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The Water Level Automatic Measurement Technology Based On Image Processing

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Abstract. Design a real-time hydrological monitoring system. Using the ARM processor and video server combination of methods, realize the characteristic features of the next place machine extraction, and then through the GPRS connect PC . Also have the power supply, low power consumption, anti-interference characteristics. The system use Wince programming, to obtain the binary image, using morphological algorithm to remove useless characteristic features, then carries on the edge refinement, use the hough transform to extract the straight line equation of water level and the bank line to compute, can get out the distance between the two in the image, according to the actual coordinate can get the actual distance. The experimental results show that the system has a real time and efficiency, effectiveness, and other characteristics, get a good recognition effect.

Introduction

Water level automatic monitoring is an important aspect of water resources automation management .In recent years， due to abnormal climate changes, all kinds of frequent occurrence of disasters, incl uding floods particularly serious, it is very apparent that water resources management is extremely i mportant.The traditional measurement of water level plays an important role in flood prevention. Ho wever, there are some limitations in the traditional contact type water level measurement,such as ins tallation site and way of supply constraints. On the other hand, the traditional non contact type water level meter, such as ultrasonic flowmeter and electromagnetic flowmeter, will appear the larger erro r, which is not suitable for this type of state river water level measurement for higher water content as well as the highly dynamic changes of river water level measurement.

The system, convenient installation, uses solar power. It is not affected by river sediment content as well as the height variation limits. In actual operation, stable and reliable performance, is not affe cted by temperature.Water regime can be real-time detection.

System scheme

Water level station, fixed to the water, served as the center station, which uses solar power. The data , uploaded from the surrounding the sensors using ZIGBEE technology to the central station, is pres erved and analysed by the ARM processor chip, in the interior of which the image are processed and characteristic features are extracted and calculated. A camera is installed on the water to conduct re al-time monitoring.

System hardware design. System structure diagram as shown in Fig.1. The system is mainly com posed of a peripheral device, processor, power supply module and a data transmission device.

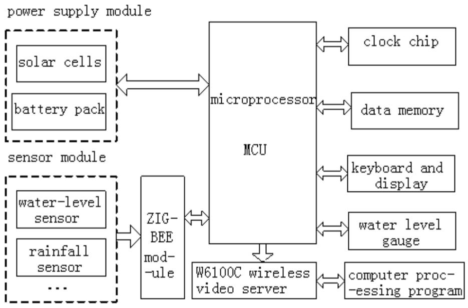

Fig.1 System hardware chart

Power supply design. In order to reduce system power waste, our system of regional respectively supply strategy, to achieve the device to separate control purposes. When the system is needed runn ing, the power supply module for the whole system; when not needed, the power module is the powe r supply only to the necessary device. At this time, the system enters a sleep mode. System ARM pr ocessor pins were used in order to control the base current of the transistor, the transistor when appr opriate conduction or cut off, in order to realize that the non power supply device power managemen t. So that we can achieve power management to not ofen needed power devices. It can make the pow er supply mode of the system more flexible, achieve the effect of saving energy.

Low power design. Taking the microprocessor as the core of the detection system is the main pro blems for low power design. We chose a dormant mode in ARM chip: in idle mode and the power mode. The additional power consumption can be optimized through the prohibition of peripheral fun ction and peripheral clock divider. In addition, now some microprocessor at work, can use the intern al and external clock, one for high speed and one for low-speed clock. Making use of the ARM proc essor is now more popular phase-locked loop (PLL) technology, the microprocessor clock frequenc y of the system can be controled by the program. So that the microprocessor uses different clocks du ring different time periods in order to achieve low power consumption. Low voltage is selected for t he power supply system. According to the formula of the energy and power, as well as directly prop ortional to time. So, it plays a very important role that Low voltage power supply mode is selected f or the system of low energy consumption in a low power system. In the choice of system voltage sta bilizing chip, chip reset and other peripheral components, its very low power consumption device wa s selected.

System software

Because the system uses solar power and GPRS transfer, the image, collected by the video server dir ected, is not easy to be long time transmitted. Therefore, the system is designed that the image featur e extraction was calculated in ARM processor, and data was transmitted when PC inquires or overru n.

Image preprocessing. Gray image is converting the color image into black and white image. Bec ause gray images was easier operated than color images, so generally the color image is converted to gray image. This conversion does not determined the standard. So the system adopts weighted gray.

Generally speaking, the results are based on the original image of RGB 3 components as well as t heir right to strike. The solving of the 3 subscales is in accordance with the 0.38,0.49,0.11 of the wei ght distribution in the system.Fig.2 is the original RGB image by gray processing

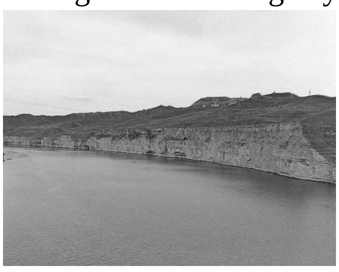

Fig.2 Gray image

Histogram equalization. Histogram equalization is achieved by adjusting the histogram contrast to enhance image contrast. The image histogram can be made by equalization algorithm to meet certain requirements. Equalization algorithm, achieved by nonlinear image stretch reassigned image pixel value, makes gray uniform distribution,as show in Fig.3,then analysis of histogram, choose appropriate threshold, makes binary processing for the image, separate target and background.

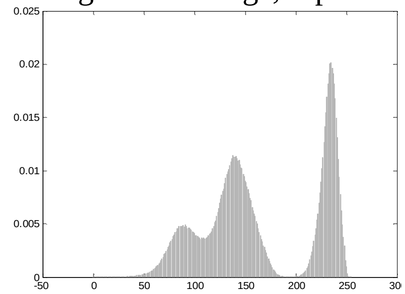

Fig.3 Gray-level histogram

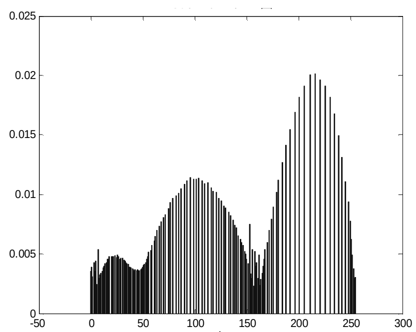

Fig.4 Histogram equalization

Procedures using Otsu threshold. Otsu threshold method is a threshold in the histogram is divided into two groups. When the two groups were divided into variance, the larger decides the threshold. Now, with an image of the gray value of $1 \sim m$, the gray value i of the pixel number is n_i, we can obtaine:

The total number of pixels: $N = \sum_{i=1}^{m} n_i$ （1）

The gray value of the probability: $p_i = \frac{n_i}{N}$ （2）

Then T will be divided into two groups $C_0 = \{1 \sim T\}$ and $C_1 = \{t+1 \sim m\}$, Each probability is generated as follows:

C_0 generated probability: $w_0 = \sum_{i=1}^{T} p_i = w(T)$ （3）

C_1 generated probability: $w_1 = \sum_{i=T+1}^{m} p_i = 1 - w_0$ （4）

The average value of C_0: $\mu_0 = \sum_{i=1}^{T} \frac{ip_i}{w_0} = \frac{\mu(T)}{w(T)}$ （5）

The average value of C_1: $\mu_1 = \sum_{i=T+1}^{m} \frac{ip_i}{w_1} = \frac{\mu - \mu(T)}{1 - w(T)}$ （6）

In the formula, $\mu = \sum_{i=1}^{m} ip_i$ is the overall image of the average gray value; $\mu(T) = \sum_{i=1}^{m} ip_i$ is the average gray value when the threshold is T. so the entire sampling gray mean value is

$$\mu = w_0\mu_0 + w_i\mu_i \tag{7}$$

we can get the formula making use of the variance between two groups as follows:

$$\delta^2(T) = w_0(\mu_0 - \mu)^2 + w_1(\mu_1 - \mu)^2$$

$$= w_0 w_1(\mu_1 - \mu_0) = \frac{[\mu w(T) - \mu(T)]^2}{w(T)[1 - w(T^*)]} \tag{8}$$

T was changed from 1 to m ,and was calculated when the valu of the formula was the largest,whi ch means that we can get T^* when the value was $\max \delta^2(T)$.At this time, T^* was the threshold value. And $\delta^2(T)$ is the threshold selection function.

No matter there are any obvious twin peaks in the image histogram, this method can get satisfact ory results. Therefore, this method is the best method of automatic threshold selection.Fig.5 is the t wo value image which use of Otsu threshold method for gray image processing.

Fig.5 Two value image

Morphology filtering. Due to the banks and shadow effects, the value of the two image is still a l ot of dark areas in the graph 4. Dark areas will need to be filled and edge smoothing in order to facil itate the next step edge thinning processing. The closing operation and corrosion properties of the fil ter may be used for mathematical morphology processing and filtering processing for the binary ima ge.

When the binary images are calculated by closing operation, based on mathematical morphology, the target information would be connected into a whole. At last, the unwanted clutter signal would be filterted out.

Fig.6 Morphological processing

And by utilizing morphological dilation, from Fig.6 we know that Image within the blank area is filled up in order to edge thinning.Fig.7 show the conclusion.

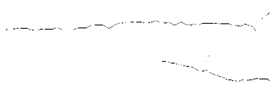

Fig.7 Edge thinning

Line extraction. Hough, the most commonly used linear detection method, the basic principle is t hat all data points on the line are mapped into the parameter plane straight line or curve. When colli nearity data points in the parameter plane intersect at one point, the majority of intersection of straig ht line is the best fitting curve. And the straight line extraction problem is transformed to a counting problem.

Hypothesis:

Line 1： $y = a_1x + b_1$ The Water Margin Linear Equations

Line 2： $y = a_2x + b_2$ Shore based edge linear equations

The polar coordinate equation was used to avoid vertical slope of a line of infinite problem.

transform algorithm of Hough as follows:

1) The parameter space are certain quantization.

2) Set every unit in parameter space as an accumulator.

3) The accumulator is initialized to zero.

4) The corresponding accumulator ,which the point meet the special parametric equation, should plus 1 for each point of the image space.

5) Maximum value totalizer displays corresponding the parameters of the model.

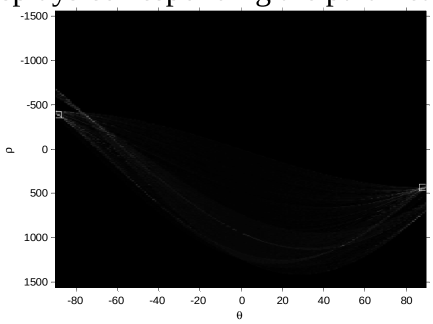

Fig.8 Hough transform

Polar coordinate parameter space mapping was shown in the Fig.8. We can see the Hough transfo rm results: parameter space in the two peak.

$\rho_1 = -388, \theta_1 = -89$

$\rho_2 = 438, \theta_2 = 88$

Based on polar coordinates to Cartesian coordinates, polar coordinate in the procedures will be tr ansferred into cartesian equation. We can get the water edge straight line equation:

Line1： $y = 15.29x + 387.94$

Line2： $y = 39.05x + 446.3$

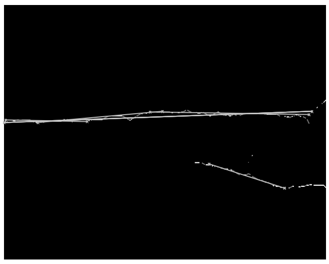

Fig.9 Linear extraction

Due to the position of the camera and shooting angle, in Fig. 9,two straight lines did not reach the parallel results.

In order to achieve compromise effect, through the coordinate origin (0,0) perpendicular to the str aight line fitting (Line1) line (Line3), the equation is $y = -\frac{1}{k}x = 0.04x$.

Line3and Line1 intersect at point A.Line3and line2 intersect at point B. And then we can calculat e the distance between A and B $d = 109.13$.

The distance will be converted to sub-pixel resolution pixel distance D:

$$D = k_1 \times d \tag{9}$$

In the formula, k_1 is the image pixel interval and coordinate numerical conversion factor. According to the pixel distance D, we can calculate the water margin and the physical distance

$$L = k_2 \times D \tag{10}$$

In the formula, k_2 is the conversion coefficient of the image pixel interval and the actual physical coordinates.Using this system in different distance L next measured results as is shown in Table 1.

Table 1 Model simulation results

L[m]	Actual value [m]	simulation value[m]	Deviation[%]
0.2	10	10.023	0.23
1	10	10.052	0.52
2	10	10.075	0.75

As the physical distance L which between water edge and reference edge increases, the water level deviation is more and more big.Therefore,the closer the distance between the calibration line and the water, the more accurately.So we in the practical application should be combined with the site condition nearly may reduce the distance between them. In real application, also need to consider the camera resolution, resolution poor camera with distance reduce will produce the deviation, but affect the measurement result. This laboratory use camera for MV - VD030SC, the highest resolution can reach 640 * 480.

Conclusions

The system uses ARM and image processing technology. Water level line height was calculated by the image processing technology on the water line. Otsu threshold method and Hough transformation are more suitable than other methods for automation system.

The practical application show that, Compared with the water level value by artificial measure, water level value by the system has higher precision. The error is less than 1%, which achieved satisfactory results.

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