Design of Monitoring System for Urban Low-Lying Water

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Abstract: The Internet of things technology is applied to establish a low-lying ponding monitoring system, which includes information acquisition system and information management system. This GPRS, 4G, Java, Internet of things and large database technology are applying to build a data acquisition hardware platform. On this basis, the basic database of road ponding and the monitoring and early warning system of road ponding in low-lying land are established. Thus, the application requirements of road ponding information query, management, monitoring, water level change analysis and water level overrun alarm based on map are realized. At the same time, the control of relevant drainage facilities has been integrated. The modern management means of road low-lying land ponding monitoring has been improved. And the management and control level of municipal road ponding has been comprehensively improved.

1. Introduction
In recent years, with the rapid development of urbanization, the management of urban drainage pipe network is facing severe challenges. Compared with the development of informatization, the management mode and management method of urban drainage pipe network lags behind. New management technologies and means are not adopted to obtain the real operation data of drainage pipe network in time. It can’t effectively predict the daily maintenance effect of pipe network. Reasonably formulate economic and efficient pipe network maintenance can’t be planned to carry out accurate management and auxiliary decision-making.

Some large and medium-sized cities have established road ponding monitoring systems. But most of the road ponding monitoring systems built at present still monitor the urban overpass and severely waterlogged road sections over the years through video monitoring, electronic water gauge and manual control. The monitoring can only cover some important sections and nodes. However, there is no special real-time monitoring system for waterlogging in cities. When rainstorm occurs, it is often unable to give timely and accurate waterlogging situation, so it is difficult to take reasonable countermeasures. When ponding occurs in urban low-lying areas, it will not only block the road and affect the traffic, but also endanger the life safety of traffic personnel. During the rainstorm, pedestrians fell into the inspection well with the well cover washed away by water and drowned in the excavated overpass are reported every year. Building a real-time monitoring system for road ponding, especially low-lying tunnel ponding, has become an urgent need to improve the modern management of drainage network by providing urban drainage managers with a new perspective to observe and browse the dynamic operation of drainage network [1].

2. System scheme design
Aiming at the problem of ponding on the pavement in case of Rainstorm in a district or county in China
in recent years, a monitoring platform for urban road low-lying land is established. A road area water monitoring network is built through Internet of things technologies such as water level sensor. Thus, it can realize the application requirements of map-based road ponding information query, management, monitoring, water level change analysis, water level overrun alarm. And the relevant drainage facilities are integrated to improve the modern management means of road low-lying land ponding monitoring, and comprehensively the management and control level of municipal road ponding.

A drainage system suitable for urban roads is established to monitor and warn the water level of low-lying areas, inspection wells, overpasses under the expressway and street ponding points in real time, data analysis and threshold warning, so as to timely find and locate faults and problems and reduce road congestion. The overpass and tunnel ponding monitoring points can be linked with the local drainage pump station to automatically control the start and stop of the drainage pump unit according to the ponding water level. The drainage system can fully grasp the current situation of urban drainage and take flood control and drainage measures in time, so as to realize the monitoring, dispatching and management of urban drainage system [2-3]. The schematic diagram of urban networking monitoring framework is shown as Figure 1.

![Figure 1. Schematic diagram of urban networking monitoring framework](image)

2.1 System hardware design

The construction of urban road ponding monitoring system mainly includes information acquisition system and information management system. The hardware part of ponding automatic monitoring and early warning is the core part of the system. The information acquisition hardware part mainly collects rainfall information and water level data of ponding. After analyzing and processing the collected relevant data, it is stored in the external memory and realized the real-time display and transmission of data. According to the overall scheme design of the system, the hardware design scheme of urban road ponding monitoring system terminal is shown in Figure 2.
The system hardware circuit includes STM32 core module, power module, external data memory module, display module, water level sensor module, rainfall sensor module and clock circuit.

2.1.1 design of road ponding monitoring system. The road ponding monitoring system adopts the water level sensor TC401, which is designed with the digital idea, and has a sampling circuit, a control and processing circuit and a data communication circuit. The technical parameters of water level sensor are shown in Table 1.

The water depth data is collected through a fixed spacing electrode sequence. Because the internal circuit is sealed with epoxy resin and the high and low potential threshold of the electrode is adjustable, it can’t be affected by factors such as sludge deposition, water surface freezing, environmental temperature and humidity, water quality conductivity and so on. Its measurement accuracy is not affected by the change of sensor range. However, waterproof and insulation treatment shall be done at the connection of signal line.

Table 1. the technical parameters of water level sensor

| name                   | parameters                           |
|------------------------|--------------------------------------|
| working voltage        | 9~18VDC(12VDC)                       |
| resolving power        | 5mm,10mm,20mm optional               |
| working temperature    | -30~+50℃                             |
| single length          | 0.8m,1.2m,1.6m optional              |
| maximum Cascade Range  | 0~15m                                 |

The output signal of the water level sensor is a switch signal. But the microprocessor processes the logic signal. So, it is necessary to process the output signal of the sensor.

2.1.2 communication mode design. Network communication is the core component of urban road ponding automatic monitoring and early warning system. STM32 is connected with MG301 through a group of serial ports, and then controls MG301 module through at command to complete initialization, access network, transmit data and other operations. The host is connected to the central server through the GPRS module which establishes the network connection through the set external network IP address and mapping port of the server host. Then PPP (Point to Point Protocol) protocol and TCP/IP (Transmission Control Protocol / Internet Protocol) protocol are used to ensure the establishment of connection between the module and the server host and the transmission and reception of data.

The mobile phone can send SMS with specified instructions to the SIM card number on the host to change port number, serial port baud rate, host time, server IP and other parameters. The function flow of GPRS sending data is shown in Figure 3.
2.1.3 design of ultrasonic ranging system. Ultrasonic ponding information collection, ultrasonic ranging controls the sensor to transmit and receive ultrasonic through STM32, calculates the distance \( s \) by using the time difference \( T \). That is, the propagation time of ultrasonic in the air, and processes the error of the collected data \(^{4-6}\).

The sensor A07 module has three output modes: PWM processing value output, UART automatic output and UART controlled output. It is mainly set by software. Different models can be selected to set the module to different output modes. The sequence diagram is shown as Figure 4.

![Figure 4. A07 sequence diagram](image)

When RX lead receives a falling edge pulse, the module will be awakened from sleep mode to enter the working mode, and start the detection function for 5 ~ 15 times. When the detection is completed, TX lead will output high-level pulse width signal, and the high-level duration of module TX lead corresponds to the distance between the detection target and the module. The trigger cycle of the module must be greater than 2.5s. If the module does not detect an object, the TX lead will output a fixed 50ms pulse width.

The UART automatic output mode outputs the measured distance value according to the UART communication format. In this mode, there is no need to add a trigger signal. The working cycle of the module is 160ms, and the automatic measurement is once. After 5 to 15 times of measurement, the TX lead will output the measured distance value. The response time is 0.9s to 2.5s. The work cycle and response time can be customized according to customer needs. This output mode can reduce the use of single-chip microcomputer I/O port, and only one I/O port can realize distance measurement.

2.2 System software design

After system initialization, the CPU compares the real-time water level data collected by the water level
sensor with the set warning water level. If the real-time water level data does not exceed the warning water level, the system continues to monitor and compare the real-time water level data. If the real-time water level data exceeds the warning water level, the real-time local water level data will be released in real time through GSM short message and GPRS wireless data transmission. The system software flow chart is shown in Figure 5.

A complete system is inseparable from the monitoring of the system state. In order to better coordinate the software and hardware, it is necessary to closely monitor the whole system. In this system, the timer T0 interrupt service program is responsible for data reading, processing and output display tasks. The A/D conversion is sampled every certain time, and the corresponding processing is carried out. The liquid level display is realized through the LED driving circuit. The liquid level monitoring process is shown in Figure 6.

Figure 5. system software flow chart  
Figure 6. flow chart of liquid level monitoring

### 3. Conclusion

The system uses simulation to build the hardware part, and only carries out networking test. The system operates stably and continuously monitors the ponding in urban low-lying land, which basically achieves the expected purpose of system design. The next step is to build the real hardware system, improve data acquisition equipment, cooperate with municipal departments and meteorological bureaus to promote this convenient service as soon as possible while improving data reliability.

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