Research on Automatic Technology of New Urban Sewage Inspection and Treatment

Zhihao Hu¹, Yiliu Tan² and Cuimei Li¹, *

¹ School of Communication and Electronic, Jangxi Science & Technology Normal University, Nanchang 330013, China
² Jiangxi Water Group Co., Ltd., Nanchang 330072, China

*Corresponding author e-mail: licuimei@jxstnu.edu.cn

Abstract. The automatic control technology is more and more widely used in sewage treatment systems. The thesis elaborated on the new urban sewage treatment technology and control process, analyzed the PLC-based sewage treatment control system structure, realized the control of power equipment and testing equipment, and finally completed the remote monitoring of the SBR sewage treatment based on MCGS. Simultaneously, the paper uses big data analysis and statistical methods to analyse and compare the routine monitoring and important monitoring data of sewage treatment, effectively saving monitoring, feedback, improvement, and release time. The actual operation results show that the system is stable and reliable and can remotely monitor and control equipment operation in real-time.

Keywords: Urban sewage treatment, single-chip microcomputer, sensing, equipment control.

1. Introduction
In the urban sewage analysis system's treatment process, the sewer as the detection point is a wet channel with an erosion mixture. The mixture has both anionic active surface expansion (AAT) and non-ionic surface expansion (NIT). Substantial random volatility, so it is difficult to establish an accurate mathematical model. When the sewage concentration exceeds the predetermined surface expansion concentration limit value, process operation adjustment is an essential link in sewage treatment related to whether sewage treatment can be Full-time domain compliance. However, there is still no practical and effective method to avoid the interference of inappropriate foam and suspended solids in the online analysis of sewage, even offline measurement is only suitable for protocol measurement, and its operating system is very complicated [1]. Therefore, it is challenging to solve all problems with an accurate process model. But with the acceleration of China's industrialization process, environmental pollution problems have become increasingly prominent, the voice of sustainable development has become higher and higher, and the treatment of industrial pollution has also increased. The more urgent, the requirement to introduce a new type of automation control model is very urgent.

With the expansion of industrial and agricultural production scale and the development of information technology, the application of process information monitoring systems that provide on-site real-time information has become more and more extensive. Chinese sewage treatment technology...
started late, and sewage treatment automation lags behind that of developed countries. In recent years, the sewage treatment monitoring system has changed from simple field instrument detection. Computer centralized control to PLC control and DCS control. Automation technology has developed rapidly. The ever-changing intelligent instruments and actuators have integrated digital communication functions, which have improved the efficiency and accuracy that ensures the quality of sewage treatment. Therefore, a reliable and stable monitoring system integrating multiple bus technologies has become the primary trend in developing domestic sewage treatment automation systems. This paper develops a sewage treatment monitoring and management information system based on the high-speed mobile Internet. The use of information technology can significantly save human resources and material resources. In the past, many people needed to analyse and deal with the problems on-site. Only a few experts can remotely provide data analysis solutions and use big data technology to find key points to solve the problem, which saves cost and time.

2. System Architecture

2.1. Description of the sewage treatment process

Used in the urban integrated sewage treatment system using aerated biological filter sewage treatment process: the coarse grid first removes domestic sewage to remove the larger suspended solids in the water, and then flows into the sump of the lifting pump house, and is lifted by the submersible sewage pump. Then it flows into the grit tank, and the fine sand and sludge that settles down enter the thickening sludge tank, and the dry mud is transported out after dehydration [2]. The treated sewage flows into the C/N tank, and the organic matter is degraded and nitrified in the aerated biological filter. The C/N tank effluent enters the N filter to complete the denitrification treatment and then flows into the clean tank. The process flow is as follows: As shown in Figure 1.

![Figure 1. Process flow of the aerated biological filter](image)

During the entire sewage treatment process, it is necessary to monitor the operating status of the pumps and valves related to the grille machine, lifting pump house, grit tank, aeration tank, the clean water tank, and thickening sludge tank, and at the same time monitor the influent COD, effluent COD, DO, TN, NH3-N, and other parameters are monitored. These data are transmitted to the GPRS module through the PLC and then sent to the monitoring centre server through the Internet network.
2.2. Overall system design
The sewage treatment intelligent monitoring system architecture based on the Internet of Things mainly
designs the overall topological structure and functional structure of the system and plans for the system's
overall design and implementation. The implementation objectives mainly include sewage treatment
data collection based on the Internet of things and sewage treatment process prediction and control based
on deep learning [3]. The system uses wireless sensor nodes as the data sensing equipment of the Internet
of Things to monitor the sewage water quality of the sewage treatment equipment and every intermediate
link in the sewage treatment process. The monitoring results are delivered to the cloud computing
storage platform. On the cloud computing storage platform, run deep learning algorithms to process and
analyse monitoring data, generate prediction results, and intelligently control sewage treatment
equipment. The overall technical scheme of the system is shown in Figure 2.

![Figure 2. The overall technical scheme of the system](image)

2.3. Intelligent prediction and control design of the sewage treatment process based on deep learning
Based on the intelligent prediction and control of sewage treatment based on deep learning, the machine
learning DBN of unsupervised learning is used to model sewage treatment prediction. To obtain
generative weights, unsupervised greedy layer-by-layer implementation is adopted during pre-training.
In the training process, the Gibbs sampling principle is adopted. The visible vector value is mapped to
the hidden layer unit, and then the visible unit is reconstructed from the hidden layer unit. These new
visible units are mapped to the hidden layer unit to obtain a new Hidden layer unit [4]. In a typical DBN
network with only one hidden layer, the joint probability density distribution can describe the
relationship between the input vector $x$ and the implicit vector $g':$

$$P(x, g', g^2, g^3, ..., g) = P(x | g^1) P(g^1 | g^2) P(g^2 | g^3) ... P(g^i | g^{i+1}) P(g)$$  \hspace{1cm} (1)

Among them $P(g^i | g^{i+1})$ is the conditional probability distribution. Think of the hidden layer $g^i$ as
a random binary vector with $n'$ elements $g_i$:.

$$P(g^i | g^{i+1}) = \prod_{j=1}^{n'} P(g_j^i | g^{i+1}) P(g_j^i = 1 | g^{i+1}) = \text{sigmoid}(b'_j + \sum_{k=1}^{n'} w_{jk} g^i_k)$$ \hspace{1cm} (2)

Among them, $\text{sigmoid}(t) = 1/(1+e^{-t})$, $b_j'$ is the deviation value of the j-th unit in the ith layer and $w_{ij}$ is
the ith layer's weight matrix. After the training is over, you need to do fine-tuning training for DBN.
According to the input data's loss function and the reconstructed data, the BP algorithm is used to fine-
tune the correlation network parameters to minimize the loss function. The formula of the loss function
is:

$$L(x - x') = \| x - x' \|^2$$  \hspace{1cm} (3)
Among them \( x \) is the true value of the training data and \( x' \) is the value of the fitting function of DBN. Considering that the final discharge water quality is the final direct indicator, the final water quality is taken as the indicator of the sewage treatment results, and the discharge water quality is predicted by constructing a DBN network [5]. The DBN network is constructed by combining multiple RBMs from the bottom up. The input of the prediction model includes the parameters of each process and the sewage water quality after each process. The construction process of sewage treatment forecast DBN network is shown in Figure 3.

![Figure 3. Sewage treatment prediction DBN network training process](image)

### 2.4. System hardware design

According to the plant's actual situation, the entire sewage treatment process comprises water collection wells, adjustment tanks, buffer tanks, HUASB, dosing links, Fenton reaction tanks, primary air flotation, sand filter, and other processing units. The leading electrical equipment includes: mechanical grille, rotary screen, mud scraper, submersible pump, fan, dosing pump, etc.; and there are measuring equipment such as liquid level meter, flow meter, PH meter, dissolved oxygen meter. According to the actual process and control requirements, this system selects Siemens SIMATIC S7-300 PLC as the system's core controller. The frequency converter adopts the Siemens MM440 general frequency converter, which has a modular design, flexible configuration, and multiple protection characteristics.

This system uses the LabVIEW monitoring system based on Siemens S7-300PLC as the control centre, and three control levels are set according to the process requirements: on-site control, centralized control in the central control room, remote control in different places, and the control priority is sequentially reduced [6]. The field related processing unit transmits the liquid level, PH, temperature, and other information to the upper computer through the PLC through the sensor, the inverter transmits the operating frequency information to the upper computer through the USS bus, and the LabVIEW and PLC programs are sent out after relevant analysis and processing based on the incoming data Control instructions are given to the corresponding equipment to realize the automatic operation of the entire sewage treatment process.
3. Remote monitoring system for sewage treatment based on MCGS

3.1. The function of the remote monitoring system for sewage treatment based on MCGS

MCGS industrial control configuration software is a set of compelling monitoring software. Its main functions include integrated animation display, dual machine hot backup, engineering reports, process control, equipment control, data acquisition, network data transmission, data, curves, etc. Used in sewage treatment monitoring system. First, centrally monitor the processing system to complete data processing, automatic data collection, report output, real-time curve, and historical curve, etc.; second, realize the time start and program start of related equipment in SBR; third, realize Sewage treatment field equipment is remotely controlled; fourth, parameter alarms are completed, and the operator can monitor the changes in the liquid level in each pool in real-time online.

3.2. MCGS configuration monitoring realization

Constructing the MCGS remote monitoring system includes the following steps: First, create a new monitoring screen. According to the sewage treatment process, establish the corresponding configuration screen. The focus is to establish status indicators, limit switches, buttons, rotary switches, float level switches, drain solenoid valves, Roots blowers (aeration fans), water solenoid valves, clean water pumps, submersible pumps, and other equipment. The detection equipment must have data output, and each execution device has a remote-control switch. Second, connect PLC equipment. The upper computer and field equipment must establish a connection with the lower computer PLC for data exchange. Select Siemens S7-200SMART series PLC, select TCP protocol for the communication protocol, and test whether the connection is successful through the network port. Third, define variables [7]. On-site detection data variables are mainly switched type, including status detection information of various liquid level switch signals, solenoid valves, and water pump working status. The output variables are mainly the start and stop signals of float type liquid level switch, emptying solenoid valve, Roots blower (aeration fan), water solenoid valve, clean water pump, submersible pump, and other equipment. By connecting the I, Q, M, and V registers in the PLC, the variable names are determined, and data exchange is realized.

3.3. The structure and realization of a remote monitoring system

The liquid level of the lift pump sump varies significantly with the seasons. The liquid level is higher in spring and summer and lowers in autumn and winter. Lifting pumps are one of the most power-consuming equipment in sewage treatment pumping stations. To save energy, select lift pumps reasonably, and extend the equipment's service life, and this project adopts a liquid level control mode. Lifting pump liquid level control is shown in Figure 4. When the liquid level of the lifting pump pool rises, one pump is started when the liquid level is ≥2.0m, two pumps are started when the liquid level is ≥4.0m, and three are started when the liquid level is ≥5.0m. One pump, when the liquid level is greater than or equal to 10m, an alarm signal will be issued; when the liquid level of the lift pump pool drops, one pump will be shut down when the liquid level is less than or equal to 3.5m, two pumps will be shut down when the liquid level is less than or equal to 1m, and all pumps when the liquid level is less than or equal to 0.5m. Stop working and send out an alarm signal when the liquid level is less than or equal to 0.3m. At the same time, the PLC program calculates the running time of each lifting pump, giving priority to the start and stop of the lifting pump, and the priority to stop the lifting pump with a long-running time, to achieve a proper selection of the start and stop of the lifting pump and prolong the life of the equipment.
4. Conclusion
Aiming at the problems of long system development cycle, low efficiency, and low reusability in the remote monitoring system of sewage treatment. The thesis's protocol solves the problem that the inverter's remote control is susceptible to substantial electrical interference. The thesis designs a sewage treatment monitoring system that integrates multiple bus technologies. Application results show that the system can comprehensively complete the data collection and equipment control tasks in the sewage treatment process and solve centralized monitoring of decentralized sewage stations and information collection of multiple protocol measurement and control equipment.

Acknowledgments
The study was supported by "National Level Project on Innovative Entrepreneurship Training for University Students, Jiangxi Province" (Grant No. 201811318021).

References
[1] Apperl, B., Pressl, A., & Schulz, K. Feasibility of locating leakages in sewage pressure pipes using the distributed temperature sensing technology. Water, Air, & Soil Pollution, 228(2) (2017) 82-98.
[2] Onkal-Engin, G., Demir, I., & Engin, S. N. Determination of the relationship between sewage odour and BOD by neural networks. Environmental Modelling & Software, 20(7) (2005) 843-850.
[3] Gebicki, J., Byliński, H., & Namieśnik, J. Measurement techniques for assessing the olfactory impact of municipal sewage treatment plants. Environmental monitoring and assessment, 188(1) (2016) 32-45.
[4] Hauser, F. M., Metzner, T., Rößler, T., Pütz, M., & Krause, S. Real-time wastewater monitoring as tool to detect clandestine waste discharges into the sewage system. Environmental Forensics, 20(1) (2019) 13-25.
[5] Gostelow, P., Parsons, S. A., & Stuetz, R. M. Odour measurements for sewage treatment works. Water research, 35(3) (2001) 579-597.
[6] Yang, X., & Wang, E. A nanoparticle autocatalytic sensor for Ag+ and Cu2+ ions in aqueous solution with high sensitivity and selectivity and its application in test paper. Analytical chemistry, 83(12) (2011) 5005-5011.
[7] Preininger, C., Klimant, I., & Wolfbeis, O. S. Optical fiber sensor for biological oxygen demand. Analytical Chemistry, 66(11) (1994) 1841-1846.