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An Efficient Hybrid Intelligent Method for Electricity Price Forecasting

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Abstract

In this paper an efficient method is proposed for electricity price forecasting. This paper focuses on Locational Marginal Price (LMP) that efficiently maintains power markets by alleviating transmission network congestion. There are complicated behaviors of the time series due to uncertain factors in the power markets. From a standpoint of market players, a sophisticated method is required to forecast LMP effectively. The proposed method makes use of the hybridization of GP (Gaussian Process) of hierarchical Bayesian estimation, EPSO (Evolutionary Particle Swarm Optimization) of evolutionary computation and fuzzy c-means of allowing data to belong to two or more clusters. EPSO is used to improve the accuracy of parameters in MAP (Maximum a Posteriori) estimation for GP. The use of fuzzy c-mean is useful for increasing the number of learning data for GP to deal with spikes. The effectiveness of the proposed method is demonstrated for real LMP data.

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Keywords: "Gaussian Process ;Hierarchical Bayesian Estimation; forecasting; EPSO; evolutionary computation; fuzzy c-mean; clustering"

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Nomenclature

$\mathbf{C}_N$	covariance matrix of from t_1 to t_N
c	scalar of $K(x_{N+1}, x_{N+1})$
D	given data
F	cost function of fuzzy c-mean
g_{jk}	attribute of fuzzy c-mean
g_{best}	best solution in a group of populations
I	unit matrix
$K(\bullet, \blacklozenge)$	kernel function of $\bullet$ and $\blacklozenge$
$\mathbf{k}$	vector elements $K(x_n, x_{N+1})(n = 1, \ldots, N)$
m	parameter of fuzzy c-mean such as $m > 1$
m_M	dimension number in Mahalanobis kernel
$N(\bullet, \blacklozenge)$	normal distribution with average $\bullet$ and variance $\blacklozenge$
$P(\bullet \vert \blacklozenge)$	posterior distribution of $\bullet$ given $\blacklozenge$
p_{besti}	best solution in population *i*
Q	covariance matrix of y_n
Q_M	covariance matrix of Mahalanobis kernel
R_{nh}	basis function
rand	uniform random number of [0, 1]
S_i^t	location of population *i* at time *t*
t_n	target variable
$\bullet^T$	transpose of matrix $\bullet$
V_i^t	velocity of population *i* at time *t*
w_h	weights of R_{nh}
w_0- w_2	weights of PSO updating rule
w_{i3}	initial value of random number for g_{best} in EPSO
w_{i0}^*- w_{i3}^*	adaptive weights of EPSO updating rule
y_n	output of GP
$x_1, \ldots, x_n$	any point set
δ_{ij}	Kronecker delta
δ_M	parameter of Mahalanobis kernel such that $\delta_M > 0$
μ_{N+1}	average of predicted value at time *N+1*
v_k	centre of cluster *k* in fuzzy c-mean
θ	hyperparameters
θ_{MAP}	MAP estimates of θ
σ_G	width of Gaussian kernel
σ_{N+1}^2 .	variance of predicted value at time *N+1*
σ_w^2	variance of w_h
τ	learning rate
$\Vert \bullet \Vert$	Euclidean norm of vector $\bullet$

1. Introduction

In recent years, power market plyers are concerned with maximization of profit and minimization of risk. Specifically, they are interested in the behavior of electricity price. As one of electricity prices, LMP is very important since it reflects demand conditions at each node in transmission networks and plays a key role to alleviate transmission network congestion [1-6]. As the deregulation of power networks is widely spread, power market players are afraid