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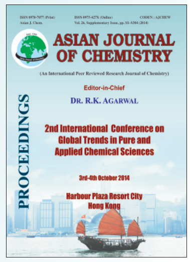

Probability of Extreme Learning Machine Applications in Wastewater Treatment Operating Mode Recognition

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Sewage treatment process of central plains water instantaneous changeable and sewage treatment system resistance and load ability, often leads to the effluent quality can't satisfy the design index. Effective identification of sewage operation condition changes on the optimization of sewage treatment and safe system operation is very important. In this paper, by using the theory of extreme learning machine set up sewage treatment process of instantaneous variables and operating conditions, the prediction model according to the average output value, respectively establish sample function, determine the conditional probability density function. According to the principle of Bayesian computation of posterior probability and finally determine the sample classification. The model was validated using test data of desulfurization wastewater waste gas washing. The results show that, the model predicted results can meet the engineering requirements.

Keywords: Wastewater treatment, Extreme learning machine, Bayesian classification, Exhaust gas scrubbing.

INTRODUCTION

At present, the running state in the process of sewage treatment and monitoring of recognition to a great extent affected by the operating personnel's experience, easy to be affected by subjective factors. With the requirements of increasingly stringent environmental indicators, the increase scale of the sewage treatment system, sewage treatment system are complicated. Compared with other industrial processes, the instability of sewage treatment process is more apparent. Such as sewage flow of hydraulic and water quality components fierce change and impact load, the sewage treatment system in the process of unsteady long, highly nonlinear characteristics[1].

So, the effective identification in the process of sewage treatment operation state for guiding the stable operation of wastewater treatment process and operation optimization is very important. Based on the theory of probability and extreme learning machine, to establish the forecast model of independent variables and characterization of sample classification, the output estimate fluctuations near the code value. Parameters of the nonlinear gauss normal distribution density function is linear. In this paper, a nonlinear least-squares conditional density function parameter estimation method and is verified on the test data[2].

EXPERIMENTAL

Extreme learning machine theory: Suppose N different samples $(x_j, y_j) \in R^n \times R^n$, hidden node number is L (number of hidden node, model expression is

$$f_L(x_j) = \sum_{i=1}^{L} \beta_i G(a_i, b_i, x_j) \quad (1)$$

Topology is shown in Fig. 1.

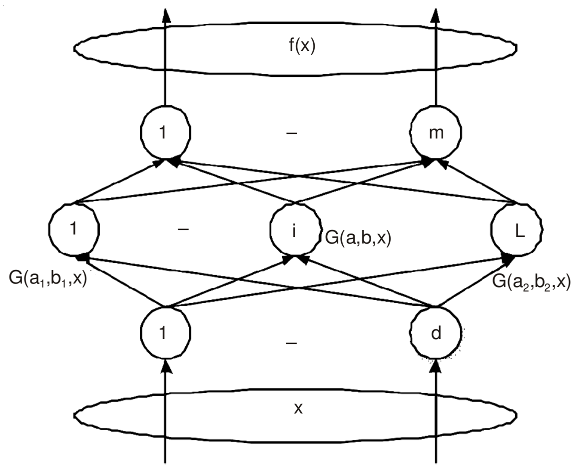

Fig. 1. Structure of extreme learning machine network; a_i = Connect the i hidden nodes of the model input weights; b_i = Deviation of the i hidden node; $bias_c$: Deviation of c

The estimate error between the real value and the sum of squares expression output weight number sequence model $\min: \|H\beta - Y\|^2 \,\&\, \|\beta\|$, the least squares solution $\hat{\beta} = H^{+}Y$. Sample j standard deviation SEP_j, the deviation[3] of c is $bias_c$.

$$\mathrm{SEP}_j = \sqrt{(1+h_j)\times \mathrm{MSEC}_{bc}} \quad (2)$$

$$\mathrm{bias}_c = \frac{1}{N}\sum_{i=1}^{N_c}(\hat{y}_i - y_i)^2 \quad (3)$$

Probability density function: Assuming that the probability density function of the Gaussian distribution.

$$g_j(\hat{y}) = \frac{1}{\mathrm{SEP}_j\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\hat{y}-\hat{y}_j}{\mathrm{SEP}_j}\right)^2} \quad (4)$$

The sample average probability density function[4] $p(\hat{y}|\omega_c)$.

$$p(\hat{y}|\omega_c) = \frac{1}{N_c}\sum_{j=1}^{N_c} g_j(\hat{y}) = \frac{1}{\sigma_c\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\hat{y}-\mu_c}{\sigma_c}\right)^2} \quad (5)$$

Bayesian decision theory: For an unknown sample x_u classification, the classification of samples into a category of finite category. First calculate the predicted output values of the samples x_u, set to $\hat{y}_u$. Let $\{\omega_1, \omega_2, \cdots \omega_C\}$ denote the limited C categories, all the samples $N = \sum_{c=1}^{C} N_C$. According to the number of samples percent of the total samples to determine a priori probability function[5] $P(\omega_c) = N_c/N$. A posteriori probability functions can be calculated by Bayesian formula[6].

$$P(\omega_c|\hat{y}_u) = \frac{P(\hat{y}_u|\omega_c)P(\omega_c)}{\sum_{C=1}^{C} P(\hat{y}_u|\omega_c)P(\omega_c)} \quad (6)$$

RESULTS AND DISCUSSION

Wastewater treatment process: In this paper, diesel engine exhaust gas washing wastewater as the research object. The wastewater treatment process is shown in Fig. 2.

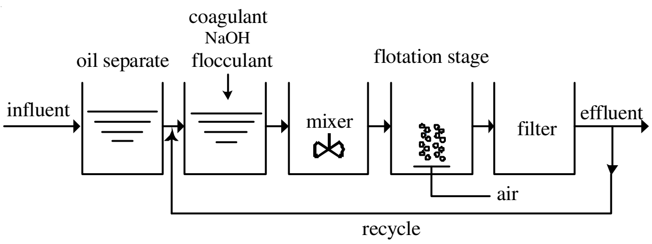

Fig. 2. Wastewater treatment process

The first stage, known as the separation stage, is constructed for the separation of free oil from the wastewater. The water content in the separated oil depends on the quality of the oil. The oily emulsified water is pumped from the oily water buffer tank to the oil separation tank by a feed pump. In the bottomof the separation tank dispersion water (pressurized water saturated with air) is added to the oily water. The dispersion water is made by circulating treated water and adding compressed air into it in a separate tank. As the dispersion water is released to the lower pressure in the tank, micro bubbles are formed. In the tank the bubbles rise and help the oil rise to the surface, from where it is skimmed to an internal oiltank. From the internal oil tank the oil is pumped to the sludge tank. The water is collected into an integratedtank for further treatment in the flotation stage.

From the oil separation stage the emulsified water is lead through a series of mixers. Treatment chemicals are dosed with dosing pumps to the injection points on the mixers. The purpose of the chemical treatment is to break the emulsified oil in the water into particles and to make them into larger flocks that are easily separable by means of the flotation.

After the mixers the water enters the flotation stage. Again the dispersion water is injected to the bottom of the flotation tank. The micro bubbles produced are mixed with the suspended material[7]. Gas bubbles attach to the solids forming solids/gas flocks, which are lighter than water and therefore rise to the surface and form a floating layer. The layer is removed by scraping and guided into the solids collecting tank unit. From there it is pumped to the solid Pac, solids tank or sludge tank.

The operational variables and influent wastewater characteristics for simulation are given in Table-1.

TABLE-1
OPERATIONAL VARIABLES AND
INFLUENT WASTEWATER CHARACTERISTICS

Symbol	Value	Unit
Q	0.5	m^3/h
pH_0	6.8	–
COD_0	54.2	mg/L
SS	38.4	mg/L
DO	4.35	mg/L
Tu	9.8	FNU

Conclusion

This work has shown that analysis and modeling of data is an adequate tool for obtaining important process information. The experimental results indicate that the method is feasible. All of these aspects enlarge our process know-how and will be used as an important step in a future work involving statistical process control in a wastewater treatment system.

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