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Water Level Intelligent System of Data Acquisition and Early Warning

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Abstract

In order to improve work efficiency of hydrometric station, guarantee the accuracy and timeliness of water level data acquisition, process water level data in a timely manner and make early warning of risk, mobile devices are proposed as collection, sending and early warning terminal of water level data, and the upper computer as the receiving and processing terminal of water level data. The water level access algorithm is studied, and the stripping method is used to obtain the high-accuracy water level information. The image thinning algorithm is applied to optimize, so as to reduce the complexity of the algorithm. The programming is able to control real-time data sending, which realizes the data exchange between server terminal and communication module. Microsoft Access database is applied to the operation of water level information and the design of man-machine interface. Experimental study shows that this system can accurately acquire information in real time, undertake statistical analysis of data with many functions such as early warning, effectively improve the work efficiency of water level monitoring and improve the management level of hydrological industry.

Keywords: *water level monitoring system, dissection method, image thinning, prewitt, microsoft access*

1. Introduction

Water level monitoring is the basis of the water conservancy work. Without water level monitoring, there would be no water conservancy construction or other infrastructure. Currently, through real-time monitoring on the water level of rivers and reservoirs, water level monitoring rooms can give out the early warning on the possible floods and other disasters. However, most of the domestic hydrological stations still use the artificial monitoring method at present, which not only poses a threat to the safety of test personnel but also results in relatively large error in monitoring data that cannot meet the requirements of accuracy and timeliness [1]. With the development of computer technology and network communication technology, water level detection has also developed from single field detection to multi-site remote real-time detection, with the cross-regional, all-weather, real-time characteristics. With the development of mobile communication technology and the popularization of personal mobile terminal, real-time water level information can be sent to the server and the staff who can keep abreast of its information wherever they are. Furthermore, the water level changes within a certain period can also be analyzed through long-time records of the software, in order to make the timely preparedness.

The basic design structure of water level monitoring system is basically the same. However, various products have their own characteristics according to the market demand and their emphases on different aspects, which mainly refers to that they have different accesses to water level information. The existing products on the market mainly have the following design thoughts in terms of the access to water level information: float type, ultrasonic type, laser type, camera collection type, etc., and their respective advantages and disadvantages as well as applications are as follows: float type is widely used in reservoirs and rivers because of its advantages such as data collection stability, easy installation and low cost, but it has the disadvantage such as complex machining, short life and a significant decrease in the measurement accuracy when there is sedimentation; ultrasonic type makes use of the aeroacoustic measurement and control principle, and obtains the water level by calculating the time difference between transmission and reception of ultrasonic waves. It has an outstanding advantage and can obtain a very good measurement result. Currently, a few ultrasonic type

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products have been used in the water level monitoring. However, it also has a disadvantage that it is more obviously influenced by the weather. When strong winds and big waves appear, an error measurement will be caused and the data can not be discriminated and sent back, which will increase the workload of the processor; the computer technology development makes it possible that the intelligent image sensor can be introduced in the water level detection. The intelligent image sensor not only has a higher degree of recognition, but also can process data intelligently and send back the on-the-spot situation in the form of image or video, facilitating the analysis of staff.

2. Research on Water Level Information Acquisition Algorithm

Water level information acquisition algorithm refers to an algorithm of regarding water gauge image placed in the water as the research object, and mainly using the scale value where water line disappears in the water gauge for reference. The auxiliary line is adopted to calibrate and adjust the relative position between camera and water gauge. During the initial installation, the positions of water gauge and the mobile phone may not be parallel, or water gauge is not in the middle of the image, which needs the third auxiliary line to adjust the camera angle and the relative position between camera and water gauge in order to ensure the imaging quality. The values and Letter "E" scale in the water gauge plate are important references when the water level is read. However, the values or scales are blurred subject to a variety of external factors such as stained foot plate. Then, this algorithm will discard the digital information in the water gauge plate and find the relative position where the waterline disappears in the water gauge panel to calculate the water level . The algorithm flow is shown in Figure 1: after collecting water gauge image, use image processing method to get the scale value where water line disappears so as to obtain accurate water level information.

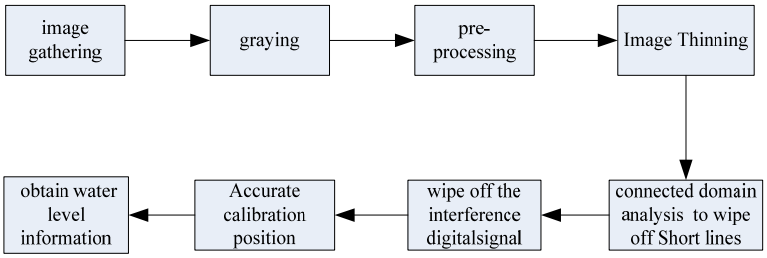


Figure 1. Obtain Water Level Information Algorithm Flow

When using this algorithm to process the image, the image shall first be grayed, because there is a lot of color information on color image, which has higher requirements for system memory and the processing speed of processor, while the grayed color image can better adapt to the status of smaller smart phone memory. Under the weighted average method, R, G and B are endowed with different weights according to the different requirements of the importance. Because the human eyes have a different sensitivity to red, green and blue, the graying formula is obtained as follows after testing:

$$Gray = 0.299R + 0.587G + 0.11B \quad (1)$$

The main purpose of image preprocessing is to eliminate the noise interference, which is achieved by adopting the spatial filtering method. This method can be divided into two aspects: smoothing and sharpening according to the different functions. Smoothing can be achieved by a low-pass filter, aiming at removing blurred details or connecting small intervals in the target picture together before extracting larger targets in order to achieve the purpose of eliminating the noise interference; sharpening refers to making use of high-pass filter to enhance the information of blurred details. The interference of tiny line type information in the

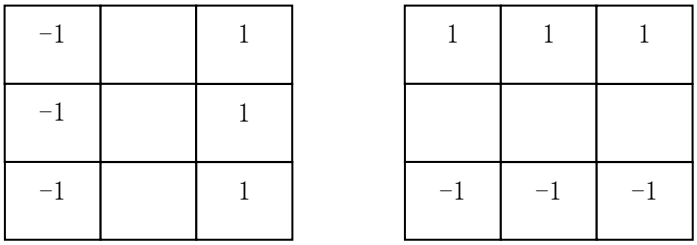
water gauge plate can be eliminated and the Letter “E” scale and numerical information can be retained by conducting the smoothing processing of image at first to remove small details.

The most commonly used smoothing filter is divided into two types: linear smoothing filter and nonlinear smoothing filter, of which the linear smoothing filter adopts the field average method to set templates. For example, take the coefficient of 3*3 template as 1. But in this way, some details in the image will be blurred out when the noise is removed. A median filter can be adopted to conduct the smoothing processing of image in order to achieve the purpose of saving the image details simultaneously with eliminating the noise. This purpose is mainly achieved by arranging the gray values of the corresponding pixels under the templates from small to big, taking the middle value and assigning it to the pixel of the center of the corresponding template.

X_1、X_2、、、X_n represent the gray values in the template. They are arranged by size as follows: X_{i1}、X_{i2}、、、X_{in}. The median Y is calculated by the Formula 2:

$$Y = Mid\left(X_1, X_2 .....X_n\right) = \begin{cases} X_{i*n/2} + X_{i*(n+1)/2} & n \quad \text{even number} \\ X_{i*(n+1)/2} & n \quad \text{odd number} \end{cases} \tag{2}$$

Isolated noise points can be eliminated by using the above filters. Because the scale line on water gauge panel in the water gauge picture has obvious stroke information, information on the water line position can be obtained through the edge detection when making the image analysis. As the scale lines are normally displayed in a horizontal way, the scale is rich in the edge of the horizontal direction. The edge information in the horizontal direction of the character can be extracted by using the operator in the horizontal direction of Prewitt operator or Sobel operator [2-5]. The present algorithm uses the Prewitt operator. The template is shown in Figure 2.



(a) (b)

Figure 2. Prewitt Operator Algorithm

Those in Figure 2(a) and Figure 2(b) respectively refer to the operators of the horizontal and vertical templates. When using the horizontal operator to extract the edge information on the scale line, the edge in the vertical direction can be ignored, to reduce interference.

In this algorithm, the high precision of scale is required. The accuracy of positioning the intermediate point will have a large impact on the performance of the algorithm. Furthermore, the scale on water gauge board has its inherent characteristics, for example: scale lines are evenly distributed, and the same scale line is horizontal. The refinement process can first consider adding prior knowledge of water gauge plate to give the refined and precise positioning to the wider edges. In the algorithm dissection method is used mainly to dissect edge pixels from outside to inside.

The main steps of dissection are as follows:

1) Foreground image value of binarized scale line is set as 255, and the background value is 0. Take a point of the vertical center line, with prior or later pixel 0-255 as the boundary and the initial point;

2) Search from the initial point to the direction of 255 pixel, delete the initial point when N foreground points successively emerge, and eliminate the noise interference;

3) search downward from the initial point in the vertical direction to determine the position of the upper and lower edge points;

4) Set the midpoint of the upper and lower edge points as the skeleton baseline position;

5) Keep the horizontal center points with the error of less than 3; connect base point to determine its position.

The study on scale line position shows that skeleton position and the upper and lower boundaries of the scale line are substantially parallel to each other. The width of the scale line remains unchanged, so the image refining algorithm can accordingly be optimized, reducing the complexity of the algorithm [6]. The specific processes are as follows:

1) Scan line by line, and mark the current foreground as the to-be-determined point;

2) Mark the last point on the corresponding column of the to-be-determined point the as background point, label the next point as the foreground point, and then determine the upper border of the scale on this point, and put the position information into the corresponding memory;

3) Cluster the position information on the upper border to derive the precise location of the upper border, and then subtract 1/2 of the scale line width in the original image to get the exact position of the water gauge scale.

As illustrated in Figure 3(b), the precise position of water level scale mark can be obtained as long as the number of iterations of operations is reduced and the operation speed is improved after optimizing the algorithm.

Although the positions of scale mark and similar scale mark noise have been obtained through the initial processing of image, the interference of the figures with straight lines can not be eliminated. Therefore, short straight lines and figures must be removed to reduce the noise interference.

The scale mark on the water gauge scale plate generally has a fixed length which can be used as a reference to define a too short or too long straight line as noise and then analyze length information of the straight line in the image, thus excluding the straight line interference.

By adopting the connected component analysis method, the independence of each straight line can be determined, the number of connected regions can be counted, and the statistics of length information can be conducted in order to eliminate the interference of scale marks. The so-called connected component analysis method refers to extracting the size and position information of the connected regions by checking the connectivity between various pixels and their neighboring pixels.

In practical applications, the connected component analysis method is divided into two types of methods: pixel labeled analysis method and run connectivity analysis method. The algorithm adopts the pixel labeled analysis method to mark the current scanned pixels through scanning a binary image from left to right and from top to bottom. It is required to check the connectivity between the current scanned pixels and the previous scanned neighboring pixels. This algorithm will take the water gauge scale mark as the analysis object. If the width of the water gauge scale mark is 1, the number of iterations can be reduced, and the operating speed can be faster. As illustrated in Figure 3(c), can be too long or too short straight line noise can be removed after the connected component analysis.

The scale in the water gauge plate can be divided into two parts, of which the right part only has uniform scale marks while the left part have both uniform scale lines and scale values. The following part is to conduct statistical identification mainly aiming at scale marks. The scale values may be treated as scale lines in the subsequent processing if they are not removed, which will affect the measurement result. Therefore, it is necessary to design an algorithm to eliminate the interference of values in the subsequent processing. The design thought of this algorithm is to directly project the right part onto the left part in order to remove the original scale lines in the left area. The process is as follows:

1) Make use of the symmetric relation to get the position of middle marking;

2) Conduct a cluster analysis of the interval between lines in the right part according to a set threshold value;

3) Project the position of scale mark in the right part onto the left part in order to eliminate the interference of the original scale in the projection area;

4) The effect after removing the interference of short straight lines and figures is illustrated in Figure 3(d).

An effective water gauge scale mark can be obtained basically after the above processing. but it is necessary to continue processing the scale mark due to a higher accuracy

requirement, and then quantify the analysis result to draw a new staff gauge. As illustrated in Figure 3(e), this paper obtains the interval length by clustering the water gauge scale mark intervals, thus obtaining an effective water gauge scale mark.

Draw a new staff gauge, and use it to find the minimum scale mark of water gauge, thus obtaining the water level. The position where water level disappears in Figure 3(f) is the water level information which is necessary to obtain. This algorithm takes looking for the position where water level disappears as a train of thought. The key lies in establishing a new water gauge model through the image processing algorithm for precise positioning of the scale marks in order to reduce errors, thus meeting the accuracy requirement required by the practical application.

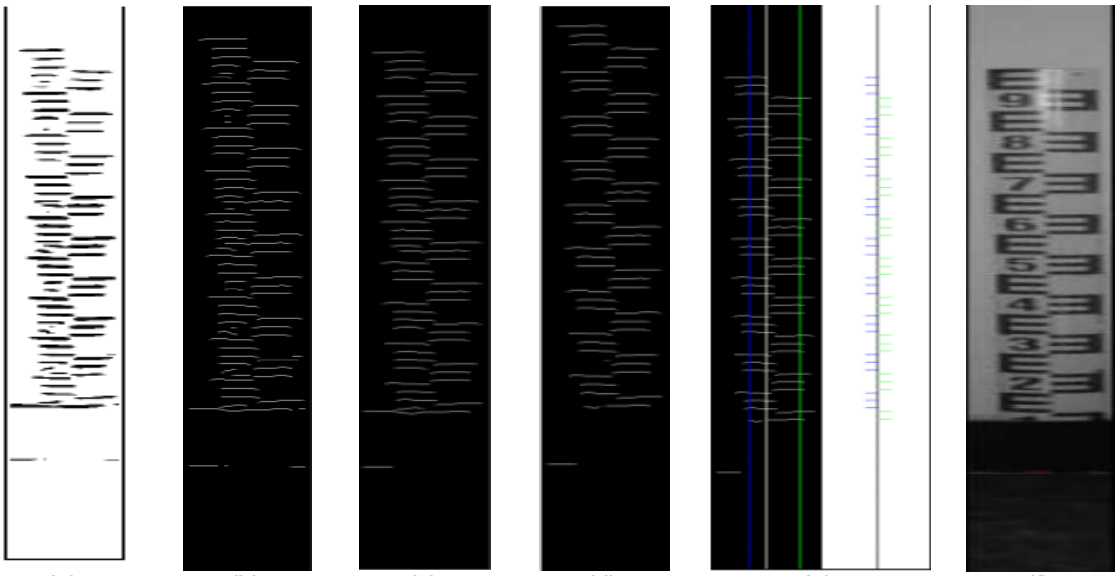


Figure 3. Algorithm Processing

Aim at algorithm accuracy and stability to perform the water level recognition experiment, with the results shown in Figure 4. Take 124 water gauge pictures of different water levels under the laboratory's man-made scene as test library, and the test results are: under the condition of the allowable error of ± 1, 124 pictures are correctly identified, and the recognition rate is 100%.

Figure 4. Experimental Results

3. System design

Water level monitoring system is composed of the control server and the dispersed water level monitoring points. The server is mainly responsible for processing and analyzing water level information, and giving early warning on hazard information; each water level monitoring point mainly uses the image analysis system developed on the mobile terminal to analyze water gauge pictures and get the water level information, and adopts GSM communications network and server to transmit the information [7]. Server analyzes and processes data, with the system structure shown in Figure 5.

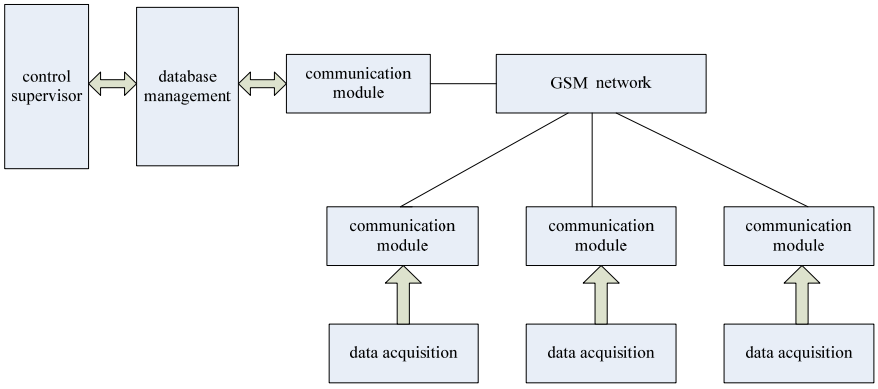


Figure 5. Water Level Monitoring System Structure chart

Information collection module takes smart the mobile terminal as the platform, requiring WP operating system, dual core 1.5GHZ processor and above, 1GB RAM and 32GB ROM, camera (equipped with the flashlight) resolution of 1280 * 768 pixels, which should have the strong capabilities of data processing and imaging.

3.1. Design of Acquisition Module

According to the application requirements, the module shall have the function of receiving and sending information. Its principle is that host computer via RS-232 asynchronous serial communication uses AT command control SIM300 GSM module to complete the whole function. SIM300 is equipped with a standard RS-232 serial interface, which via the data cable can be connected directly to a computer serial port.

A complete water level record should contain the information area code, water level time, real-time water level height, and the text format is used to improve the efficiency of encoding and transmission. The above information is replaced by letters and numbers. Its command format is shown in Table 1.

Table 1. Order Format

time	monitoring station	Water level information
twelve characters	four characters	Seven characters

An entire command contains 23 characters. The written order of water level time information includes year, month, day, hour, minute, second. Monitoring point information identifier ID shall add the area code. Water level information is constituted by the identifier WL plus water level. After receiving commands, the receiver will recover data and archive according to rules for writing instructions. The following is the command format used in the system.

Information from transmitting terminal is 130410120906ID05WL00097, consisting of a total of 23 characters. Time format: 130410120906 is obtained by the transmitting terminal when obtaining the system time, which represents 12:09:06 on 10 April, 2013; location format: ID05 is the location identifier; 05 represents the position marked by the transmitting terminal;

information format: WL00097 is the water level identifier, and 00097 represents the water level of 9.7 meters.

The transmitting terminal first extracts the front 12 characters to obtain the information about water level time, then obtains the monitoring point position information from the rear character of ID, and finally reads out the water level data after WL, thus completely transmitting and receiving the water level information [8]. In practical use, the change in water level information usually is not particularly significant in a short time. In order to reduce the cost, short message can be sent once every 10 minutes.

3.2. Server Software Design

Server program is mainly to receive, store data, control the communication module and make the data analysis. System software can be divided into three levels, as shown in Figure 6.

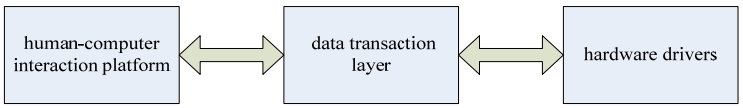


Figure 6. Upper Computer Software Flow

Human-computer interaction platform is to serve customers, and provide a wide range of menu interface according to user needs, and convert the user needs into the machine language to send to the data processing layer; data processing layer is mainly to deal with instructions from human-computer interaction platform and send to the hardware driver layer, and process data fed back from the upper and lower layers; hardware driver layer controls the communication module through the serial port.

With the characteristics of low hardware requirements, easy operation, low development cost, desktop database runs on a personal computer and is popular with individual users. Common desktop database products include Paradx, FoxBase, Visual FoxPro, Access and so on. Microsoft Access is a relational database. Access database is saved in the form of file, and the file extension is MDB. Server database uses Access, mainly based on the following advantages: a single storage mode, good object-oriented compatibility. Access database used in this system can fully meet the requirements.

Server software is designed to process mainly according to the data. Data sources of the server port mainly include such three parts as serial port data, database data, and user input data. According to the data source, the server function is mainly classified into three parts:

1) Data exchange between server and communication modules. This function is mainly to program serial port, use the serial port to achieve communication between hardware and human-computer interaction platform, receive commands and data transmitted from the human-computer interaction platform for appropriate treatment, and transmit feedback data back. This function is mainly to complete three functions of uploading data, downloading data and setting parameter.

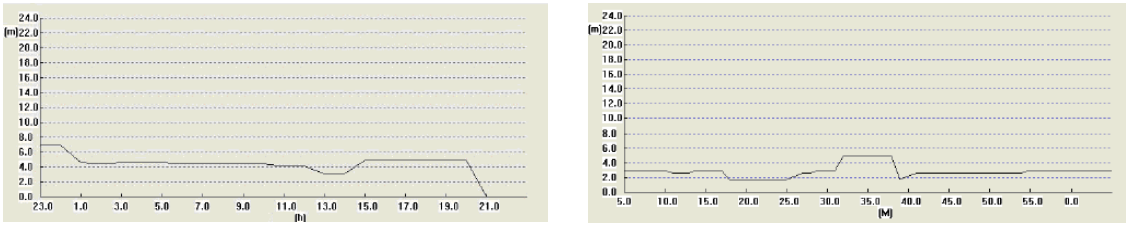
2) Manipulate data in the database. The role of database is to store data. The server program needs to manage the database. This function includes modifications to the data, query, input and output. First, it is necessary to connect management procedures and databases. In VC6.0 development environment, this paper uses ADO method to achieve connection between management program and database. Different from the traditional layers of data objects, ADO can be independently created, and can create a "Connection" object, but multiple and independent "Recordset" objects can use it [9-10].

3) Design of human-computer interaction interface. The main function of water level monitoring system is to monitor the water level, and can be divided into two functions such as the real-time alarm and water level information analysis. The operator can pre-design water level warning value, and give out the alarm when data value at the monitoring point is larger than the warning value; water level information analysis is mainly to inquire the historical water level information stored in the database and use the curve to illustrate the general direction. This paper provides two ways of curve representation. One is the curve trend of water level

information within the current one hour; the other is to inquire the curve trend of each hour within one day.

4. System Realization

Data storage types in the database are shown below. The entire information is composed of the location information, time information, and water level information. When the server receives a message, it will first judge the water level, and will give out the alarm if it exceeds the warning water level. All the data will be stored in the database. The curve data are read from the database.



(a) Water level chart of a day (b) Water level chart before one hour

Figure 7. Water Level Tendency Chart

Server program can manually select the query way, and provide the water level information of each hour within one day, as shown in Figure 7 (a) and one hour real-time water level information as shown Figure 7(b) below, and within the display area can draw the corresponding curve. The system provides the real-time alarm function. You can pre-set the alarm level. When the water level monitoring value exceeds the alarm value, early warning information column will show the information about water level position, time and water level, and give out the alarm.

The system uses the GSM communication module to transmit information obtained from data acquisition modules of each monitoring station to water level monitoring center database, and adopts the monitoring software for real-time monitoring on data of monitoring stations. It has the functions of warning, settlement & accumulation, statistical analysis and so on to achieve the scene parameter collection, real-time data communication control of the control room and the hydrological station, which can effectively improve the automation and control level of water level monitoring, and help to improve the management level of the hydrological industry.

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