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Economic Load Dispatch by Novel Bat Optimization

Manish Kashyap[1], Dr. Achala Jain[2], Vinita Swarnakar[3]
PG Scholar[1], Associate Professor[2], Assistant Professor[3]
Department of Electrical & Electronics Engineering
Shri Shankaracharya Technical Campus Junwani Bhilai Durg (C.G.)-490020
***Corresponding Author's Email -** manikashyap1997@gmail.com*

Abstract

Power plants are one of the major industries in a nation since they meet a variety of demands of the populace. In order to provide power in accordance with demand at an affordable price, this industry must operate at the lowest possible cost. Economic dispatch is a technique to power system plant optimization whose goal is to reduce costs by identifying the best configuration of generator output in accordance with electrical demand and system capacity. The main objective of Economic Load Dispatch (ELD) is to maximize the effectiveness of a power system's generating network. Performing the ELD has the primary goal of reducing the cost of generator fuel. There has been extensive research on the least cost function discovered utilizing optimization techniques. The Bat algorithm is one such method of optimization. To address the ELD issue, the Novel Bat Algorithm has been presented in this publication. Doppler Effect and the migration of bats between various habitats are concepts introduced in the Novel Bat Algorithm. By putting the suggested strategy to the test on 6-unit systems, its efficacy is demonstrated.

Keywords: *Economic Load Dispatch (ELD), Bat Algorithm (BA), Novel Bat Algorithm (NBA)*

INTRODUCTION

Power plant construction often follows economic growth in a nation. There are typically two types of power plants: thermal power plants and non-thermal power plants. The majority of the money spent on thermal power plants' fuels comes from non-renewable sources like coal and petroleum. As a result, cost optimization requires that output from the power plant's generators be produced in accordance with the power plant's maximum capacity. Economic dispatch is a common name for this strategy.

In recent years, several novel methods for minimizing a parameter in any issue have been developed as a result of the introduction of optimization techniques. Either nature serves as an inspiration for new algorithms or they depend on animal behavior. In addition to the continual creation of new optimization algorithms, several different versions of a certain method are also being created. Several additional algorithms, including NBA, are explored in relation to an economic dispatch problem. An essential duty at a power plant is called Economic Dispatch (ED), which chooses the best mix of power outputs from all producing units while keeping costs to a minimum and meeting system requirements.

Recently, academics have begun to focus on the particle swarm optimization (PSO) approach for multi-area economic dispatch. In this study, the researchers employ a minimal cost restriction while taking the number of generators and region coverage into account. The additional concerns in the economic dispatch challenge are how to reduce power system emissions as well as costs. The method proposed in this work, the bat algorithm, was inspired by nature and has a steady convergence and high computing efficiency. Yang's 2010 proposal for the "Bat algorithm" was based on the echolocation habits of the bat. This behavior enables bats to locate their prey and identify different kinds of. insects in the dark.

LITERATURE REVIEW

The Bat Algorithm is one such example. It was first introduced in [1] and has undergone several changes in an effort to determine which one is most effective. To put it another way, several iterations of the same algoritm are created to find the optimum answer to a certain problem in a given fields of study. In this research, a novel variation—the Novel Bat Algorithm (NBA)—has been explored and used to solve an ELD issue. According to [2], this is the first time the NBA has been used to solve an economic dispatch issue.

The Levy flight behaviors of bats were presented by Liu and Chumming [11], who also made the most of the property of uneven random walks to help the algorithm avoid becoming stuck in a locally optimal solution. The fractional Levy flight BA (FLFBA), which updates the velocity using fractional calculus, was introduced by Boudjemaa et al. [12] to improve the algorithm's capacity to escape from locally optimal values. By merging it with differential evolution, Fister et al. [13] proposed a hybrid BA. Aletar and Awadallah [14] separated the entire bat population into two subgroups and described the movement of.bat individuals from one group to the other by mobility in order to increase the global searching capability. The conventional BA's velocity equation was recommended to be modified by Jaddi et al. [15] in order to better balance population exploration and exploiation, while Ghanem and Jantan [16] proposed an improved BA that would increase the standard BA's diversity by utilizing a unique mutation operator.

BAT ALGORITHM

The only animal that has wings and a highly developed echolocation system is the bat. Echolocation is a technique used by the majority of bat species; among-all species micro-bats are renowned for using it extensively, whereas mega bats do not. Micro-bats utilize echo location to find food, neglect dangers, and find their resting niches at night [3]. Several bat-inspired algorithms can be created if parts of the micro-bats' echolocation traits are idealized. For ease of usage, the following guidelines are used:

1. For distance perception, all bats employ echolocation. They can distinguish between backdrop obstacles like food/prey and other prey.

2. In order to find prey, bats fly at random with a velocity of vi, a constant frequency of $fmin$ (or wavelength f), a variable frequency of f, and a loudness of $A0$. Depending on how close their targets are, they may automatically change the wavelength (or frequency) of the pulses they release as well as the rate at which they emit them (0–1).

3. Although there are various ways that loudness might fluctuate, it considered the loudness ranges from a high value A_0 to low value.

The mathematical expression that has been formulated the discussion are given below,

$$(0,1) \quad < A_i \,\&\, (f(x_i) < f(x)) \quad (1)$$

$$(x) = (xi) \quad (2)$$

$$A_i^{t+1} = vA_i^t \quad (3)$$

$$r_i^{t+1} = r_i^0(1 - e^{-\varphi t}) \quad (4)$$

Ray tracing is unused in the time delay estimation, which is another simplification. Subsequent approximations have also been utilized for convenience in addition to these simplified assumptions. Typically, a frequency's $[f_{min}, f_{max}]$ range of wavelengths $[\lambda_{min}, \lambda_{max}]$ corresponds to that frequency.

Novel Algorithm

The types of bats that actively look for habitat differ by species. Bats may modify their echolocation behavior in various settings to which they become acclimated, leading them to forage in a variety of habitats [5]. Additionally, many bat species can forage in the same environment [6].

The Doppler Effect, the Bat Algorithm (BA), and the concept of bat foraging were not taken into account. Each virtual bat is represented by its velocity, location, and trajectory in the original BA, which seeks for prey in a D-dimensional space. Another assumption made by BA is that the virtual bats would only forage in one environment. In practice, though, this isn't always the case. Doppler Effect has been incorporated into the algorithm in NBA [4] additionally; the proposed approach allows each virtual bat to adaptively account for the Doppler Effect in echoes.

Additionally, the proposed approach allows each virtual bat to adaptively Account for the Doppler Effect in echoes.

In the NBA, virtual bats are said to have a variety of habitats for foraging. The virtual bats taken into account in the BA behave mechanically, which means that they only look for food in a single environment. The bats in NBA can, however, forage in a variety of environments. In summary, the idealized NBA regulations are as follows for the sake of mathematical formulation.

1. All bats are capable of movement in many environments.

2. Every bat is capable of correcting the Doppler Effect in echoes.

3. Depending on how close their objectives are, they can modify and change their pay rate.

Comparing this strategy to other approaches, it was determined to be the most effective for simulating the Economic dispatch issue on a six-bus system.

Quantum Behavior of Bats

It is anticipated that the behavior of the bats would be such that as soon as one bat discovers food in the environment, other bats will begin eating from them right away. The mathematical formulation of the virtual bat locations is provided below [4] as a result of such an assumption:

$$x_{ij}^{t+1} = \begin{cases} g_j^t + \theta \times |mean_j^t - x_{ij}^t| * \ln\left(\frac{1}{\mu_{ij}}\right), & if\ rand_j(0,1) < 0.5, \\ g_j^t - \theta \times |mean_j^t - x_{ij}^t| * \ln\left(\frac{1}{\mu_{ij}}\right), & if\ rand_j(0,1) < 0.5 \end{cases}$$

B. Mechanical Behavior of Bats

In air, sound travels at a speed of 340 m/s. The bats are unable to go faster than this. The bats also counteract the Doppler Effect, and this counteraction rate has been formally denoted as CR. It differs amongst several bat species. To prevent the possibility of division by zero, a value is taken into consideration as the lowest constant in the computer. The value of CR∈ [0, 1] and the inertia weight w∈ [0,1] Here, CR is assigned 0 if the bats make no attempt to account for the Doppler Effect and 1 if they fully do so. Now, the description is explained using the subsequent mathematical equations [4].

$fi, = fmin+(fmax-fmin)*rand$ (0,1)(6)

$$f_{i,j} = \frac{c+v_{i,j}^t}{c+v_{g,j}^t} * f_{i,j} * (1 + CR_i * \frac{g_j^t - x_{i,j}^t}{|g_j^t - x_{i,j}^t| + \theta}$$

$$v_{i,j}^{t+1} = w * v_{i,j}^t + (g_j^t - x_{i,j}^t) * f_{i,j}$$

$$x_{i,j}^{t+1} = x_{i,j}^t + v_{i,j}^t$$

METHODOLOGY

The Bat algorithm is suggested to determine the overall generator cost that will be transferred in accordance with load demand. Here is how the BAT algorithm works to solve economic dispatch:

1. Set the population of bats to their initial positions (xi) and speeds (vi). In this instance, the definition of xi is ; power produced by the ith generator, where I = (1, 2,..., n), and n is the number of generators. The value of xi is produced at random between [P_{min}] Moreover, vi 's initial value is (0).
2. Set the loudness, pulse rates , and frequencies fi of each bat to their initial values. The requirement $fmin \leq f_i \leq fmax$ must be met by frequency. Depending on the size of. the problem's domain, $fmin$ and $fmax$ are determined, and the starting frequency fi is distributed uniformly at random within the range [f_{min}, f_{max}]. Loudness fluctuates in the range [A_{min}, $A0$], whereas pulse ri is randomly allocated in the range [0, 1 Amin is the lowest value, while A0 is a huge positive number, therefore [$Amin$, $A0$] in this example is [0, 0.9]. In this issue, the definitions of fmin and fmax are 1 and 5, respectively
3. The maximum number of iterations. Steps 4 through 15 are completed

repeatedly until the maximum number of iterations is reached.

4. Determine the fitness value for each population of bats, which is calculated as the sum of all generating costs (Equation 1) Utilizing data on Generator Capacity netto and Heat Rate netto, the coefficient values for , and ci are calculated to determine the total cost for each generator in Equation 1. The cost of the entire generator is determined by taking into account the average transmission loss percentage and load demand.

$$minF_i(P_i) = \sum_{i=1}^{n}(a_iP_i^2 + b_iP_i + c_i)\left(\frac{kcal}{hr}\right) \times fuelcost\left(\frac{IDR}{kcal}\right)$$

1. Find the worldwide best site (solution candidate) x, in this scenario that has the lowest overall cost out of all the bats or generators.

2. Eq. 5 is used to modify the frequency of the bat population.

$$fi = fmin + (fmax - fmin)$$

3. Update Velocities,

$vi\ t{+}1 = vi\ t + (xi\ t - x0)$

And location,

$xi\ t{+}1 = xi\ t + vi\ t{+}1$

4. If (rand>ri)

$$xi\ t{+}1 = x_i\,t + v_i\,^{t+1}$$

5. Create regional solutions centered on the ideal answer.

$$xi\ t{+}1 = x0 + \varepsilon At$$ `

Where $\varepsilon \in$ [-1, 1] is a random no., &$A\ t$ is the avg. loudness of all the bats at t time step.

6. End if

7. Utilizing Equation 1, get the fitness value from the new solution.

8. if (rand<Ai&$f(xi) < f(x0)$)

9. Accept the fresh approach

10. Increase,

$ri\ t{+}1 = ri\ t\ [1 - e\ (-\gamma t)\ ]$

And decreases ,

$Ai\ t{+}1 = \alpha Ai\ t$

Where α= arbitrary constant whose values in range (0,1) & γ = constant whose value is >0

11. end if

12. Apply the optimal solution for the present bat population as the most amount of electricity produced by all generators at the lowest possible cost.

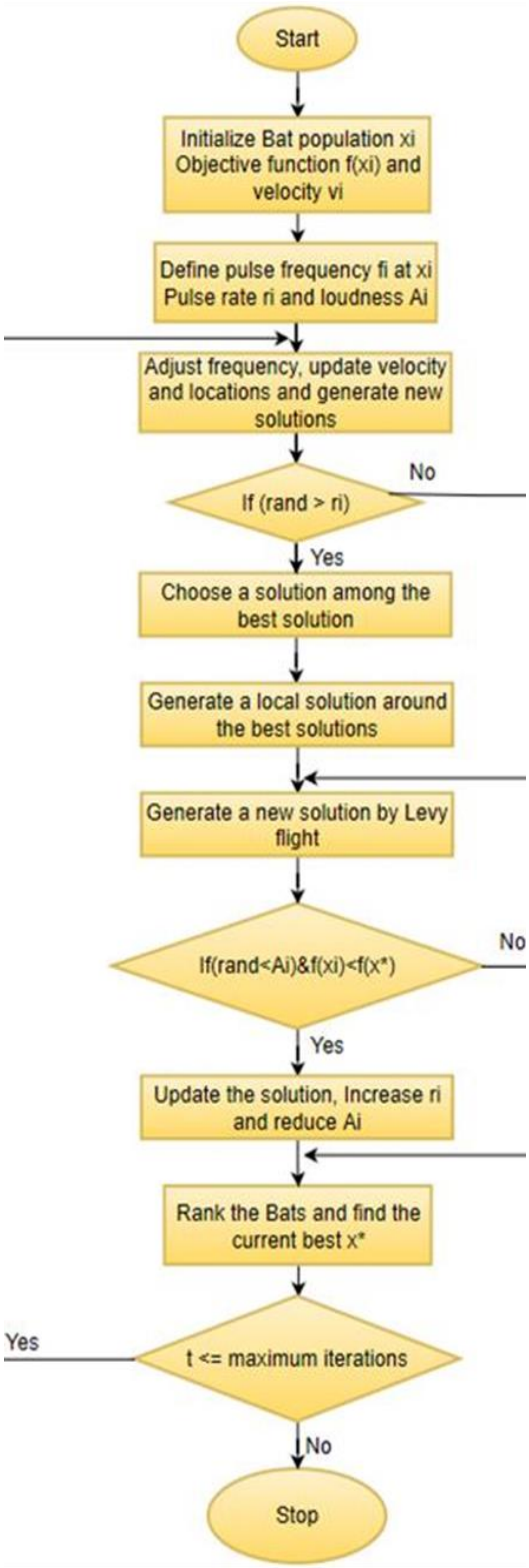

Fig: Novel Bat Algorithm

RESULT

Experiments are carried out utilizing data from a subsidiary of a state owned firm involved in electricity generation. The maximum/minimum value of generating capacity netto and rate of heat netto data are utilized. Six generators are used as the population in this study.

This section presents and contrasts the outcomes of several tested ideologies. An analysis of the various strategies was undertaken alongside the MATLAB/play working level to establish the practicability of the various procedures.

The proposed tactics and emission dreams are independently restricted.

Table .1: The ABC control parameters chosen are as follows

Unit	a_i	b_i	c_i	P_{min}	P_{max}
1	0.001562	7.92	561	100	600
2	0.001940	7.85	310	100	400
3	0.004820	7.97	78	50	200
4	0.001390	7.06	500	140	590
5	0.001840	7.46	295	110	440
6	0.001840	7.46	295	110	440

B= [0.00014 0.000017 0.000015 0.000019 0.000026 0.000022, 0.000017 0.000060 0.000013 0.000016 0.000015 0.000020, 0.19 0.000013 0.000065 0.000017 0.000024 0.000019, 0.000019 0.000016 0.000017 0.000071 0.000030 0.000025, 0.000026 0.000015 0.000024 0.000030 0.000069 0.000032, 0.000022 0.000020 0.000019 0.000025 0.000032 0.000085]

Table .2: Comparison table

Method	Load (MW)	Unit 1 (MW)	Unit 2 (MW)	Unit 3 (MW)	Unit 4 (MW)	Unit 5 (MW)	Unit 6 (MW)
CGA	800	109.17	104.08	52.04	305.05	114.83	114.83
QCGA	800	104.89	104.89	51.74	314.18	113.16	113.16
BeeOA	800	100	100	50	305.63	122.19	122.19
Proposed	**800**	**100**	**100**	**50.001**	**287.8087**	**172.0138**	**110.0407**
CGA	1200	142.55	117.80	58.90	515.20	182.78	182.78
QCGA	1200	131.50	129.05	52.08	494.08	200.61	200.61
BeeOA	1200	123.76	117.68	50	448.42	230.06	230.06
Proposed	**1200**	**188.8091**	**157.4033**	**55.1872**	**378.3594**	**268.5630**	**195.7059**
CGA	1800	222.42	190.73	95.36	555.63	367.92	367.92
QCGA	1800	250.49	215.43	109.92	572.84	325.66	325.66
BeeOA	1800	247.99	217.719	75.18	588.04	335.52	335.53
Proposed	**1800**	**326.3963**	**254.1717**	**97.6238**	**590**	**368.5903**	**264.6760**

CONCLUSION

The paper above discusses the Novel Bat-Algorithm for a economic dispatch convey problem. The modifications to this method include the Doppler Effect theory and bats' habitat-hopping behavior. This method outperforms the others in terms of providing the lowest cost for test scenarios of a six generator bus system with a power demand of 800, 1200 & 1800 MW. The 6 generator test bus scenario takes power loses into account but ignores the effects of valve loadings. Thus, it can be said that NBA is a reliable algorithm for the tests that were run. The robustness of this approach may be tested for larger dimensional challenges. The Bat algorithm may efficiently disperse a generator's output, resulting in reduced cost and transmission loss. As a result, optimizing the bat algorithm is an approach that shows promise for addressing issues with an economic dispatch in the power systems.

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