

The research and design of the portable rivers and lakes' water quality on-line monitoring instrument

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Abstract: Focused on the present situation of the rivers and lakes' water quality monitoring in China, the monitoring way is single and undeveloped, and water quality evaluation is difficult. A portable rivers and lakes' water quality online monitoring instrument is developed, which can achieve the real-time remote monitoring of water quality parameters, analysis and process as well as water quality intelligent assessment. It completed the integration of serial technology and 3G communication technology with small size and portability. The instrument can obtain the real-time water quality parameters information through the water quality sensors. Its onboard software enables multiple functions of real-time water quality parameters display, historical data curve display and query, and the analysis of the water quality evaluation, etc. At the same time, the instrument can upload real-time water quality data to the upper monitoring system through 3G network. Meanwhile an intelligent water quality assessment algorithm is presented, which uses artificial neural network LVQ (Learning Vector Quantization) analysis method to evaluate water quality. The algorithm is embedded into the instrument software. Finally the evaluation result is proved which provides a new application platform for water environment monitoring and management.

Introduction

In recent years, with the rapid development of industry and agriculture, a large number of excessive industrial waste water and living waste water was directly discharged into rivers and lakes, which led to the content of nitrogen and phosphorus in the rivers and lakes significantly exceeded the standard, the rivers and lakes accelerated eutrophication, the phenomenon of water bloom was becoming more and more popular, the lake ecological environment was caused serious damage. Even it was a major threat to the survival of mankind. Therefore, to carry out monitoring and evaluation of rivers and lakes water quality has become a pressing matter of the moment^[1-2].

At present, our country adopts the method of water quality monitoring is still relatively backward, such as manual sampling laboratory analysis method, the shore station fixed monitoring method and so on^[3-6]. These methods have the disadvantages such as single monitoring data, inconvenient carrying and transportation, huge volume, expensive cost and maintenance cost, and desynchronization real-time on-line monitoring, which have been restricting the development of water quality monitoring in China.

At the same time, it is difficult to establish an effective water quality assessment model because of the relatively complex formation mechanism of water pollution. In this regard, some domestic

scholars have proposed some water quality evaluation methods, such as subjective weighting method, analytic hierarchy process and so on^[7-10]. However, these methods have different degrees of problems about changing with the time gradient and the unreasonable weight coefficient, etc. So it has been difficult to find a suitable method to evaluate the water quality.

To solve the above problems, this paper developed a portable rivers and lakes' water quality on-line monitoring instrument to achieve real-time data acquisition and display, history curve query and display, wireless remote transmission data to the upper monitoring system. At the same time, it also has the function of complex intelligent water quality evaluation and analysis. The paper proposes to LVQ analysis method of a kind of ripe artificial neural network on water quality of comprehensive evaluation, to achieve a comprehensive evaluation and effective analysis of the water quality of rivers and lakes.

The overall framework of the portable rivers and lakes' water quality on-line monitoring instrument

The overall framework of the portable rivers and lakes' water quality on-line monitoring instrument as shown in Figure 1.

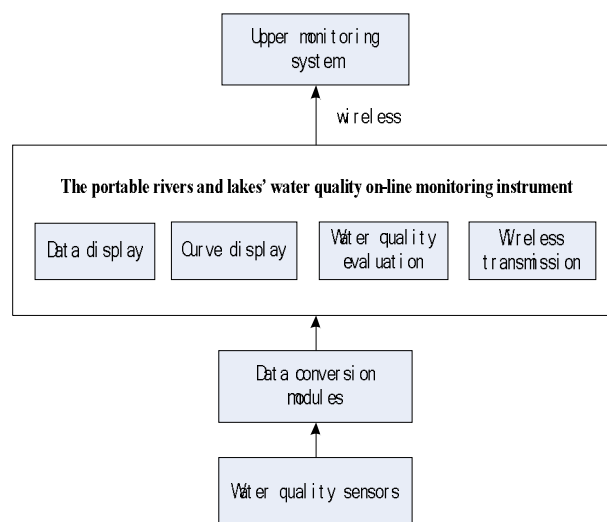


Figure 1 Overall frame chart of portable water quality on-line monitoring instrument
 the portable rivers and lakes' water quality on-line monitoring instrument connect with water quality sensor through data conversion module. The water quality sensor was directly put into the water. Water temperature (Temp), electrical conductivity (T.D.S), dissolved oxygen (DO), ammonia nitrogen (NH₃-N), chemical oxygen demand (COD), potassium permanganate (KM_nO₄) and other water quality parameters were monitored. Through the data conversion module, data parameters collected were read and passed the portable rivers and lakes' water quality on-line monitoring instrument, and through the LCD display interface in real time online display, people can also view the historical data of parameters change curve. In addition, the collected data would be sent to the upper monitoring software through the 3G wireless remote transmission technology. The instrument also had a built-in intelligent water quality evaluation algorithm, which can be used to analyze the data of water quality parameters and water quality evaluation.

The hardware Integrated design of the portable rivers and lakes’ water quality on-line monitoring instrument

This portable rivers and lakes’ water quality on-line monitoring instrument include its body portion, the data conversion module section and water sensor portion,with a small,easy to carry, simple operation,good interaction and so on.Figure 2 is the portable rivers and lakes’ water quality on-line monitoring instrument physical map.



Figure 2 the portable rivers and lakes’ water quality on-line monitoring instrument physical map. the design of the portable rivers and lakes’ water quality on-line monitoring instrument

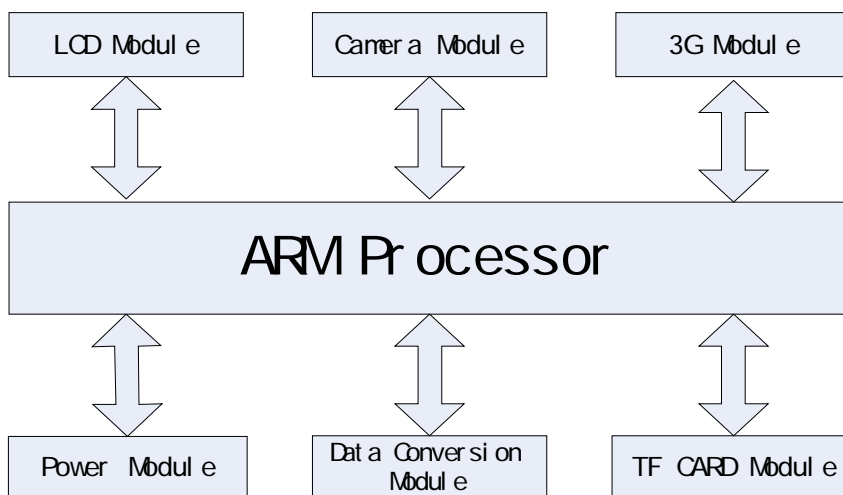


Figure 3 the portable rivers and lakes’ water quality on-line monitoring instrument hardware circuit diagram

As shown in figure 3,This portable rivers and lakes’ water quality on-line monitoring instrument master controller adopts the design of ARM9 series processor.Power module is mainly used for instrument equipment power supply.Data conversion module is mainly used for external water quality sensors.Camera module is mainly used for monitoring of the surface.3G module is mainly used for data communication with upper monitor system.LCD module is mainly used to display real-time data ,historical curve and the water quality evaluation results.TF CARD module is mainly

used for storage water quality parameters of collected information.

The design of data conversion module

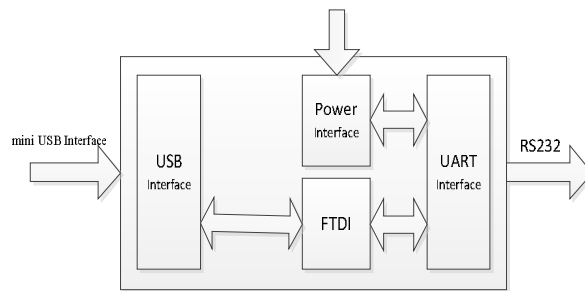


Figure 4 data conversion module structure diagram

As shown in figure 4, data conversion module adopts FTDI chip inside. Device does not need to load any drivers. Meanwhile, the data conversion module also has a water sensor supply power interface that can be connected to the 12 V DC for the water quality sensor power supply. UART interface adopts the design of 9-pin RS232 interface that can be directly connected with the water quality sensors. USB interface adopts the design of mini USB interface that can be directly plugged into the portable rivers and lakes' water quality on-line monitoring instruments.

Water quality sensors

The water quality sensor is mainly composed of the main body, battery box, waterproof connector, shell and water quality parameters of the probe, collar attachment devices, etc. water quality parameters probe is connected with the body via a threaded groove, convenient installation. Internal use 12V DC power supply, water sensor can be directly put in the water for long-term online monitoring water quality information, simultaneous detection of temperature (Temp), chemical oxygen demand (COD), dissolved oxygen (DO), potassium permanganate (KM_nO_4), ammonia nitrogen (NH_3-N), and other indicators of water quality parameters.

The software design of the portable rivers and lakes' water quality on-line monitoring instrument

The overall design of the software

This software adopts the thought of modular design, packages different functions into many sub modules, which is advantageous to the software module in the call and optimize the data processing speed. The instrument software main interface as shown in figure 5, this portable rivers and lakes' water quality on-line monitoring instrument software adopts humanized interface, software main interface from top to bottom is divided into real-time data display area, commonly used action button area and history curve of display area. Real-time data display area can display temperature, chlorophyll, transparency, electrical conductivity, chemical oxygen demand, dissolved oxygen, PH, ammonia nitrogen and potassium permanganate nine parameters at the same time. Receive button is used to control the receiving data on and off in common operations button area. The drop-down button is used to query the history of the related parameters curve. Water Quality Assessment button is used for water quality evaluation and analysis. Wireless transmission button is used to transmit data to the host monitoring system. History curve display area is used to display the history curve of each parameter.

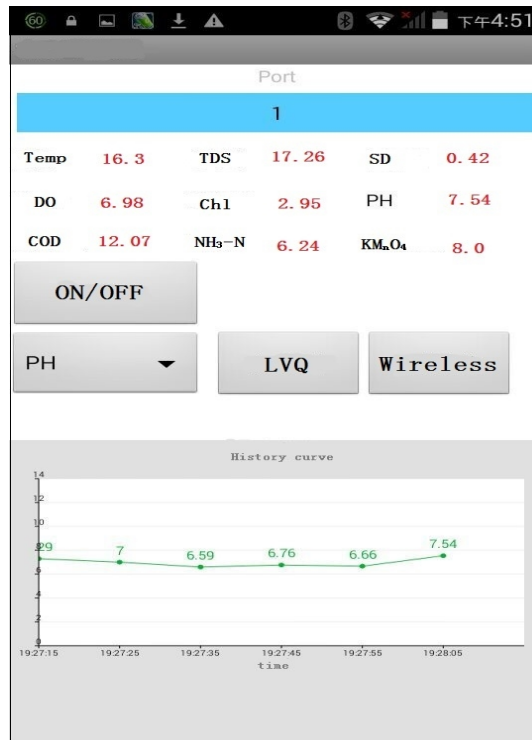


Figure 5 the portable rivers and lakes' water quality on-line monitoring instrument software main interface

The design of water quality evaluation module

water quality evaluation as an important part of the entire portable rivers and lakes' water quality on-line monitoring instrument, correct choose evaluation method to analyze water quality situation, which can provide a effective decision-making and management of water environment. Artificial neural network is based on in-depth study of the human brain structure and activity mechanism, imitate the cranial nerve system structure and activity mechanism of formation of the calculation method, since it has the parallel processing, self-organization, self-learning and self-adaptive characteristics, widely used in the field of artificial intelligence. Therefore, water quality evaluation module uses neural network LVQ (Learning Vector Quantization) algorithm to improve the accuracy of water quality assessment, and provide a reference for subsequent management of water environment.

LVQ network structure and working principle

Learning vector quantization network is proposed on the basis of the competitive structure of network, LVQ network will competitive learning thought and supervised learning algorithm together, in the process of network learning, through the teacher signal distribution category of input samples, thereby overcoming the disadvantages of self-organizing network using unsupervised learning algorithm brings lack of disaggregated information.

LVQ network consists of input layer neurons, competitive layer neurons and output layer neurons, there are n input layer neurons receive input vector, completely connections with competition layer. Competitive layer with two neurons, divided into several groups and are arranged one dimensional linear array. Each neuron in the input layer and competitive layer connected only in a group of neurons, the connection weights is fixed at 1.

LVQ network learning algorithm steps are as follows:

- (1) Initialization Each neuron weight vectors $w_j^1(0)$, $j = 1, 2, \dots, M$ in the Competition

layer assigned small random number, determine the initial learning rate $\eta(0)$ and training times K.

(2) Input sample vector X.

(3) Find the winning neuron j^* .

$$\|X - W_j^1\| = \min_j \|X - W_j^1\| \quad j = 1, 2, \dots, M \quad (1)$$

(4) According to the different rules to adjust the winning neuron weights. when network classification results are consistent with teachers signal, adjust the weights to the input sample direction:

$$W_j^1(k+1) = W_j^1(k) + \eta(k)[X - W_j^1(k)] \quad (2)$$

Otherwise, it will reverse the direction of the input sample to adjust weight :

$$W_j^1(k+1) = W_j^1(k) - \eta(k)[X - W_j^1(k)] \quad (3)$$

Other non-winning neuron value remains unchanged.

(5) Update the learning rate

$$\eta(k) = \eta(0) \left(1 - \frac{k}{K}\right) \quad (4)$$

When $k < K$, $k = k + 1$, go to step (2) enter the next sample, repeat the steps until the $k = K$. In the training process must guarantee $\eta(k)$ for monotone decreasing function. In addition, search for winning neuron directly used to determine the minimum Euclidean distance, so there is no need for the weight vector and the input vector normalization processing.

Water quality evaluation algorithm simulation based on LVQ

This paper adopts the MATLAB software simulation of some samples, according to our country set the standard of water quality evaluation and the portable rivers and lakes' water quality on-line monitoring instrument the actual condition of monitoring of water, choose dissolved oxygen, ammonia - nitrogen, chemical oxygen demand, potassium permanganate four indicators as a monitoring index of water quality evaluation, finishing the Beijing section of the water quality of rivers and lakes as the training sample of LVQ network, as shown in Table 1.

Table 1 part of the rivers water quality parameters of data table in Beijing

No.	Sites	DO	NH ₃ -N	COD
1	YuYuanTan	9.57	0.34	14.07
4.38				
2	Bayi Lake	6.98	1.59	43.35
9.77				
3	Jingxi eighteen Lake	8.53	0.47	11.09
3.59				
4	Miyun Reservoir	9.07	0.21	12.07
3.93				
5	Qinglong Lake	0.50	0.85	7.70
0.90				
...
...				

Selection of more than 80 sets of data as the LVQ neural network training samples, establish LVQ network, setting up the relevant parameters, input layer has four neurons, competition layer select 12

neurons,output layer has three neurons,learning rate was set to 0.1.After the network training to 400, the error of the LVQ network stability is less than 0.03. Select 10 sets of water quality monitoring data for verification,the verification results are shown in table 2.

Table 2 Evaluation results show table

Sites	DO	NH ₃ -N	COD	KM _n O ₄	LVQ evaluation results	Expert evaluation results
1	5.14	2.43	4.70	5.71	IV	IV
2	5.26	2.08	4.00	6.05	IV	IV
3	7.71	0.95	5.57	22.20	V	V
4	7.23	1.59	1.90	4.62	II	II
5	4.83	1.43	4.22	21.10	III	IV
6	1.72	3.47	4.80	4.47	III	III
7	1.76	3.63	1.93	2.96	II	II
8	8.65	1.08	6.16	22.00	V	V
9	1.89	3.32	1.44	2.46	III	III
10	1.58	3.58	1.36	2.26	II	II

Verified by 10 groups of water quality monitoring data,based on LVQ neural network algorithm has practical application significance in the field of water quality evaluation,in the evaluation of ten sets of data,nine sets of data results are consistent with the expert evaluation,Another set of result is close to the existing evaluation results.Therefore,The LVQ network embedded the portable rivers and lakes' water quality on-line monitoring instrument,thereby providing a reference for the monitoring and management of water environment.

Conclusion

In this paper, the design of the portable rivers and lakes' water quality on-line monitoring instrument used both serial port communication technology and the 3G wireless communication technology, it's small volume and easy to carry. It has functions including the real-time online monitoring about water quality parameters of lakes, historical curve change query, water quality evaluation and analysis and the data to the monitoring system of water quality parameters through 3G wireless network. At the same time, for the problem in other water quality evaluation algorithm, this paper puts forward a kind of artificial neural network LVQ intelligent analysis algorithm which is embedded in the instrument software, realizing the effective evaluation of rivers and lakes water quality. That provides an effective reference for the environmental protection department to conduct decision and control about water bloom.

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