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Research in Automobile Exhaust Gas of Sulfur Dioxide and Nitrogen Dioxide Monitoring WSN and Optimization Coverage Algorithm

Zhou Yushan*, Zhang Yiwei,Chu Linlin, Liu Congning, Shi Yunbo
The Higher Educational Key Laboratory for Measuring & Control Technology and Instrumentation of Heilongjiang Province
Institute of Measurement-Control Technology & Communications Engineering, Harbin University of Science and Technology, Harbin, China
zys2131009@126.com

Abstract—**For help solving the air pollution problem caused by the mass increasing of Sulfur Dioxide And Nitrogen Dioxide automobile exhaust gas, we have designed a Zigbee wireless monitoring network to monitor the Sulfur Dioxide And Nitrogen Dioxide in automobile exhaust gas, and build this monitoring system in hardware and software. Also, we use a Artificial Fish Swarm Algorithm to optimize the network covering area. According to a simulation result, the network coverage could be increased to more than 95%, and it makes the network nodes more efficient, reduced the redundancy nodes, lower the system energy consumption, to meet the design qualification.**

Keywords-component; automobile exhaust gas; wireless sensor network; coverage ;Artificial Fish Swarm Algorithm;

I. INTRODUCTION

Since the Reform and Opening, China's economic development has made rapid progress, automobile industry has grown rapidly and people's living standards constantly improved. With the massive increase in the number of cars, pollution gases in the atmosphere, such as Sulfur Dioxide, Nitrogen Dioxide, etc , have increased sharply in the city, making the air quality worse, which has seriously affects the population's health[1]. In addition, due to the sharp increase in the number of cars, the traffic jam is getting worse, which has a negative impact on the people's travel. Given this backdrop, how to reduce automobile exhaust has become one of the most important environmental issues people concerned. Studying on the monitoring system for automobile exhaust, which has great significance on the control of urban environmental pollution, protect air quality[2].

In this paper, a automobile exhaust of Sulfur Dioxide And Nitrogen Dioxide Gas Monitoring Wireless Sensor Network system is designed. By monitoring the terminal real-time of environmental parameters in the monitoring area, using the algorithm to optimize the system, the system coverage improved and the cost of the system improved.

II. CHLORINE GAS MONITORING WIRELESS SENSOR NETWORK SYSTEM

This system was constituted by three levels: monitoring level, transport level and management level.They include multiple monitoring nodes, relay nodes, trunk route,handheld nodes and PC monitoring center.Monitoring nodes actualize monitoring environmental parameters. Intermediate nodes send the information collecting from the subnet to trunk router after fusion processing, then trunk router transmits the information to handheld nodes and PC monitoring center. Handheld nodes and PC monitoring center are the man-machine interface of monitoring system. By handheld nodes， they improved the convenient of system. System adopts transport protocols based on star topology and uses enhanced ZigBee wireless communication modules to establish sensor monitoring network. Diagram of the whole system is shown in figure1.

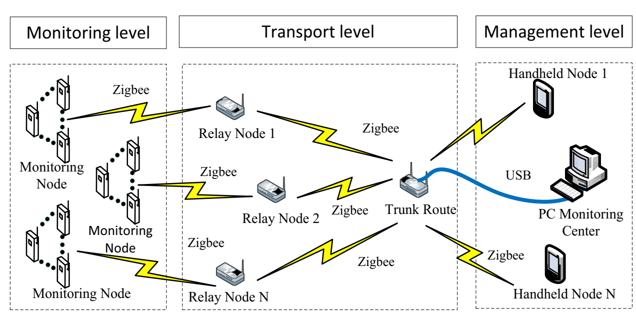

Figure 1. Diagram of the whole system

The monitoring node was divided into five parts as follows: MCU, sensor module, display and alarm module, wireless communication module and power module , as shown in figure 2. Stm32f103zet6 was adopted as the microprocessor chip, which can improve the speed of data processing and information acquisition precision[3]. The handheld node is on the same principle, so this will not discuss it.

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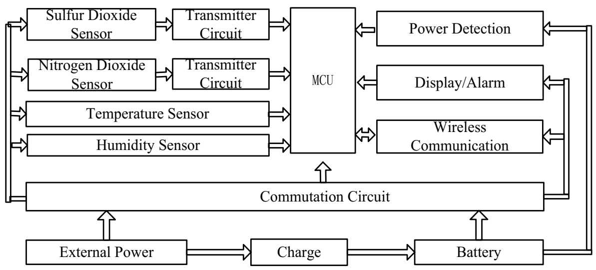


Figure 2. Structure of monitoring node

The section of sensor includes Nitrogen Dioxide sensor , transmitter circuit , temperature sensor and humidity sensor .It measured gas concentration of Nitrogen Dioxide, temperature and humidity of environment, and transmitted the sensor output range of standard voltage signal from 1V to 3V[4]. Measurement of temperature and humidity was in order to compensate the Nitrogen Dioxide gas sensor. The Nitrogen Dioxide gas sensor uses three-electrode electrochemical sensor to design detection circuit of negative current signal based on single supply, which is made through two stage amplifier circuit. Transmitter circuit of Sulfur Dioxide Sensor is on the same principle, so this will not discuss it. Transmitter circuit of sensor is shown in figure 3.And 2.5 V is used as zero potential of the circuit.

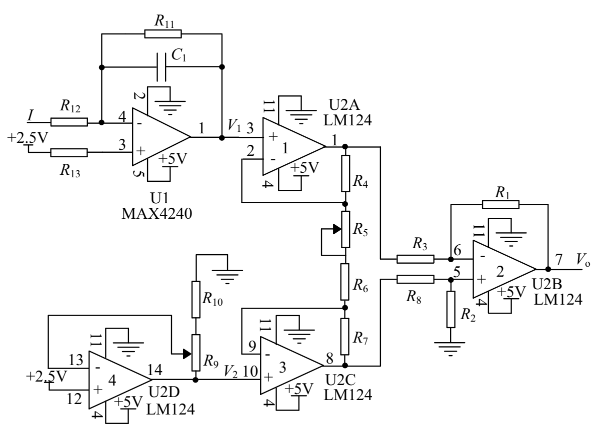


Figure 3. Signal transmitter circuit

The negative current output of gas sensor I is transformed positive voltage signal V1 by low pass filter circuit. V1 and V2 input gain adjustable operational amplifier which was made up by U2A, U2B and U2C. By two stages amplifications, MCU can read the voltage signal V0 . R4 is used to adjust the gain, and R9 is used to regulate the zero output voltage. The relationship between input and output is shown as formula (1).

$$V_o = \frac{(R_4 + R_5 + R_6 + R_7)\cdot R_{12}}{(R_5 + R_6)\cdot R_{10}} \cdot (2.5 - IR_3 - \frac{2.5\times(R_8 + R_9)}{R_8 + R_9'}) \quad (1)$$

As for the system, we require it to reduce the energy consumption and increased the working time[5].Because of it , we design a circuit of charging battery and power supply automatic switching External power can charge battery at making circuit, meanwhile, the battery did not supply the system. The power circuit is shown in figure 4.

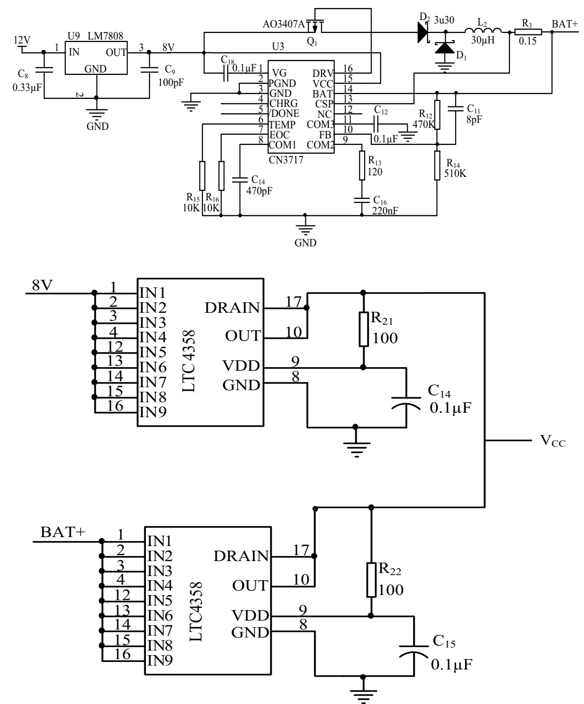


Figure 4. Circuit of charging and automatic switching.

The PC monitoring center and handheld nodes have lots of functions such as query measurement data by monitoring nodes, check on working nodes, save measurement data,etc.

III. ARTIFICIAL FISH SWARM ALGORITHM OF WSN RESEARCH

A. Principles of Artificial Fish Swarm Algorithm

The coverage optimization of wireless sensor network system was to gain the best coverage using least monitoring nodes in the premise of keeping the monitoring area was complete covered[6]. In this way, it reduced the energy consumption of the system. The primary target of optimization algorithm was to keep the coverage as large as possible. Each monitoring nodes had efficient range, and let nodes measure gas concentration in this range. Monitoring region A was assumed to be two-dimensional plane, and divided into m×n parts which the area of each was 1. In this region, we put N same sensor nodes[7] . The probability y(s_i , p) which the target joint p (x_p , y_p) was measured by monitoring node si(x_i , y_i) can be calculated by formula (1).

$$Y(s_i,p)=\begin{cases}1, & d(s_i,p)\le d_r-d_{er}\\ e^{\frac{-\lambda_1\alpha_1^{\beta_1}}{\alpha_2^{\beta_2}+\lambda_2}}, & d_r-d_{er}<d(s_i,p)<d_r+d_{er}\\ 0, & otherwise\end{cases} \tag{1}$$

Where $d(s_i,p)$ is distance between monitoring node s_i and target m , d_r is theoretically range of monitoring node, d_{er} is efficient monitoring range of node,λ_1, λ_2,β_1, β_2 are all specific parameters of the node. The probability of target joint was measured by the surrounding monitoring nodes was calculated by formula (2).

$$y(s_{all},p)=1-\prod_{i=1}^{n}(1-\mathrm{Y}(\mathrm{s}_i,\mathrm{p})) \tag{2}$$

The network coverage rate of the system f_1 was calculated by formula (3).

$$f_1=\frac{\sum_{x_i=1}^{m}\sum_{y_i=1}^{n}y(\mathrm{s}_{all},\mathrm{p})}{m\times n} \tag{3}$$

It is important that use monitoring nodes as few as possible [9].The less sensor nodes there are, the less consumption of system there will be. We defined f_2 to show the consumption rate. If there were totally S monitoring nodes, where S_0 nodes was working, the consumption rate f_2 is shown as formula (4).

$$f_2=\frac{S_0}{S} \tag{4}$$

So, the optimization model of WSN was established, considering the network coverage rate of the system f_1 and the consumption rate f_2. In the formula (5), the sum of σ1 and σ2 is 1.

$$f=\sigma_1\times f_1+\sigma_2\times f_2 \tag{5}$$

Artificial fish swarm algorithm is a stochastic global optimization algorithm proposed that can quickly find the optimal solution by simulating behavior of a fish [8]. The behavior of simulating fish have the character of foraging, bunching, follow, randomly move, and a form of bulletin board. Initially, the status of the fish was x_i and the food concentration of status was y_i[10].The simulating fish can moved to an area for a fixed distance *Step.*

1. Foraging. If the fish can find an area where the food concentration more than current position in the visible region, the fish will move toward it. After the movement the status of the fish was x_j . If the fish cannot find the area of condition after several selections, it will randomly move. After the movement, the food concentration of status was y_j. The behavior of foraging is shown as formula (6).

$$\begin{cases}X_i(\mathrm{t+1})=X_i(\mathrm{t})+\dfrac{1}{\|x_j-x_i\|}\bullet(\mathrm{Step})\bullet(x_j-x_i) & y_j\ge y_i\\ X_i(\mathrm{t+1})=X_i(\mathrm{t})+(\mathrm{Step})\bullet rand() & y_j<y_i\end{cases} \tag{6}$$

2. Bunching. The number of the simulating shoal was n in the visible region, and the shoal central location of status was x_c . If the food concentration of status y_c was more than y_i ,and much less crowd in x_c , the fish will move to the shoal central location. The behavior of bunching is shown as formula (7). δ was crowded degree.

$$\begin{cases}X_i(\mathrm{t+1})=X_i(\mathrm{t})+\dfrac{1}{\|x_c-x_i\|}\bullet(\mathrm{Step})\bullet(x_c-x_i) & y_c>>y_i\\ y_c/n>\delta\bullet y_i\end{cases} \tag{7}$$

3. Follow. If one fish in the visible region where the concentration food was maximum, and the crowd was less than current position ,so the fish will move toward it. Otherwise, the fish will foraging.

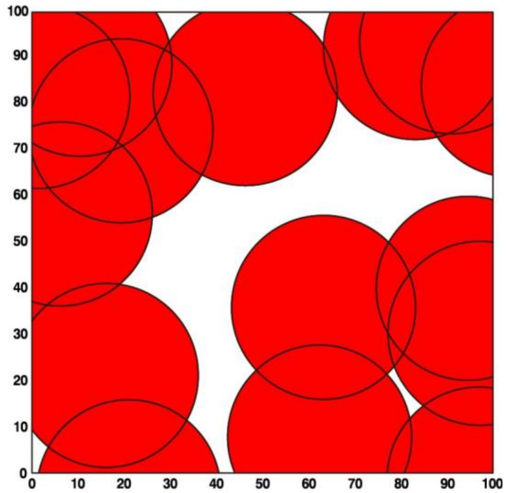
4. Bulletin board. The fish compared the food and the crowded degree to choose an area to move and recorded. If have one selection was better than the record, it will be replaced.

B. The Simulation Experiment of Artificial Fish Swarm Algorithm

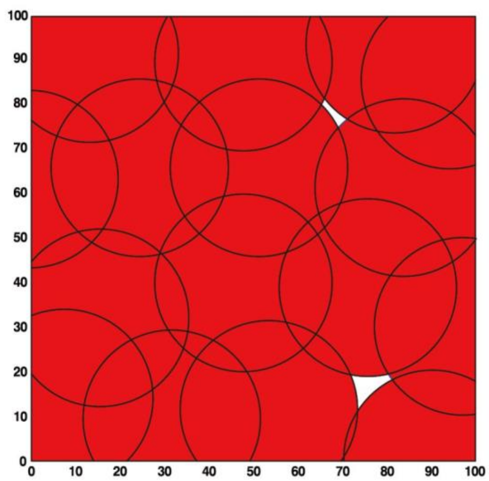
According to the food concentration, the fish chose foraging, bunching or follow and then refresh the record. The optimization solution was obtained by repeat this. Using this algorithm, we adopt the monitoring node in the system as the simulating fish and random distribution in area of 100 m×100 m. The sum of simulating fish was 30. The visible distance was 20 m, the fixed displacement distance was 3m. Operated in MATLAB 2010.

C. The Simulation Analysis of Artificial Fish Swarm Algorithm

Figure 5 shows comparison of the random distribution and coverage optimization distribution by algorithm. Coverage rate was lifted from 63.2 % to 96.4 %, and the monitoring nodes were well distributed .The usage rate of monitoring nodes was lifted up, and the energy consumption also reduces by 56.7 %.



a）Initial status



b）Optimization status

Figure 5. NComparison of Optimization result

IV. CONCLUSIONS

This paper designed completely the Sulfur Dioxide And Nitrogen Dioxide gas monitoring wireless sensor network system based on ZigBee, the system of coverage radius was larger than 2 km. By Artificial Fish Swarm Algorithm, the communication range is observably increased. The usage rate of monitoring nodes was also lifted up. Reduce the cost of the system. It can satisfy actual requirements.

This system can be widely used in the field of data acquisition and monitoring system.

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