Chapter 7

Augmented Lagrange Hopfield Network for Combined Economic and Emission Dispatch with Fuel Constraint

Vo Ngoc Dieu
Ho Chi Minh City University of Technology, Vietnam

Tran The Tung
Ho Chi Minh City University of Technology, Vietnam

ABSTRACT

This chapter proposes an augmented Lagrange Hopfield network (ALHN) for solving combined economic and emission dispatch (CEED) problem with fuel constraint. In the proposed ALHN method, the augmented Lagrange function is directly used as the energy function of continuous Hopfield neural network (HNN), thus this method can properly handle constraints by both augmented Lagrange function and sigmoid function of continuous neurons in the HNN. For dealing with the bi-objective economic dispatch problem, the slope of sigmoid function in HNN is adjusted to find the Pareto-optimal front and then the best compromise solution for the problem will be determined by fuzzy-based mechanism. The proposed method has been tested on many cases and the obtained results are compared to those from other methods available the literature. The test results have shown that the proposed method can find good solutions compared to the others for the tested cases. Therefore, the proposed ALHN could be a favourable implementation for solving the CEED problem with fuel constraint.

NOMENCLATURE

a_i, b_i, c_i emission coefficients for thermal unit i
d_i, e_i, f_i fuel cost coefficients for thermal unit i
B_{ij}, B_{0i}, B_{00} transmission loss formula coefficients
F_{ik} fuel delivery for thermal unit i during subinterval k, in tons

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F_i^{min}, F_i^{max} lower and upper fuel delivery limits for thermal unit i, in tons
M number of subintervals of scheduled period
N total number of thermal units;
P_{Dk} load demand of the system during subinterval k, in MW
P_{Lk} transmission loss of the system during subinterval k, in MW
P_{ik} output power of thermal unit i during subinterval k, in MW
P_i^{min}, P_i^{max} lower and upper generation limits of thermal unit i, in MW
Q_{ik} fuel consumption function of thermal unit i in subinterval k, in tons/h
t_k duration of subinterval k, in hours
X_{i0} initial fuel storage for unit i, in tons
X_{ik} fuel storage for unit i during subinterval k, in tons
X_i^{min}, X_i^{max} lower and upper fuel storage limits for thermal unit i, in tons
$V_{p,ik}$ output of continuous neuron representing for output power P_{ik}
$V_{f,ik}$ output of continuous neuron representing for fuel delivery F_{ik}
$V_{x,ik}$ output of continuous neuron representing for fuel storage X_{ik}
$V_{\lambda,k}$ output of multiplier neuron associated with power balance constraint
$V_{\gamma,k}$ output of multiplier neuron associated with fuel delivery constraint
$V_{\eta,ik}$ output of multiplier neuron associated with fuel storage constraint
$U_{p,ik}$, $U_{f,ik}$, $U_{x,ik}$ inputs of continuous neurons corresponding to the outputs $V_{p,ik}$, $V_{f,ik}$ and $V_{x,ik}$, respectively
$U_{\lambda,k}$, $U_{\gamma,k}$, $U_{\eta,ik}$ inputs of multiplier neurons corresponding to the outputs $V_{\lambda,k}$, $V_{\gamma,k}$ and $V_{\eta,ik}$, respectively
ΔP_k power balance constraint error in sub-interval k, in MW
ΔF_k fuel delivery constraint error in subinterval k, in tons
ΔX_{ik} fuel storage constraint error for unit i during subinterval k, in tons
$\Delta V_{p,ik}$, $\Delta V_{f,ik}$, $\Delta V_{x,ik}$ iterative errors of continuous neurons
σ slope of sigmoid function of continuous neurons
α_p, α_f, α_x updating step sizes for continuous neurons
α_λ, α_γ, α_η updating step sizes for multiplier neurons
φ_{0i}, φ_{1i}, φ_{2i} fuel consumption coefficients for thermal unit i
λ_k, γ_k, η_{ik} Lagrangian multipliers associated with power balance, fuel delivery and fuel storage constraints, respectively
$\beta_{\lambda,k}$, $\beta_{\gamma,k}$, $\beta_{\eta,sk}$ penalty factors associated with power balance, fuel delivery and fuel storage constraints, respectively

INTRODUCTION

Economic dispatch with fuel constraint is an important part of utility for operation and planning since it is a complex problem with a long range of time periods and a large set of constraints and variables. The fuel used by a thermal generating unit may be obtained from different contracts at different prices. The fuel contracts are generally under a take-or-pay agreement including both maximum and minimum limits on delivery of fuel to generating units over life of the contract. The fuel storage for units is usually within a specified limit to allow for inaccurate load forecasts and the inability to deliver on time of suppliers (Asgarpoor, 1994). On the other hand, thermal generating units generate toxic gases during power production due to fossil fuels and this is also considered as a source of environment pollution