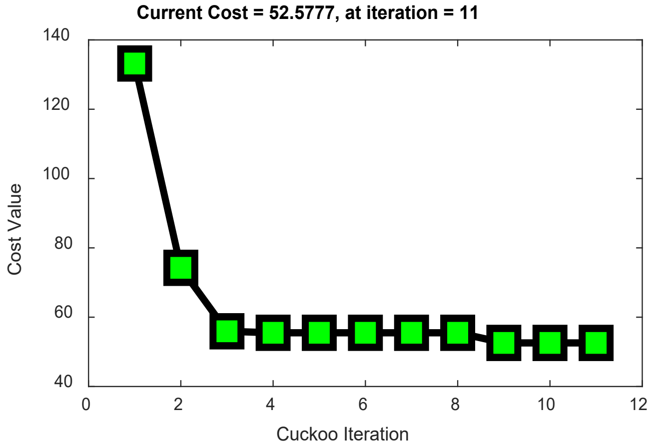

Fig. 4 The Cost Value Diagram of COA iteration 11, Current Cost 52.57

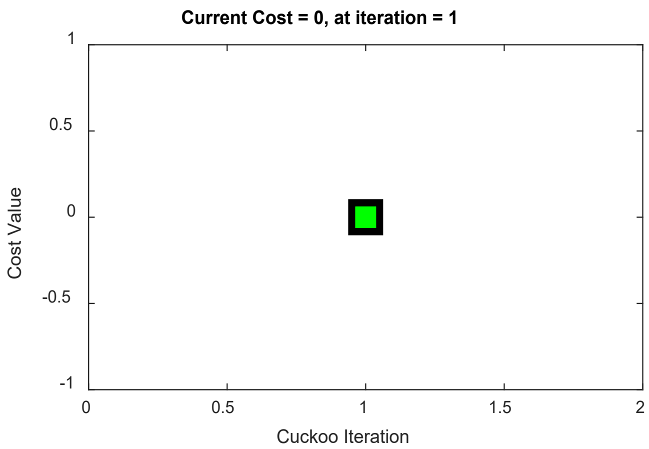

Fig. 5 The Cost Value Diagram of COA iteration 11, Current Cost 52.57

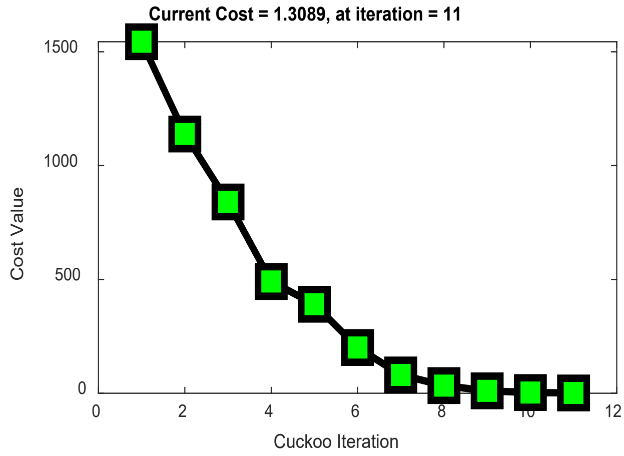

Fig. 6 The Cost Value Diagram of COA iteration 11, Current Cost1.3

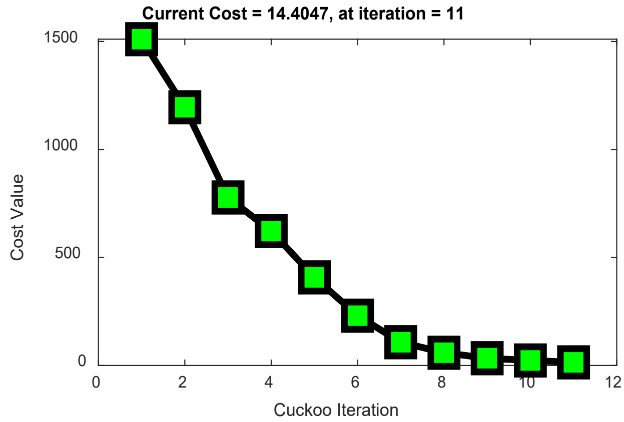

Fig. 7. The Cost Value Diagram of COA iteration 11, Current

Cost14.40

VI. CONCLUSION

Algorithms based on the idea of swarm intelligence similar to cuckoo search achieve high results in solving a wide range of nonlinear optimization problems, which explains their integration in other fields. This class of algorithms is chosen to minimize the intelligence of the individual while maximizing the intelligence of the swarm as a whole.

The minimization is completed by the reduction of the number of parameters, favoring more independence and abstraction vis-à-vis the constraints of the problem treated. On the other hand, the maximization of the intellect, the swarm is achieved by a better design of the solution space and a good search balance between the promising regions and on a global scale for the discovery of new regions.

FEATURE WORK

In the next work we will use the cuckoo method in a wind turbine system connected to the grid with three-level inverters using a new M5P indirect control from the DFIG. because the previous work used the method for simple regulators to have an optimized system

ACKNOWLEDGEMENTS

I thank professor Ilham cloak for his invitation as a researcher and his work advice, and I thank Turkey Government Scholarships who accepted us as scholarship holders, as well as the YTB office for these events for foreign students.

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