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OPTIMIZATION TECHNIQUES IN POWER SYSTEM: REVIEW

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Abstract — **Power systems are very large and complex, it can be influenced by many unexpected events this makes Power system optimization problems difficult to solve, hence methods for solving these problems ought to be, an active research topic. This review presents an overview of important mathematical optimization methods those are Unconstrained optimization approaches Nonlinear programming (NLP), Linear programming (LP), Quadratic programming (QP), Generalized reduced gradient method, Newton method, Network flow programming (NFP), Mixed-integer programming (MIP), Interior point (IP) methods and Artificial intelligence (AI) techniques such as Artificial Neural Network (ANN), fuzzy logic,Genetic Algorithm (GA), Particle Swarm Optimization (PSO),Tabu Search (TS) algorithm, etc. and Hybrid artificial intelligent techniques are discussed. And also applications of optimization techniques have been discussed. Finally classification, application area, observation, conclusion, and recommendation for future research work will be forwarded.**

Keywords— **NLP, QP, AI, Hybrid AI, PSO, GA, etc.**

I. INTRODUCTION

It's known that Power systems are very large, complex and geographically distributed. Therefore, to take the advantages in simplifying the problem and its implementation it is necessary to utilize most efficient optimization methods. Related to the power system operation numerous activities require optimum searching techniques K wang Lee. Et al. (2008) Many researchers working with optimization techniques to solve economic issue, reliability, quality, optimal load flow, protection, cost and soon. D. Hore. et al. (2013) presented about Artificial Intelligence methods such as GA, PSO, BFO, ANN that used for Optimal Power Flow and economic load dispatch problem.

K. Liu. et al. (2006) combined adaptive genetic algorithm with Simulated annealing was presented to solve active power loss minimization. J. Lu. et al. (2010) presented the techniques of GA and PSO are combined to obtain good particles from genetic algorithm for the initial population input of PSO. A. Badar. et al. (2014) Improved or hybrid artificial intelligence methods have been discussed after Genetic algorithm, Particle Swarm Optimization, Ant Colony Optimization, Tabu Search, Simulated Annealing and Differential Evolution presented. Binitha S. et al. (2012) presents an overview of biologically inspired optimization algorithms which grouped by the biological and application areas. O.P. Malik. (2004) the possibility of implementing an adapting controller using different approach has been presented. G. Hwang. et al. (2007) to determine the optimal PID gain Craziness based Particle Swarm Optimization (CRPSO) and binary coded GA methods has been proposed. V. Mukherjee. et al. (2008) propose the hierarchical fuzzy PSS to enhance stability.

M. Caner. et al. (2008). was used Bacteria Foraging Optimization (BFO) technique. S.P. Ghoshal. et al. (2009) to design PSS A robust adaptive fuzzy controller proposed. A. Badar. et al. (2014) has been presented an overview of different artificial intelligence (AI) optimization techniques used in power optimization problems and a Hybrid or improved AI techniques. Yuvaraja T. et al. (2015) was presented the performance of the implemented PSO algorithm for solving an optimization problem that is related to improving the quality of the power supply in a Microgrid scenario. S. Khajeh. et al. (2016) was presented Genetic algorithm for Optimal Reconfiguration of Power Distribution Systems in radial 33 buses distribution network. S. H. Kiran.et al. (2016) has been presented Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC) with Hybrid-Genetic Algorithm (H-GA) for determination of sizing of FACTS.

A. K. Khamees. et al. (2017) proposed shuffled frog leaping algorithm and grey wolf optimizer, to solve the optimal power flow problem in electrical power system. C. M. K. Sivalingam. et al. (2017). Interactive artificial bee colony (IABC) was proposed to obtain reactive power optimization after comparing the results obtained from IPSO, QPSO, ABCO, and IABCO. Ö.P. Akkaş. et al. (2018) propose genetic algorithm to minimize fuel cost tested on 6-generator test system by ignoring line losses. S. Dean. et al. (2018) proposed a multi-stage procedure, called Coarse-ID control, that estimates a model from a few experimental trials, estimates the error in that model with respect to the truth, and then designs a controller using both the model. C.T.M. Clack .et al. (2015) shows that linear programming techniques can represent an electrical power system from a high-level without undue complication brought on by moving to mixed integer or nonlinear programming. Different optimization techniques with its invention year shown in Fig. 1:

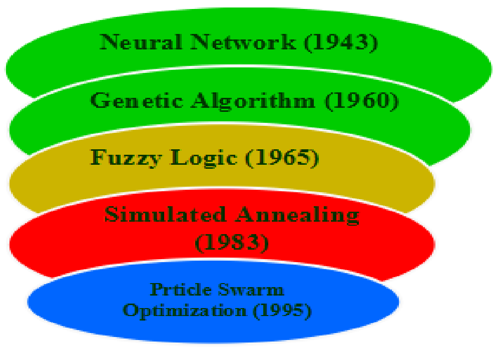

Fig. 1: Some optimization methods with its invention year

II. OVERVIEW OF OPTIMIZATION TECHINIQUES

The main objective of optimization is to minimize undesirable things (e.g. cost, energy loss, errors, etc.) or maximize desirable things (e.g. profit, quality, efficiency, etc.) since its mathematical model, subject to some constraints. Optimization is a commonly encountered mathematical problem in all engineering disciplines. It literally means finding the best possible/desirable solution. Optimization problems are wide ranging and numerous, hence methods for solving these problems. From the view of optimization, the various techniques including traditional and modern optimization methods, which have been developed to solve power system operation , control and planing problems.

III. CLASSIFICATION OF OPTIMIZATION TECHNIQUES

Basically optimization techniques are classified into three groups. Which are traditional method, Artificial intelligent method and hybrid artificial intelligent techniques.

A. Traditional Method

Traditional methods are optimality mathematical rigorous in some algorithms and problems can be formulated to take advantage of the existing sparsity techniques applicable to large-scale power systems. Those methods are Unconstrained optimization approaches Nonlinear programming (NLP), Linear programming (LP), Quadratic programming (QP), Generalized reduced gradient method, Newton method, Network flow programming (NFP), Mixed-integer programming (MIP), Interior point (IP) methods and soon[50-56].

B. Artificial Intelligent Techniques

Artificial Intelligence (AI) techniques proved to be effective tools to resolve many power system problems and that they could be more effective when properly joined together with conventional mathematical approaches [43-46]. These techniques are Artificial Neural Network (ANN), Fuzzy logic, intelligent optimization, genetic algorithm, particle swarm optimization and soon. Different PSSs were proposed based on these AI techniques [2,5,7,12,16,29,61,64,67,95].

C. Hybrid AI Techniques

Power system problems may effectively solved by the strengths and capabilities or fit the assumptions of a single AI technique. One approach to deal with these complex real world problems is to integrate the two or more techniques in order to combine their strengths and overcome each others weaknesses to generate hybrid solutions [29]. Those techniques are Fuzzy neural network systems Fuzzy/ neural/expert/genetic systems, Simulated annealing with, fuzzy/genetic/expert systems and soon [21-28].

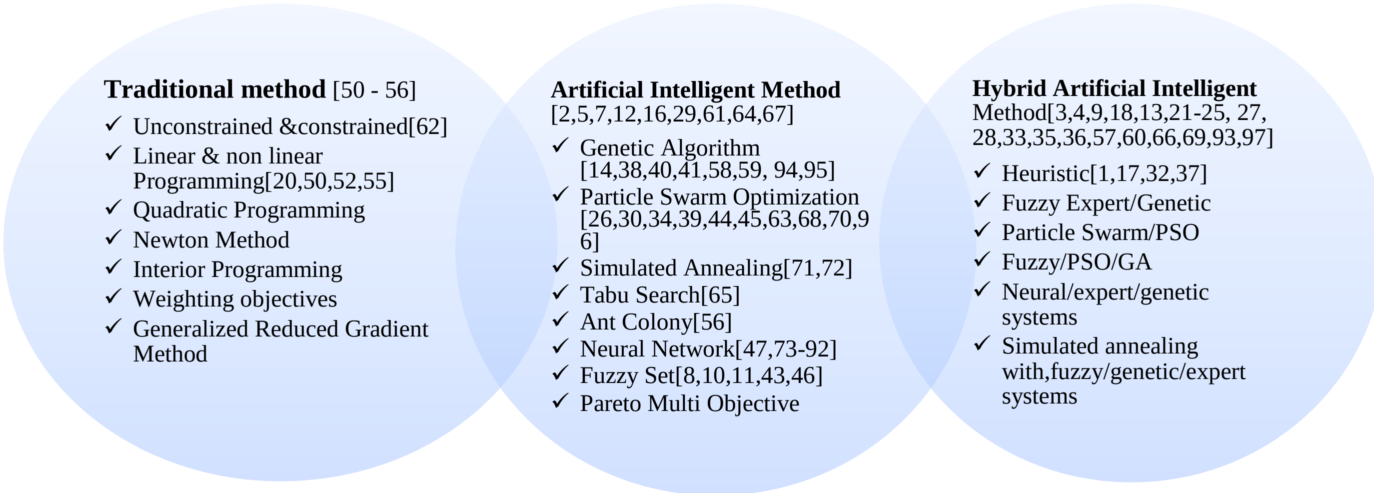

Fig. 1: Classification of optimization techniques and related works

IV. APPLICATION AREAS OF OPTIMIZATION TECHNIQUES

Optimization techniques are applicable on different power system stages such as generation, transmission , distribution and customers side for minimizing different problems, and its percentage applicability as shown Fig. 3: The application areas are shown in table 1 and its classification with optimization problem is shown in Fig. 2:

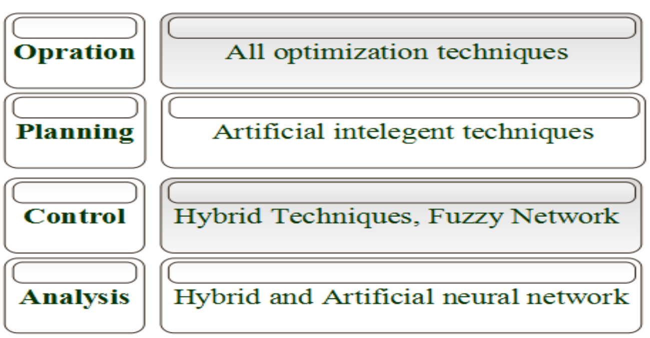

Fig. 2: Classification of optimization methods with its application depend on table 1.

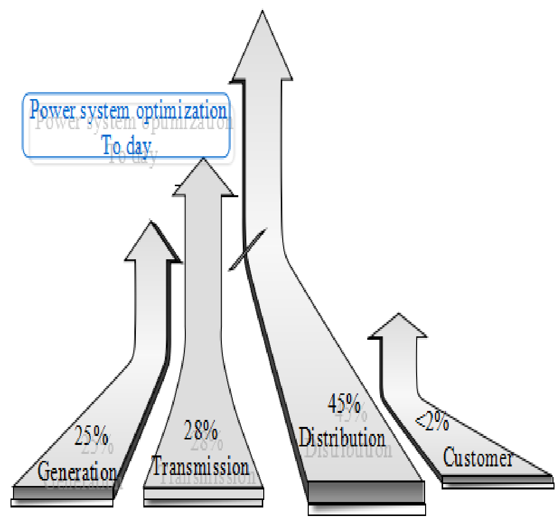

Fig.3: Optimization techniques percentage applicability on power systems today

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Table 1: Application of optimization techniques and related works.

Operation [2,5,12-19,26,27,31-34,38-42,45,46,50-66,68-71,81-90,96,97]	Control [3,4,6,7,9,10,36, 43,44,79, 92]	Planning [20-23,25,28,35,67, 72 - 78,80, 91,94,95]	Analysis [8,11,24,47,93]
✓ Constrained load flow ✓ Unit commitment / economic dispatch ✓ Optimal power flow ✓ Voltage/Var and loss reduction ✓ Dynamic load modeling ✓ Short-Term load forecast ✓ Network reconfiguration and load reduction ✓ Market operations, etc. ✓ Fault diagnosis ✓ Stability/Transient stability ✓ Static and dynamic security assessment	✓ Prioritizing investments in distribution network ✓ Optimal protection and switching device placement ✓ Reactive power control ✓ Power system control ✓ Relaying ✓ FACTS (Flexible AC Transmission System) control	✓ Reactive power planning ✓ Generation expansion planning ✓ Generation and distribution ✓ Generation scheduling ✓ Maintenance scheduling ✓ Power mix planning ✓ Capacitor placement/ voltage control ✓ Hydro scheduling ✓ Long term load foretasting	✓ Power system stabilizer ✓ Power plant operation optimizer

V. ADVANTAGES AND DISADVANTAGES ARTIFICIAL INTELLIGENT TECHNIQUES OVER TRADITIONAL METHODS

A. Advantages

- Artificial intelligent methods applicable for smart grid because of it's modernity.
- Genetic algorithm needs only rough information of the objective function and places no restriction such as differentiability and convexity on the objective function.
- Genetic algorithm works with a set of solutions from one generation to the next, and not a single solution, thus making it less likely to converge on local minima.
- Genetic algorithm the solutions of developed are randomly based on the probability rate of the genetic operators such as mutation and crossover; the initial solutions thus would not dictate the search direction of GA.
- Fuzzy logic is more accurately represents the operational constraints of power systems and Fuzzified constraints are softer than traditional constraints
- Ant Colony Search technique has been mainly used in finding the shortest route for transmission network
- The advantages of simulated annealing are, general applicability to deal with arbitrary systems and cost functions its ability to refine optimal solution, and its simplicity of implementation even for complex problems.

B. Disadvantages

- Poor computational of the Ant Colony Search is the main drawback of this technique.
- The major drawback of simulated annealing is repeated annealing.
- Genetic algorithm method is requires tremendously high time.

VI. OBSERVATIONS

- Some authors work with hybrid artificial intelligent technique's for better performance of all optimization problem.
- Others indicating Swarm intelligence have more potential in power system analysis and they are also the most recent in the field of computational intelligence technique.
- Many researcher indicates that simulated annealing are selected for arbitrary system , cost functions, refine optimal solution and simplicity of implementation complex problem.
- Artificial intelligence problems require use of knowledge bases to store human knowledge, operator judgment particularly in practical solutions, experience gained over a period of time, characterization by network uncertainty, load variations, etc.
- Power system optimization is aimed at improvements in more areas than cost: reliability, efficiency, economics, environmental friendliness, security.

VII. CONCLUSION AND RECOMMENDATION

A. Conclusion

Power system planning and operation raises many important decision making problems, which are generally stated as large scale, nonlinear, mixed integer continuous, and non-convex stochastic and or robust optimization problems. Many researcher works with different optimization techniques but still the issue is not solved. Using artificial intelligent techniques is the better choice compared with traditional methods but for any power system optimization problem hybrid artificial intelligent optimization techniques are still not comparable. Generally this review indicates which optimization techniques appropriate for power system problem such as profit, quality, efficiency and soon.

B. Recommendation

- It is recommended that using PSO and BFO based techniques are faster and more advance method for finding optimum load flow solutions.
- Using Improved or hybrid artificial intelligence methods are recommended to combine the better performance characteristics of various search methods .
- GWO is the most useful technique for solving the complicated OPF problem.
- IABCO was one among various optimization methods that produces better results. Maintenance of voltage profile, reduction of power loss, and optimization of reactive power has been facilitated by the algorithm.
- Usage of meta-heuristic genetic algorithms is recommended to find the optimal location for placing the FACTS device.

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