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An Improved PSO (IPSO) Method to Solve Multi-Area Economic Dispatch

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Abstract - The purpose of the MAED problem is to optimize the distribution of producing resources across multiple locations in order to meet demand while minimizing costs and conforming to operational limits. Advanced procedures such as IPSO are often required since traditional optimization strategies fail miserably when faced with the complexities of multi-area systems. By integrating adaptive parameter adjustment methods, diversity maintenance techniques, and problem-specific operators, IPSO improves upon standard Particle Swarm Optimization (PSO) algorithms. The Multi Area Economic Dispatch (MAED) problem is addressed in this study by introducing enhanced PSO (IPSO). In addition, the control equation's operational parameters are adjusted so that the swarm's social and cognitive behaviors are more balanced. 40 generators make up the test setup that was used to determine how well the suggested technique worked. When applied to the large-dimensional MAED issue, IPSO shows great promise, according to the findings of the application.

Keywords: - Economic Dispatch, Algorithms, Energy, Fuel, Swarm Optimization

I.Introduction

When it comes to optimizing power systems, the economic dispatch (ED) problem is a major obstacle, particularly in complicated and interconnected multi-area power systems. In order to fulfill the demand and adhere to operational restrictions, efficient economic dispatch makes sure that generation resources are distributed optimally across numerous locations. Numerous optimization methods have been suggested to address this complex issue; however, Particle Swarm Optimization (PSO) has been the go-to method owing to its efficacy and ease of use. When dealing with multi-area economic dispatch, however, classic PSO approaches struggle due to its complexity and inherent volatility.

The IPSO method is a huge step forward in power system optimization because it provides a more nuanced way to deal with the problems caused by multi-area economic dispatch. When applied to complicated multi-area systems, classical PSO algorithms may be made more resilient, have faster convergence, and more accurate solutions with the help of IPSO by including new methods and improving critical parameters. To set the stage for what is to come, this introduction will give you a rundown of what the IPSO approach is and how it has impacted power system optimization. Solving the economic dispatch problem boils down to finding the best way to distribute generation resources across different regions in order to fulfill demand while keeping costs down and taking into account limitations imposed by things like transmission line capabilities, environmental rules, and generator limits. Power exchanges between areas, varied demand patterns, and uncertainty in renewable energy integration are just a few of the extra complications introduced by the linked nature of power networks in a multi-area scenario. Due to the increased difficulty of the optimization problem, sophisticated optimization methods are required to deal with the nuances of multi-area economic dispatch.

To varied degrees of success, the economic dispatch problem has been tackled using traditional optimization approaches, such as evolutionary algorithms and gradient-based techniques. The high-dimensional search space and non-linear limitations that are typical of multi-area systems, however, reduce their efficacy. On the other hand, metaheuristic optimization algorithms like PSO have become popular because they can quickly traverse complicated search spaces and discover near-optimal solutions without using gradient information. Traditional PSO algorithms learn from the actions of groups of people, such as fish schools or flocks of birds, and then use that information to refine a set of potential solutions (particles). While conventional PSO approaches work well for economic dispatch in a single area, they have problems when applied to systems with more than one area, such as a lack of variety in solutions, inferior performance when dealing with limitations, and early convergence. Due of these restrictions, optimization methods that can handle the specifics of multi-area economic dispatch issues are much needed.

To overcome these obstacles, a new strategy for improving PSO algorithm performance in multi-area economic dispatch applications called Improved PSO (IPSO) has been proposed. To address the shortcomings of classic PSO techniques and make them more applicable to tackling complicated optimization issues in power systems, IPSO contains a number of improvements and upgrades. Adjustable procedures for adjusting parameters, variety maintenance tactics, and operators designed to address the unique challenges of multi-area economic dispatch are some of IPSO's most prominent aspects. Adaptive control parameter adjustment, including inertia weight and acceleration coefficients, is one of IPSO's unique qualities that allows it to optimize various parameters. To improve convergence speed and solution quality, IPSO dynamically adjusts these settings depending on the swarm's development and the problem's features. This allows for an appropriate balance between exploration and exploitation. Also, to keep solutions diverse and avoid early convergence, IPSO incorporates diversity maintenance techniques including mutation operators and crowding-based selection.

In addition, IPSO uses operators and heuristics that are relevant to the topic, meaning they are designed to handle the specifics of multi-area economic dispatch issues. Methods for dealing with limitations like transmission line restrictions and reserve needs are part of this, as are plans to deal with the unknowns of demand predictions and renewable power production.

Compared to conventional PSO algorithms and other optimization methods, IPSO achieves better performance by tailoring the optimization process to multi-area system complexities.

II.Review Of Literature

Chopra, Namarta et al., (2021) Premature convergence, entrapment in the local optimal solution, and stagnation in the solution as the number of iterations is increased are some of the drawbacks of the particle swarm optimization technique, which is an optimization strategy that has been successfully utilized in a variety of engineering problems. However, it does have certain drawbacks, such as these. This article provides a novel hybrid technique that is built by merging the stochastic and deterministic approaches. The hybrid method is developed by combining the two approaches used in the previous article. The conventional particle swarm optimization is merged with the simplex search strategy in order to alleviate the constraints and enhance the results. This is done with the intention of overcoming the limits. The rise in the results is explained by testing the recommended algorithm in a real environment constrained economic dispatch scenario that includes losses. This scenario was used to see how the program performed. The results that were achieved are compared to the results that were acquired using traditional PSO as well as other optimization approaches that have been published in the literature. In addition, the approach that was presented is assessed by employing a number of benchmark functions in order to demonstrate that it is suitable for usage in a range of engineering software applications. Taking into consideration the outcomes, it is evident that the technique is both effective and dependable throughout the entirety of the genuine applications.

Abbas, Ghulam et al., (2017) Some modern metaheuristic optimization techniques are being used to solve a single-objective economic dispatch (ED) problem. The already complex dispatch issues are made much more so when operational and system restrictions are considered. Network transmission losses, valve-point loading (VPL) effects, ramp rate limits (RRL), prohibited operating zones (POZ), multiple fuel (MF) options, spinning reserve, and similar factors are all examples of such constraints. To meet the ever-increasing demand, a number of steam admission valves are sequentially opened. The heavy constraints drastically change the linear smooth dispatch problem from convex to highly nonconvex, nonlinear, and nonsmooth. It is difficult to find the optimal solution to a limited nonlinear problem utilizing optimization methods based on deterministic numerical and convex features. This is due to the fact that the issue is contained. One of the metaheuristic optimization methods commonly used to solve this challenging and time-consuming dispatch problem is particle swarm optimization (PSO), which makes use of a large computation. Part one of this two-part article provides a comprehensive overview of PSO and its variants, which include changes to PSO's core structure. Our goal in writing this study is to identify potential solutions to the limited ED issue. Part II is devoted to solving the ED problem and focuses entirely on studying hybrid versions of PSO, which combine PSO with other optimization methods. Readers may be able to understand how PSO may be enhanced to be more computationally efficient thanks to the survey's presentation.

Nguyen, T.T. & Vo, Dieu (2016) In this article, eight IPSO algorithms are introduced to tackle the Combined Heat and Power Economic Dispatch (CHPED) issue. These programs account for transmission losses and the effects of valve point loading on fuel cost function. Determining the power and heat output of the available units is crucial to the issue since it will help minimize the overall fuel cost while satisfying power and heat demands and limits. By adjusting a few parameters and assuming a Cauchy distribution, the proposed IPSO algorithms work. We used six separate test systems to validate the efficacy of the IPSO approaches. In three of these systems, transmission losses were disregarded because the fuel cost function of pure power units was quadratic. In two of these systems, transmission losses were considered because the fuel cost function was nonconvex. Finally, in one large-scale system, transmission losses were disregarded because the fuel cost function was nonconvex. When looking at solution quality and computation time, IPSO techniques outperform other approaches in the literature. Based on this, it seems like the offered options are the way to go. Therefore, the proposed IPSO methods would effectively address the nonconvex CHPED problem.

Kumar, Nimish et al., (2015) Scheduling the outputs of the connected producing units of the plant is the main objective of the Economic Load Dispatch (ELD) problem, which aims to fulfill load demands while minimizing operating costs and satisfying all operational limitations. A recent and successful solution to the ELD problem was to use particle swarm optimization techniques, which are based on swarm behavior. A stochastic optimization approach based on populations is driven by a social psychological metaphor. Three improved PSO algorithms, IPSO-A, IPSO-B, and IPSO-C, were developed and implemented in this study to handle ELD for IEEE 5, 14, and 30 bus systems. Combining the inertia weight with the constriction factor is one way to solve the ELD problem using conventional partial differential optimization (CPSO). Twenty independent experiments using PSO algorithms have been carried out. We have determined the standard deviation, maximum and minimum fitness, and average fitness for every algorithm. The results show that the proposed improved PSO techniques provide the most consistent variety of results at the lowest operating cost.

Sharma, Rakesh et al., (2014) This study introduces a trustworthy and effective method for solving economic dispatch (ED) problems by using the particle swarm optimization (PSO) method. This PSO method is superior since it is faster to compute. In this study, we compare the cost in Rs./hr. and C.P.U. time for 15 runs with the same swarm size and number of iterations. After looking at many methods, we could find that PSO provides a better result in less time. At the end of a certain amount of repetitions, one may also learn how the particle converged in search space to the global best solution point. The C.P.U. time may also be obtained with the same number of iterations but with different sizes. Overall, the PSO technique outperforms its predecessors in terms of efficiency and effectiveness when it comes to solving ED problems.

Wu, Peifeng et al., (2014) An improved particle swarm optimization (IPSO) approach is used to address the economic dispatch problem (EDP). There are two distinct approaches to position updates in the IPSO. Although we are still in the early phases of the iteration process, everyone in the population is expected to update their position based on their best experience, most likely. Later on in the iterative process, the individual will revise their viewpoint based on the population's most beneficial experience, which they can likely deliver. After the position is updated, the IPSO also includes a mutation operator. By preventing the population from converging too soon, this operator may increase its diversity. In order to solve EDP with valve point effect, IPSO has been used. When applied to EDP, the experimental findings show that IPSO is an effective solution.

Chiang, Chao-Lung (2012) An improved version of the particle swarm optimization (IPSO) technique for power economic dispatch (PED) that accounts for units with prohibited operating zones (POZ) is introduced in this work. With its migration capacity and hastened functionality, the IPSO can actively study possible solutions and execute searches efficiently. Managing the power system's inequality and equality needs has never been easier than using the multiplier update (MU) approach. To prove that the proposed algorithm works, we look at a real-world example and compare the computing results of the recommended method to those of other methods. Combining IPSO with MU, or Modified Unimodal Optimization, is the name of the game in the suggested method. Multiple benefits accrue from this integration: simplified implementation, handling of non-convex fuel cost functions, increased efficiency compared to Particle Swarm Optimization with the MU (PSO-MU), and the capacity to solve the optimal Power Economic Dispatch (PED) problem for generators with Piecewise Quadratic Cost Functions (POZ) using a small population size.

Pandit, Manjaree (2011) To lower the astronomical costs of producing power in fossil fuel plants, economic dispatch is essential. Typical gradient-based optimization methods fail miserably when applied to the economic dispatch problem for practical generators, which is now a difficult, non-convex, multimodal optimization problem. There are a number of constraints that, when met, increase the degree of complexity. This research aims to improve upon previous work on particle swarm optimization by developing IPSO, a strategy for handling static and dynamic economic dispatch issues that are not convex. When dealing with complex multimodal functions, the traditional PSO method suffers from the problem of premature convergence. By resetting the velocity vector when saturation occurs, IPSO improves CPSO's search capabilities. Its second objective is to create an ideal balance between local and global search using a parameter automation approach. We have tested IPSO in five different standardized environments to see how well it performs. The results are evaluated against the current literature and found to be on par with or even better than it.

Park, Jong-Bae et al., (2010) In this paper, we provide an improved particle swarm optimization (IPSO) approach to solving economic dispatch (ED) problems with nonconvex cost functions. For nonconvex optimization problems with heavy constraints, particle swarm optimization (PSO) approaches have many advantages, but they do have certain drawbacks. Some examples of these issues include the exploration problem, which is when you get stuck in local optima because of premature convergence; the exploitation problem, which is when you can't find nearby extreme points; and the constraint handling problem, which is when you don't have an efficient mechanism to deal with constraints. Incorporating chaotic sequences, linearly decreasing inertia weights, and a crossover operation method, this study proposes an upgraded Particle Swarm Optimization (PSO) framework. Improving the PSO's ability to discover and use solutions is the aim. To top it all off, we take equality and inequality constraints into consideration using an expert constraint management methodology. Three separate nonconvex Economic Dispatch (ED) problems are handled by the proposed Integrated Power System Optimization (IPSO). Among these difficulties include valve-point

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effects, ramp rate limits in prohibited operating zones, losses in the transmission network, and the use of several fuels simultaneously. It is also integrated into Korea's vast electrical grid. The results are also compared to those from the most cutting-edge methods that are currently accessible.

III.Proposed Algorithm

A non-convexity in the generator cost function is seen as a result of valve-point loading effects, and the suggested approach is evaluated on four different locations including a system with forty generators. By use of six tie-lines, all of the regions are linked to one another. The greatest number of iterations that are deemed to be possible for this system is 1500, and the population size is specified to be fifty. In order to build the suggested technique, MATLAB was used, and the simulations were performed on a personal computer equipped with an Intel i5 processor, 3.2 GHz, and 4 GB of random access memory (RAM).

IV.Results And Discussion

The experiments that are performed on this system are what establish the best possible value for ks. PSO runs with ks ranging from 0.05 to 0.25 and a step size of 0.05 were recommended for the goal of achieving the desired consequence. When the value of ks is 0.10, it has been noticed that the optimum value of the average fuel cost and the standard deviation (STD) is reached. As a result, the value of ks that will be used for simulations is 0.10. This system is now being used to implement the planned IPSO, and the results of the application, which were acquired after 100 trials, are provided in Table 1. From a computational perspective, the table also indicates that IPSO is far less resource-intensive than any of the other methods. To emphasize the impact of the suggested changes in the control equation of the Particle Swarm Optimization (PSO), the resulting variations of PSO are categorized as 'b', 'c', and 'd'. 'a' represents the conventional PSO, 'b' represents 'a' with exponential adjustments in the inertia weight, 'c' represents 'b' with the inclusion of previous experience in the cognitive component, and 'd' represents the proposed Improved PSO (IPSO).

Table 1: Comparing fuel cost

Method	Best fuel cost ($/hr)	Average fuel cost ($/hr)	Worst fuel Cost ($/hr)	CPU time (s)
RCGA	129909.7	-	-	159.8
EP	124572.2	-	-	145.1
DE	124546.5	-	-	135.2
ABCO	124011.1	-	-	127.1
IPSO	122460.3	123228.0	125566.6	47.2

Figures 1 and 2 provide a comparison of the convergence characteristics for the set of best and average fuel cost, respectively.

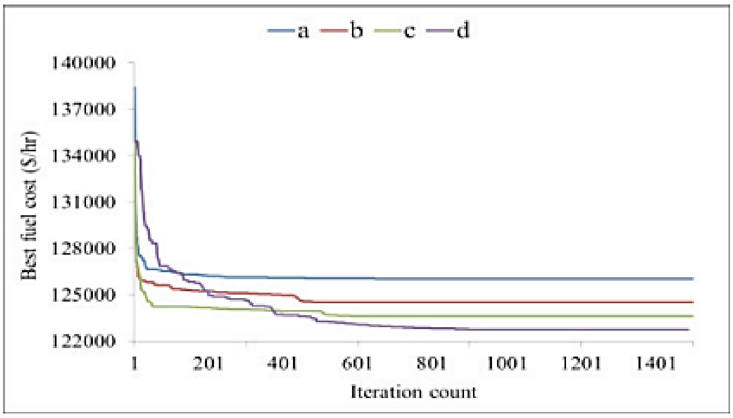

Figure 1: Convergence feature for best fuel cost

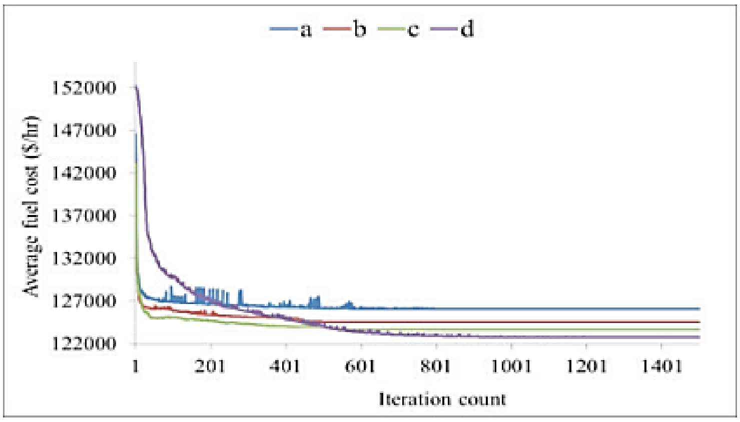

Figure 2: Convergence feature for average fuel cost

Figure 1 demonstrates that modifying the inertia weight, cognitive component, and social component in the control equation of the basic PSO leads to improved convergence characteristics by progressively avoiding local trappings. Upon examining the picture, it is evident that the initial pattern of convergence is generally uniform, except for IPSO. Therefore, the incorporation of the constriction factor in the social component of a particle's velocity is a significant contributing element to the enhanced convergence in IPSO. Figure 2 also supports this view. It is clear from the graphic that particles are not able to locate the potential area during early iterations when IPSO is used alone. Consequently, it's beneficial to use this area carefully, which results in higher-quality solutions.

V.Conclusion

The feasibility of the suggested approach has been examined for addressing the intricate MAED issue in a test generation system of significant magnitude, including diverse operational limitations. The application results demonstrate the efficacy of the suggested strategy and its ability to avoid being stuck in local minima. The analysis of application outcomes demonstrates that the suggested approach is capable of generating superior quality solutions and is more computationally efficient compared to other known strategies. It is important to mention that the suggested IPSO does not need any extra mechanism to prevent local entrapment, and use an empirical formula to limit the velocity of particles, hence reducing the search space. Furthermore, it is unaffected by the starting condition of particles.

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