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# Economic load dispatch problem using improved flower pollination algorithm

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## ABSTRACT

***In this paper, we have designed an improved flower pollination algorithm to find the optimal solution for the economic load dispatch (ELD) problem. The solution to the ELD problem reduces the generation cost and power losses in the smart grid. In the proposed algorithm, we have considered a three-unit system. The performance analysis of the proposed algorithm is done based on generation cost and power losses. Further, it is compared with the popular optimization algorithm such as particle swarm optimization, genetic algorithm, and flower pollination algorithm. The evaluation results show that the proposed algorithm takes 3602.9 $/h generation cost and 9.3205 power losses which is far lesser than existing optimization algorithms.***

***Keywords***: *Chaotic Map Algorithm, Economic Load Dispatch, Flower Pollination Algorithm, Smart Grid, Generation Cost.*

## 1.INTRODUCTION

In recent times there is the formation of a new society of resource-utility maximization and the latest advancement in the market system. These advancements made the practical optimization problem an important aspect for economic load dispatch (ELD) [1]. The definition for the same is described below:

It describes the fact that the generator cost for the power system is growing at a minimum rate, and depends upon various constraints. These constraints consist of various factors such as the electrical prerequisite of the user, minimizing the power system losses, keeping the active power generation in the defined range, and other factors like that. In the current times, the ELD directly or indirectly affects various important factors of the complete power system such as safety and economic benefits. It is a big part of the discussion to minimize the cost of the generator of the overall power system for both national and international researchers [2]. The solution for the problem related to the economice dispatch has been optimized and resolved with various old optimization methods. These conventional methods includes Newton technique, Gradient-based technique, method of linear and quadratic programming. These traditional methods are not able to resolve the complex issues [3]. In order to resolve these issues Global minimum intelligent technique can be utilize. In the recent times, different experimental methods are used to resolve the problems related to the complex optimization. These experimental methods includes Particle Swarm Optimization (MPSO), Genetic Algorithm (RGA), Flower Pollination and Gravitational Search Algorithm and other related Algorithms [4-8]. In the current work, we considered FPA algorithm as this algorithm shown various advantages compared to other algorithms. These advantages includes identification of local and global space in an efficient manner in the objective function [9]. It also has the advantage to shift around the spacces to produce the efficient results. However, the FPA is trapped into local optima.

The main goal of this paper is to design an algorithm to find the optimal solution for the economic load dispatch (ELD) problem. To achieve this goal, we have designed an improved flower pollination algorithm. In the improved FPA algorithm, the chaotic map algorithm is deployed to generate the initial population. The performance analysis of the proposed algorithm is done based on generation cost and power loss. The results show that the proposed algorithm provides superior results as compared to the existing optimization algorithms such as GA, PSO, and FPA.

The remaining paper is as follows. Section 2 gives an overview of the chaotic map and flower pollination algorithm. Section 3 presents the proposed method in which an improved FPA algorithm is designed. Section 4 shows the experimental results are performed for the proposed algorithm for the three-unit system. Conclusion and future scope are drawn in Section 5.

## 2.RELATED WORK

In this section, an overview of the chaotic map algorithm and flower pollination algorithm is given to understand the proposed algorithm.

**2.1 Chaotic Map Algorithm**

The logistic map is a discrete, one-dimensional nonlinear system that displays a quadratic nonlinearity [10]. The logistic map is given by the function $f : [0,1] \rightarrow \Re$ defined by

$$f(x) = \mu x (1-x) \quad (1)$$

this can be demonstrated as the equation given as follows:

$$x_{n+1} = f(x_n) = \mu x_n (1-x_n) \quad n = 0,1,2,.., \quad (2)$$

in the above equation $x_n \in (0, 1)$ and $\mu \in (0, 4)$.

Where μ denotes the bifurcation or control parameters and xn denotes the state at the time frame of n. xn+1 in this equation signifies the subsequent state and n signifies the discrete-time. Reoccuring iteration off increases the sequence points. In the below-given points, different dynamic properties are discussed with the help of the logistic map termed as the orbit.

The different characteristics of the logistic maps are discussed as follows:

- The maximum value of f is achieved on x=0.5 for μ/4.
- For x ranging between 0 to 0.5 will show the symmetricity in the range of 0.5 to 1.
- f maps [0, 1] back into [0, 1] for $0 \leq \mu \leq 4$. If the value of x goes higher to the value of 1, the divergence of iteration occurs to $-\infty$.
- The logistic map behaviour is highly dependent on the μ.

**2.2 Flower Pollination Algorithm**

Most of the existing plants are a type of flowering plant with around 2.5 Lacs species all over the world. The word Pollination in this algorithm means the approach of reproduction in the plants [11]. The process of Pollination includes the method of pollinating the flower to other flowers with the help of the wind or different other means such as butterflies, bees, and insects and including the mammals like bats. The Flowering plants developed a method of generating the nectar that pulls the pollinators for the increased chances of pollination. Apart from this, some of the plant species and pollinators generate co-evolutionary flower constancy. this method of plant pollination gave the inspiration for the development of the Flower Pollination Algorithm.

**2.3 FPA in Optimization Context: Nature's Inspiration**

Before the detailed discussion of the Flower Pollination Algorithms, it is important to understand the basics of pollination in flowering plants. Pollination has two main methods i.e. biotic and abiotic.

Biotic Pollination: In this form of pollination, birds and insects act as the main pollinators. This method is also known as the cross-pollination method. This is the primary method of Pollination in the plants, around 90 percent of the flowering plants is adapted for this method of pollination. As the pollinators can move and fly, the pollination can be carried out for a long distance. By this method, global pollination is also possible due to the high flights of the birds. If the pollen is considered as the solution vector, the technique is almost as the global search.

Abiotic Pollination: In this form of pollination there is no requirement of the pollinators. Due to this the method is also termed the self-pollination method. Around 10 percent of the flowering plants adopt this method of pollination. As the pollination is self-driven, it can be done with the help of diffusion or the passing wind. As the pollination process is local and short-distant, the method is quite considerable for the local search.

Flower Constancy: sometimes the plant and pollinator come into the corporation to minimize the energy utilization and granting the success of the pollination. In this method, the pollinator does not roam around for looking for the different flower type and only go on the certain flower type. That lead to minimum usage of energy and on the other hand's flower generate nectar in the reward to the pollinator. This increases the chance of visiting the pollinator and improves the chances of the pollinator's reproduction success. This method is utilized for the development of the optimization algorithm, termed the flower pollination algorithm [10]. The summary of the characteristic components for FPA is shown in Table 1.

**Table 1 Pollination and its Optimization Components**

| Flower pollination | Optimization components (in FPA) |
|---|---|
| Pollinators (insects, butterflies, birds) | Moves/modification of variables |
| *Biotic* | Global search |
| *Abiotic* | Local search |
| Lévy flight | Step sizes (obeying a power law) |
| Pollen/flowers | Solution vectors |
| Flower constancy | Similarity in solution vectors |
| Evolution of flowers | Iterative evolution of solutions |
| Optimal flower reproduction | Optimal solution set |

It demonstrates the association of the optimization term with the context of the flowering plants. Based on these characteristics, a standard flower pollination algorithm can be easily demonstrated.

 

### 2.4 Flower Pollination Algorithm

As the FPM algorithm is inspired by nature's method and imitates the method of pollination in the flowering plants. The four rules given by Yang in the year 2012 is taken as an idealization of the Flower Pollination Algorithm and the overall summary of these rules are given as follows:

Rule 1 The Global Pollination method is based on the method of abiotic or cross-pollination method. In this method, the pollen is carried out by the pollinators on long flights.

Rule 2 In the method of Local pollination method the inspiration is taken from the abiotic and self-pollination method.

Rule 3 The constancy of the flower is taken as the probability of reproduction and is proportional to the matching type of two flowers.

Rule 4 Switch probability p ∈ [0, 1] is a controllable aspect in both the global pollination as well as local pollination bassed of some external factors. These factors include wind and pollinators. Local Pollination has a higher switch probability in the pollination activity.

### 2.5 Pseudocode of the Flower Pollination Algorithm

The pseudocode of the flower pollination algorithm is shown in Figure 1.

**Algorithm 1** Flower Pollination Algorithm pseudo-code

```
Objective min f(x), x ∈ ℜ^d
Initialize a population of n flowers/pollen with random solutions
Fins the best solution g* in the initial population
Define a switch probability p ∈ [0, 1]
Calculate all f(x) for n solutions
t=0
while t ≤ MaxGeneration do
  for i = 1, ..., n do
    if rnd ≤ p then
      Draw a (d-dimensional) step vector L which obeys a Lévy distribution
      Global pollination via x_i^{t+1} = x_i^t + L * (g* − x_i^t)
    else
      Draw from a uniform distribution ε ∈ [0,1]
      Randomly choose j and k among all solutions
      Do local pollination via x_i^{t+1} = x_i^t + ε (x_j^t − x_k^t)
    end if
    Calculate all new f(x^{t+1})
    if f(x^{t+1}) ≤ f(x^t) then
      x^t = x^{t+1}
    end if
  end for
  Find the current best solution g* among all x_i^t
  t = t + 1
end while
```

**Figure 1 Pseudocode of the Flower Pollination Algorithm**

## 3. PROPOSED METHOD

In this section, the proposed method is explained that designed for economic load dispatch problem using an improved flower pollination algorithm. The flowchart of the proposed algorithm is shown in Figure 2. The steps are performed for the proposed algorithm are given below.

1. Define the initial control parameters of the improved FPA algorithm such as initial population, number of iterations, constant parameters, and power plant parameters which includes power generation boundary of the power plant, cost coefficient, and loss coefficient
2. The chaotic logistic map algorithm is used to generate the initial population.
3. Evaluate the fitness function of the initial population and store the optimal solution.
4. The population is updated using the flower pollination algorithm. Further, evaluate the fitness function of the updated population and compared it with the previous optimal results. If the updated population is superior to the previous optimal results then the optimal solution is updated else no update in the optimal solution.
5. The whole process is repeated until stopping criteria are not found.
6. The performance analysis is done for the proposed algorithm.

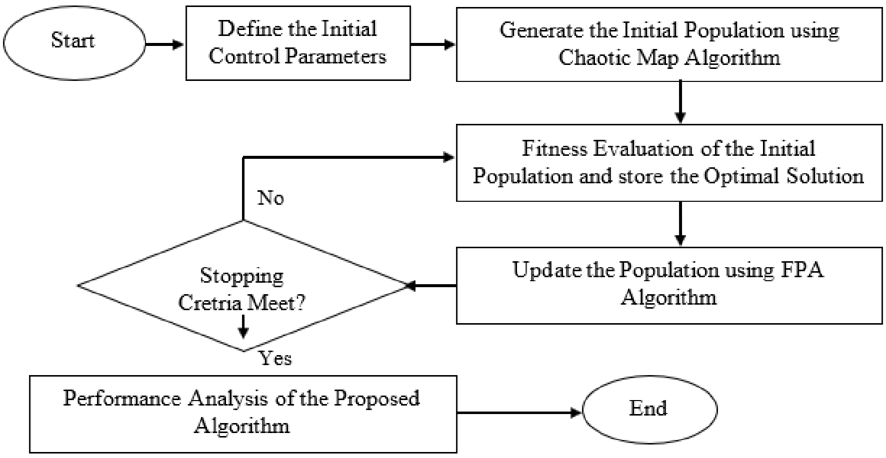


**Figure 2 Flowchart of the Proposed Algorithm**

## 4. EXPERIMENTAL RESULTS

To validate the performance of the proposed algorithm, the algorithm is coded and simulated in MATLAB. In this paper, we have taken a three-unit system case study under consideration. The unit characteristics are given in Table 2. In this case, each individual Pg contains three generator power outputs, such as P1, P2, and P3, which are generated randomly. The dimension of the population is equal to 3 X 100.

**Table 2 Generating Unit's Capacity and Coefficients**

| Unit | $P_{min}$ MW | $P_{max}$ MW | $\alpha$ $ | $\beta$ $/MW | $\gamma$ $/MW$^2$ |
|---|---|---|---|---|---|
| 1 | 50 | 250 | 328.13 | 8.663 | 0.00525 |

Next, Table 3 provides the statistical results that involved the total power, generation cost, and power loss. The results show that the proposed method takes less generation cost and provides fewer power losses.

**Table 3 Comparative Analysis based on Various Parameters with the Existing Methods [9]**

| Parameters | Existing Methods [9] | | | Proposed Method |
|---|---|---|---|---|
| | GA | PSO | FPA | |
| P1(MW) | 194.26 | 209 | 207.64 | 201.32 |
| P2(MW) | 50 | 85.92 | 87.284 | 81.836 |
| P3(MW) | 79.627 | 15 | 15 | 26.168 |
| Total Power(MW) | 323.89 | 309.92 | 309.92 | 309.32 |
| Generation Cost ($/h) | 3737.2 | 3621.8 | 3619.8 | 3602.9 |
| Power Loss | 24.012 | 9.9833 | 9.9204 | 9.3205 |

## 5. CONCLUSION AND FUTURE SCOPE

In this paper, we have designed an improved FPA algorithm to find the optimal solution to the ELD problem. In the improved FPA, the initial population is generated using the chaotic map algorithm to overcome the local optima problem of the FPA algorithm. In the experimental results, a 3-unit system case study is taken and various performance parameters are calculated for it. The results show that the proposed method takes less generation cost and power losses as compared to the existing optimization algorithms. In the future, we will explore other optimization algorithms that provide a fast convergence rate to find the optimal solutions.

## 6. REFERENCES


[1] Zhang, J., Zhang, J., Zhang, F., Chi, M., & Wan, L. (2021). An Improved Symbiosis Particle Swarm Optimization for Solving Economic Load Dispatch Problem. *Journal of Electrical and Computer Engineering*, *2021*.

[2] Park, J. B., Jeong, Y. W., Shin, J. R., & Lee, K. Y. (2009). An improved particle swarm optimization for nonconvex economic dispatch problems. *IEEE Transactions on power systems*, *25*(1), 156-166.

[3] Ayalew, M. F. ECONOMIC LOAD DISPATCH PROBLEMS IN SMART GRID: A REVIEW.

[4] Nemati, M., Braun, M., & Tenbohlen, S. (2018). Optimization of unit commitment and economic dispatch in microgrids based on genetic algorithm and mixed integer linear programming. *Applied energy*, *210*, 944-963.

[5] Panigrahi, B. K., Pandi, V. R., & Das, S. (2008). Adaptive particle swarm optimization approach for static and dynamic economic load dispatch. *Energy conversion and management*, *49*(6), 1407-1415.

[6] Younes, Z., Alhamrouni, I., Mekhilef, S., & Reyasudin, M. (2021). A memory-based gravitational search algorithm for solving economic dispatch problem in micro-grid. *Ain Shams Engineering Journal*.

[7] Abdelaziz, A. Y., Ali, E. S., & Abd Elazim, S. M. (2016). Implementation of flower pollination algorithm for solving economic load dispatch and combined economic emission dispatch problems in power systems. *Energy*, *101*, 506-518.

[8] Jebaraj, L., Venkatesan, C., Soubache, I., & Rajan, C. C. A. (2017). Application of differential evolution algorithm in static and dynamic economic or emission dispatch problem: A review. *Renewable and Sustainable Energy Reviews*, *77*, 1206-1220.

[9] Suman, M., & Sakthivel, V. P. (2018). SOLUTION TO ECONOMIC DISPATCH PROBLEM USING FLOWER POLLINATION ALGORITHM. *International Journal of Pure and Applied Mathematics*, *118*(18), 3827-3832.

[10] Kaur, A., Pal, S. K., & Singh, A. P. (2020). Hybridization of Chaos and Flower Pollination Algorithm over K-Means for data clustering. *Applied Soft Computing*, *97*, 105523.

[11] Alyasseri, Z. A. A., Khader, A. T., Al-Betar, M. A., Awadallah, M. A., & Yang, X. S. (2018). Variants of the flower pollination algorithm: a review. *Nature-Inspired Algorithms and Applied Optimization*, 91-118.


 