A PSO Based Control Strategy for Combined Emission Economic Dispatch with Integrated Renewables

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Motivation And Project Goals:

- High penetration of integrated renewable energy sources requires scheduling of both conventional and renewable energy generators, to minimize the emission of pollutants and maximize the renewable energy resources.
- Design and implement a particle swarm optimization (PSO) based control strategy to control each independent region of power system and minimize the operational cost for the combined emission economic dispatch (CEED) problem.
- To develop an optimized cost function for calculating the operating cost for the power system based on the fitness of each particle(generator), wind and solar O&M cost.

Problem Formulation:

- The fuel cost function:
  \[ F_i(P_i(t)) = a_i + b_i * P_i(t) + c_i * P_i^2(t) + \sum_{j=1}^{n} e_{ij} * \sin[(P_i(t) - P_{ij})^2] \]
  Where, \( a_i, b_i, c_i \) and \( P_{ij} \) are coefficients of fuel cost and generator output and \( e_{ij} \) are coefficients to model valve point loading effect

- The emission cost function:
  \[ E_i(Y_i) = \alpha_i + \beta_i * Y_i + \epsilon_i * \exp(\mu_i * P_i(t)) \]
  Where, \( \alpha_i, \beta_i, \epsilon_i, \mu_i \) and \( P_i \) are the coefficients of emission cost and output of conventional generator respectively.

Conclusion:

- A combined emission economic dispatch problem was solved with effective integration of intermittent renewable energy sources via a PSO based control algorithm
- Optimally integrated wind and solar in the power system.
- Minimized the operational cost of traditional generators and found the optimal cost for the whole system for 24 hours.
PSO Algorithm and Evaluation of PSO

PARTICLE SWARM OPTIMIZATION: ALGORITHM STEPS

- **Step 1**: Initialize population and define the acceleration coefficients and weight inertia.

- **Step 2**: Create the structure for the particles and randomly select set points.

- **Step 3**: Define each particle Initial position and velocity, then for each particle calculate its best cost, position and find the global best.

- **Step 4**: Calculate the new velocity for every particle and update its new position, then, finally evaluate its fitness.

- **Step 5**: Repeat step-4 for all the combinations.

- **Step 6**: The objective function is used to evaluate optimized cost for all particles associated with all combinations at each time-interval.

EVALUATION OF FITNESS OF PSO:

The constraints have been set for the conventional generators, and wind generators. Thus if the constraints are violated then a penalty is applied to the cost function.

\[
C_{n} = \left( \sum_{i=1}^{j} G_{n} \right) - (T_{k})
\]

\[
\text{Pen}(k) = M\times \text{Pen}(k)
\]

\[
\text{Fitness}(k) = (C(k) + \text{Pen}(k))
\]

Where:

- \( C_{n} \) is the constraints for each \( n \)-th generator and wind generator.
- \( \text{Pen}(k) \) and \( \text{Fitness}(k) \) is penalty and fitness at \( k \) time-interval.
- \( M \) is the max fuel cost per unit and total demand.
- \( (T_{k}) \) is the max fuel cost per unit and total demand.
Results

Cost Comparison for Area-1

Load Bus Voltage Comparison Area-1

Cost Comparison for Area-2

Cost Comparison for Area-3

Load Bus Voltages (Base Case)

Load Bus Voltages (Optimal Case)
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