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A comparative analysis for economic Laod dispatch with GA and PSO based solution

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Abstract
This paper presents an approach based on genetic algorithm as well as particle swarm optimization to solve the economic load dispatch (ELD) problem. A comparative analysis has been performed for both the processes in terms of fuel cost, allocation vector and transmission losses. Finally the performance of genetic algorithm has been analyzed to be better as compared to the pso based approach.

Keywords: ELD, GA, OPF, PSO, Mutation, Cross-Over.

Introduction

In a practical power system, power plants are not at the same distance from the centre of load and their fuel costs are different. Also, under normal operating condition the generation capacity is more than the total load demand and losses. Thus there are many options for scheduling generation
In an interconnected power system, the objective is to find the real & reactive power scheduling of each power plant in such a way as to minimizing the operating cost this means that the real &reactive power are allowed to vary within certain limits, so as to meet a particular load demand within minimum fuel cost. This is called optimal power flow (OPF) problem.
The OPF is used to optimize the power flow solution of a large scale power system.
This is done by minimizing selected objective functions while maintaining an acceptable system performance in terms of generator capability limits.

Operating Cost of a Thermal Plant

The factors influencing power generation at minimum cost are

- Operating efficiencies of generators
- Fuel cost
- Transmission losses

The most efficient generator does not guarantee minimum cost as it may be located in an area where fuel cost is high.
Again if the plant is located far from the load center, Transmission losses may be considerably higher and hence the plant may be overly uneconomical.
Hence the problem is to determine the generation of different plants such that the total operating cost is minimum

Proposed Method

Economic load dispatch problem is allocating loads to plants for minimum cost while meeting the constraints. It is formulated as an optimization problem of minimizing the total fuel cost of all committed plant while meeting the demand and losses. The variants of the problems are numerous which model the objective and the constraints in different ways.
The basic economic dispatch problem can described mathematically as a minimization of problem of minimizing the total fuel cost of all committed plants subject to the constraints.

$$Minimize \sum_{i=1}^{n} \mathrm{F_i}(P_i) \tag{A1}$$

$F_i(P_i)$ is the fuel cost equation of the 'i'th plant. It is the variation of fuel cost ($ or Rs) with generated power (MW).Normally it is expressed as continuous quadratic equation.

$$F_{ij}(P_i) = a_i P_i^2 + b_i P_i + c_i, \quad P_i^{\min} \le P_i \le P_i^{\max} \tag{A2}$$

The total generation should meet the total demand and transmission loss. The transmission loss can be determined form either B_{mn} coefficients or power flow.

$$\sum_{i=1}^{n} P_i = D + P_l \tag{A3}$$

$$P_l = \sum_{i}^{n} \sum_{j}^{n} B_{ij} P_i P_j \tag{A4}$$

Preliminary and background of Genetic Algorithm

Genetic algorithm(GA) uses the principles of evolution, natural selection and genetics from natural biological systems in a computer algorithm to simulate evolution. Essentially, the genetic algorithm is an optomization technique that performs a parallel, stochastic, but directed search to evolve the fittest population. The idea, in all the system based on Genetic algorithm, was to evolve a population of candidate solutions to a given problem, using operators inspired by natural genetic variation and natural selection.
Biological evolution is an appealing source of inspiration for addressing optimization problems. Evolution is, in effect, a method of searching among an enormous number of possibilities for "solutions." In biology the enormous set of possibilities is the set of possible genetic sequences, and the desired "solutions" are highly favorable organisms-organisms,

which are able to survive and reproduce in their environments. Evolution can also be seen as a method for designing innovative solutions to complex problems. The fitness criteria continually change as creatures evolve, so evolution is searching a constantly changing set of possibilities. Searching for solutions in the face of changing conditions is precisely what is required for adaptive computer programs. Furthermore, evolution is a massively parallel search method rather than a work on one species at a time. Evolution tests and changes millions of species in parallel.
Finally, viewed from a high level, the "rules" of evolution are remarkably simple: species evolve by means of random variation (via mutation, recombination, and other operators), followed by natural selection in which the fittest tend to survive over others.

Approach for Solving Eld Problem with Ga

1. Select a reference plant. For better convergence chose a plant which has maximum capacity and range. In this program. It is considered as plant 1. The reference plant allocation is fixed by the equations (A3&A4).
2. Convert the constrained optimization problem as an unconstrained problem by penalty function method.

Minimize

$$\sum_{i=1}^{n} F_i(P_i) + 1000 * abs(\sum_{i=1}^{n} P_i - D - \sum_{i=1}^{n}\sum_{j=1}^{n} B_{ij} P_i P_j)$$

3. The allocation minimum fuel cost and transmission losses can be determined.

Outline of the Ga Algorithm

- 00. START: Create random population of n chromosomes
- FITNESS: Evaluate fitness f(x) of each chromosome in the population
- NEW POPULATION

0 SELECTION: Based on f(x)

1. RECOMBINATION: Cross-over chromosomes
2. MUTATION: Mutate chromosomes
3. ACCEPTATION: Reject or accept new one

- REPLACE: Replace old with new population: the new generation
- TEST: Test problem criterium

LOOP: Continue step 1 – 4 until criterium is satisfied

Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a biologically inspired computational search and optimization method developed by Eberhart and Kennedy in 1995 based on the social behaviours of birds flocking and fish schooling.
Particle (X): It is a candidate solution represented by an m-dimensional vector, where m is the number of optimized parameters. At time t, the ith particle Xi(t) can be described as X i (t)=[X i1 (t),X i2 (t),.,X in (t)], where Xs are the optimized parameters and X ik (t) is the position of the ith particle with respect to the kth dimension; i.e. the value of the kth optimized parameter in the ith candidate solution.
Population, Pop (t): It is a set of n particle at time t, i.e. Pop (t) =[X 1 (t), X 2 (t), Xn (t)].
Swarm: It is an apparently disorganized population of moving particles that tend to cluster together towards a common optimum while each particle seems to be moving in a random direction.
Personal best (Pbest): The personal best position associated with ith particle is the best position that the particle has visited yielding the highest fitness value for that particle.
Global best (Gbest): The best position associated with ith particle that any particle in the swarm has visited yielding the highest fitness value for that particle. This represents the best fitness of all the particles of a swarm at any point of time.

Outline of the Pso Algorithm

1. Initialize the Fitness Function ie. Total cost function from the individual cost function of the various generating stations.
2. Initialize the PSO parameters Population size, C1, C2, WMAX, WMIN, error gradient etc.
3. Input the Fuel cost Functions, MW limits of the generating stations along with the B-coefficient matrix and the total power demand.
4. At the first step of the execution of the program a large no (equal to the population size) of vectors of active power satisfying the MW limits are randomly allocated.
5. For each vector of active power the value of the fitness function is calculated. All values obtained in an iteration are compared to obtain Pbest. At each iteration all values of the whole population till then are compared to obtain the Gbest. At each step these values are updated.
6. At each step error gradient is checked and the value of Gbest is plotted till it comes within the pre-specified range.
7. This final value of Gbest is the minimum cost and the active power vector represents the economic load dispatch solution.

Input Data

Data= [0.007 7 240 100 500
0.0095 10 200 50 200
0.009 8.5 220 80 300
0.009 11 200 50 150
0.008 10.5 220 50 200
0.0075 12 120 50 120];

Simulation Result

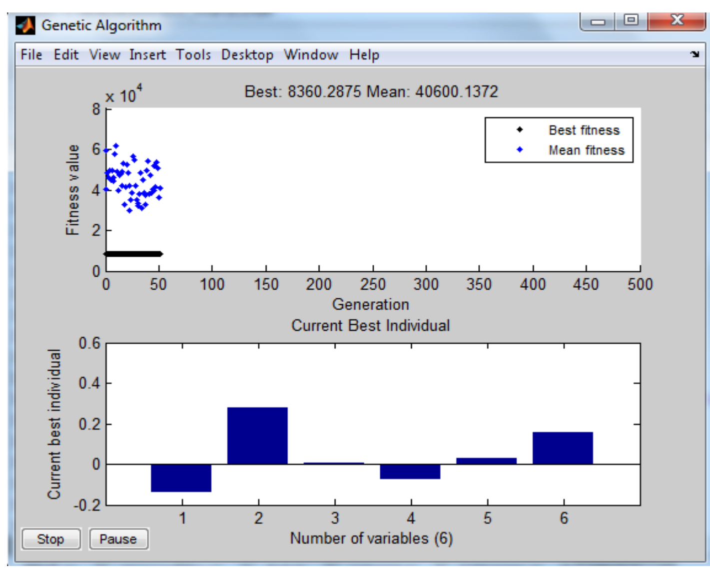

Fig 1.7: GA Results

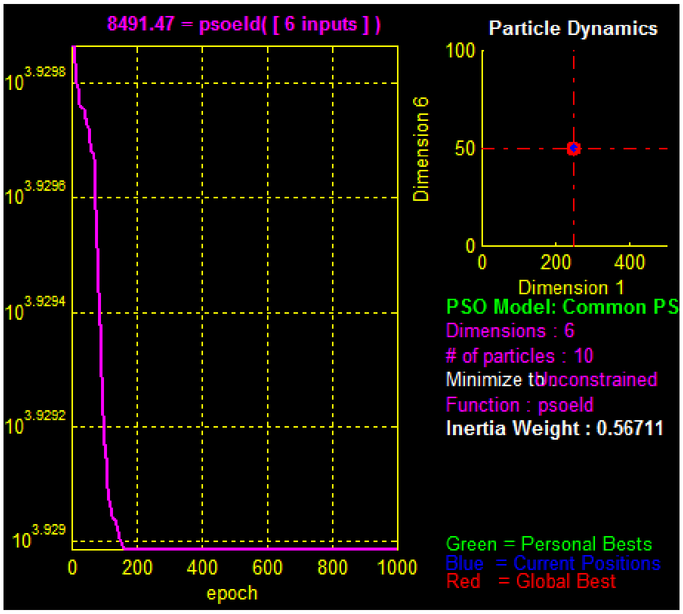

Fig 1.7: PSO Results

Results GA
F is the total fuel cost
F = 8.3603e+003
P1 is the allocation vector
P1 = 334.2802 71.1276 141.4308 50.3256 61.4439 52.0454
Pl is the transmission losss
Pl = 10.6535

Results PSO
Fcost1 is the total fuel cost
Fcost1 = 8.491469699865258e+003
P1 is the allocation vector

P1= 1.0e+002 *
2.839823520056184
0.926482631966597
1.746624718057400
0.500000000000000
0.705505479362552
0.500000000000000
Pl1 is the transmission losses
Pl1 = 21.843634944273205

Conclusion

This paper has attempted to solve economic load dispatch problem of the power system networks using genetic algorithm as well as particle Swarm optimization. The simulated results are obtained for a specified plant systems data. The Fuel Cost, allocation vector and transmission losses parameters are evaluated for both the processes and genetic algorithm is found to be the efficient technique among the two techniques.

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