Retraction Notice

The Editor-in-Chief and the publisher have retracted this article, which was submitted as part of a guest-edited special section. An investigation uncovered evidence of systematic manipulation of the publication process, including compromised peer review. The Editor and publisher no longer have confidence in the results and conclusions of the article.

JZ either did not respond directly or could not be reached.

Swimming pool safety detection device based on computer vision

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Abstract. Computer vision (CV) technology refers to the process of computer simulation of human vision and has the ability to perceive the environment and technology of the human visual function. In reality, CV is essentially the study of visual perception, a discipline that studies how to make computers see as humans do. Machine vision mainly uses computers to simulate human visual functions, extract information from images of objective things, process and understand them, and finally use them for actual detection, measurement, and control. With the frequent occurrence of safety accidents, especially in swimming, it is necessary to make adequate preparations to reduce the occurrence of accidents. Swimming is affected by many external factors. While completing swimming technical movements, trainees must overcome the stimulation of water on the body and the interference of breathing, which can lead to accidents. We aim to study the safety detection device of swimming pools based on CV and use the current popular CV technology to monitor the safety problems of swimming pools. We study the target motion trajectory detection system based on CV and use Zhang's plane calibration method to locate the camera. This research is based on how the computer back-end server realizes abnormal behavior detection, which greatly saves hardware costs. The experimental data shows that water quality is most important issue in swimming safety, accounting for 29% of the population, which indicates that water quality is the focus of users' choosing swimming as an activity. Of those surveyed, 19 people could not deal with the risks when swimming, accounting for 24% of the total group surveyed, which indicates that people's swimming safety coping ability needs to be improved. [DOI: 10.1117/1.JEI.32.1.011205]

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1 Introduction

With the development of the economy, people's living standards improve, people pay more attention to health, and increase the frequency of participating in physical exercise Swimming enthusiasts are participating increasingly in various water sports that are beneficial to the body and mind under the leadership of professional swimming coaches. Swimming has changed people's normal upright posture and normal breathing habits. Swimming involves exhaling under the water and inhaling above the water, and it requires certain movements. Although swimming can improve the body's immunity and physical and mental health, the frequency of accidents caused by swimming is also increasing. According to Ministry of Health statistics, about 57,000 people die from drowning every year, and the number of children drowning deaths each year accounts for 56.04% of the total drowning deaths. Also, more men die by drowning than women, and more are in rural areas than in urban areas. With the continuous development of technology, scientific and technological achievements are used increasingly in production and life. Computer vision (CV) technology can simulate human vision and perceive the surrounding environment, which largely makes up for the shortcomings of swimming safety. This technology can collect external data in real time to capture emergencies and provides a practical and effective guarantee for the safety of swimming venues.

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The combination of CV technology and swimming monitoring can extract useful feedback information and issue alarms in a short time. It can minimize the incidence of swimming safety accidents and eliminate hidden safety hazards in swimming venues to a great extent. The tracking and detection efficiency and false alarm rate of underwater targets are directly related to the accuracy of the whole system for drowning alarm, so the related research on the tracking and detection of underwater targets is of great significance.

This paper uses the built-in acceleration sensor of the Android device to complete the acquisition of acceleration data during swimming; it proposes data filtering, time windowing, and other preprocessing methods, as well as an optimal time window size scheme for the problem of swimming posture recognition.

2 Related Work

As a social subject, people pay the most attention to people. The current living conditions are improving day by day, and the standards for leisure projects are getting increasing. Kadir proposed a simplified CV-based application that uses an artificial neural network (ANN) that relies on a multilayer perception to accurately classify wheat kernels as bread or durum. The ANN abstracts the human brain neuron network from the perspective of information processing, establishes a simple model, and forms different networks according to different connection methods, showing good intelligence characteristics. The main visual features of four dimensions, three colors, and five textures are acquired using image processing technology. A total of 21 visual features were reproduced from the 12 main features to diversify the input population for training and testing the ANN model. The dataset of visual features is considered to be the input parameters of the ANN model. The ANN model was trained with 180 grains, and its accuracy was tested with 20 grains out of a total of 200 wheat grains.[1] Existing customer behavior research lacks quantitative and efficient research, and companies cannot accurately track consumers. CV is an expert in recognizing and tracking people's behavior, and its capabilities are suitable for investigating in-store customer behavior. Therefore, the purpose of Jingjing et al.'s research was to develop a CV-based offline consumer behavior profiling system to investigate in-store consumption behavior. He selected 71 shoe stores in China and then installed the system in the store for three months of data collection to evaluate the influence of customers' age, gender, store entry time, and regional factors on store entry behavior in China. Through systematic analysis, he successfully studied the method of improving the purchase conversion rate of in-store consumers, indicating that the system can guide enterprises to better adjust their marketing and operation strategies.[2] Xu et al. developed a fundus image quality assessment system based on CV technology and verified its accuracy by comparing the results of manual discrimination and using the system. The system is designed to automatically evaluate the image quality of each fundus image, identify the optic disc and macula, and judge whether the image is qualified or not according to the image quality discrimination rules. Through the exploration of the experimental objects, it can be seen that the evaluation process is divided into image preprocessing, image quality evaluation, image content detection, and evaluation result output. The final result shows that the accuracy of the system is higher than that of human discrimination.[3] Chen et al. introduced an online water meter verification system based on CV technology. The template matching technology is used to locate the plum needle, and the tooth values of the standby water meter and the water meter to be tested are counted during the verification. When the water meter to be inspected reaches the set value, the system automatically stops counting, calculates the error of each water meter to be inspected, and judges whether the water meter to be inspected is qualified according to the error. The field experiment results show that the system has higher accuracy and better working performance than the laser reflection measurement method on the wet disc water meter.[4] Zakwan et al. proposed an internet of things -based system to avoid accidental deaths and help parents take care of their children in swimming pools. He introduced a child drowning alert system to help parents keep an eye on their children in swimming pools. The system consists of NodeMCU and a heart rate sensor. The heart rate sensor is used to detect the heart rate of a child in a swimming pool, and the NodeMCU is where the code is implemented when an algorithm is developed to differentiate between a normal heart rate and a drowning heart. The system uses wireless fidelity to connect to a smartphone via the Blynk app. If the specified heart rate threshold is exceeded, the parent will receive an alert signal from the microcontroller. Through testing, the prototype was able to use this video simulation to detect early symptoms of a drowning condition.[5] Müller et al. proposed an adaptive neural network model for chemical data classification. The method uses evolutionary algorithms to optimize the network structure by finding sparsely connected architectures. The number of hidden layers, the number of neurons in each layer, and their connectivity are free variables of the system. Antimicrobial peptide activity was predicted from amino acid sequences using this method. Visualization of the evolved sparse network structure suggests that high charge density and low aggregation potential in solution are beneficial for antibacterial activity. However, different training datasets and peptide representations lead to vastly different network structures. In general, sparse network models are less accurate than fully connected networks. In a prospective application, Müller et al. synthesized and tested 10 de novo peptides predicted to have antibacterial activity or no activity. The two predicted antimicrobial peptides showed bacteriostatic effects against both Staphylococcus aureus and *Escherichia coli*.[6] Jin and Li proposed a zeroing neural network model that allows nonconvex sets to be used for projection operations in activation functions and incorporates new techniques to deal with inequality constraints that arise in optimization to break these limitations. Theoretical analysis shows that the zeroing neural network model has global stability and timely convergence. Finally, Jin and Li provided and analyzed illustrative simulation examples to demonstrate the effectiveness and superiority of the proposed zeroing neural network model for real-time dynamic quadratic programming subject to equality and inequality constraints.[7] Gong et al. proposed a deep-learning-based synthetic aperture radar image change detection method. This method completes the detection of changing and invariant regions by designing a deep neural network. The main guiding principle is to generate a change detection map directly from two images using a trained deep neural network. The method can omit the process of generating a difference image (DI) showing the degree of difference between the multitemporal synthetic aperture radar images, so the influence of the DI on the change detection result can be avoided. Learning algorithms for deep architectures include unsupervised feature learning and supervised fine-tuning to complete classification. Unsupervised feature learning aims to learn a representation of the relationship between two images. Furthermore, supervised fine-tuning aims to learn the concept of changed and unaltered pixels. Experiments and theoretical analysis on real datasets demonstrate the strength, feasibility, and potential of the proposed method.[8] Although these theories have discussed CV and swimming safety detection to a certain extent, the combination of the two is relatively infrequent and is not practical.

3 Method of Swimming Pool Safety Detection Device Based on Computer Vision

3.1 *Overview of the Swimming Pool*

With the development of the economy and technology, China's sports industry has also ushered in new development.[9] In the process of sports development, sports venues play a pivotal role. In fact, most gymnasiums are government-invested industries and are called public stadiums.[10,11] Public gymnasiums refer to social public stadiums, gymnasiums, and their ancillary facilities that are built through government financial appropriation or through other means to meet the needs of sports training, sports competitions, and mass fitness and entertainment. With the continuous activity of the market economy, a large number of private sports venues have appeared in the market. Here, we take the swimming pool as an example.[12]

As a branch of sports, swimming has attracted a lot of attention because of the unique environment. Swimming places often are in poor condition; water quality is not up to standard; there are no safety warning signs; swimming pools are irregular, with blind spots for sight. The safety problem here refers to safety in a broad sense, not just accidents, but it includes a series of aspects that serve safety, such as the environment, water quality, and equipment.[13,14] According to market surveys, a considerable number of swimming pools are currently poorly managed, especially in terms of water quality. The safety of water and its easy induction of infectious diseases can cause harm to humans.[15] Insufficient disinfection leads to substandard microbial control indicators related to water quality. In addition, excessive residues of disinfectants and disinfection byproducts can cause side effects in humans.

At present, there is little overall elaboration on swimming life-saving safety, and most of them focus on course training. China's model in this regard is largely based on European and American countries and mainly includes setting up advanced lifeguard training courses, and the research on teaching swimming safety is not very systematic. It mainly focuses on teaching safety norms and measures.[16,17] Lifeguards have problems such as insufficient professional skills and lifesaving equipment, imperfect assessment systems, long working hours, and weak professional responsibility. Figure 1 shows the warning state of human drowning transmission.

3.2 *Swimming Pool Underwater Video Background*

A large part of the detection of swimming pool safety is carried out in water, but the underwater environment is different from general environmental detection.[18] This paper proposes different detection schemes according to the characteristics of swimming pools. The specific conditions are as follows:

$$R = \sqrt{W_t^2 + Y_t^2 + U_t^2}. \tag{1}$$

Among them, Eq. (1) represents the brightness value of a pixel in a certain frame of image in the video, which is represented by *R*. Figure 2 shows the swimming edge monitoring system

$$\text{Colordist}(Q_r, P_r) \leq \alpha. \tag{2}$$

$$\text{Brightness}(R, < \hat{R}_n, \check{R}_n >) = T. \tag{3}$$

Among them, Eq. (2) represents the change of the pixel observation value and the color of the RGB vector. In fact, the formula expresses that the change between the two is very small. Equation (3) represents the real-time brightness range of the image.[19,20] All in all, these two formulas belong to matching function expressions. If they cannot be matched, the following function expression applies:

Fig. 1 Early warning state of human drowning transmission.

Fig. 2 Edge detection.

$$k_n = \left(\frac{w_n \bar{T}_n + T_h}{w_n + 2}, \frac{w_n \bar{D}_n + D_h}{w_n + 2}, \frac{w_n \ddot{C}_n + C_h}{w_n + 2}\right). \tag{4}$$

According to the expression of Eq. (4), if it cannot match, add 1 to the original value, and if it matches, return to the above function expression.

$$\beta_h = \max(\beta_h, (Q - g_h + a_h - 2)). \tag{5}$$

Equation (5) represents the maximum time interval during which the codeword does not appear after the training ends.

$$P = (w_b | w_b \in W, \beta_b \leq Y_p), \tag{6}$$

where Y_p represents the time threshold, b represents the codeword index, and P represents the initial codebook background that best matches the background

$$Q(v) = (t_1, t_2, t_3 \cdots t_l). \tag{7}$$

Equation (7) shows a sample set of pixel points. The sample set contains the historical pixel value of the current pixel and its neighboring pixels

$$Q(a) = ((W_h(H(b, c)) \cap (t_1, t_2, t_1 \cdots t_l))) > T_{\min}. \tag{8}$$

Among them, $H(b, c)$ represents the pixel value of the image in the two-dimensional plane, t represents the sample value in the sample set, and Eq. (8) represents the intersection between the two. The specific structure is shown in Fig. 3.

According to Fig. 3, a spherical space with the current pixel coordinate as the center and Y as the radius is established, and the point in Fig. 3 represents the sample value in the current pixel sample set.

As shown in Fig. 4, the point in the upper right corner is the unknown point, the y point is the known point, and the distance between the two points is b, which obtain as

$$b = \sqrt{(a - a_1)^2 + (b - b_1)^2 + (c - c_1)^2}, \tag{9}$$

$$\eta = \arctan b - b_1 / a - a_1, \tag{10}$$

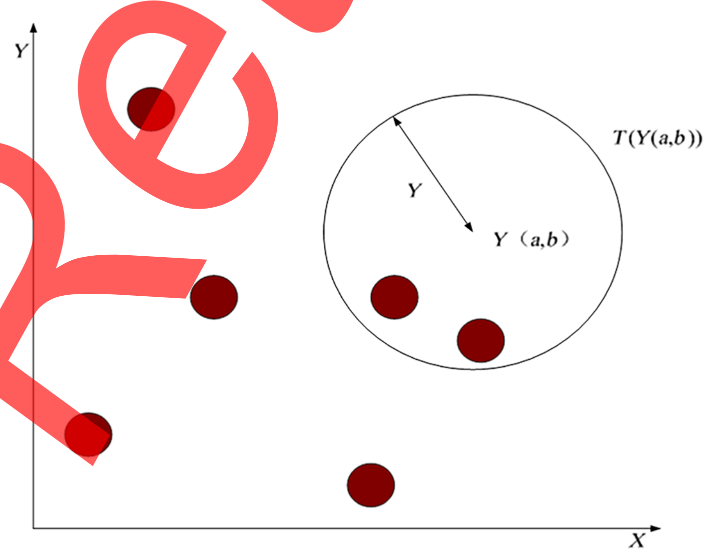

Fig. 3 Pixel point classification.

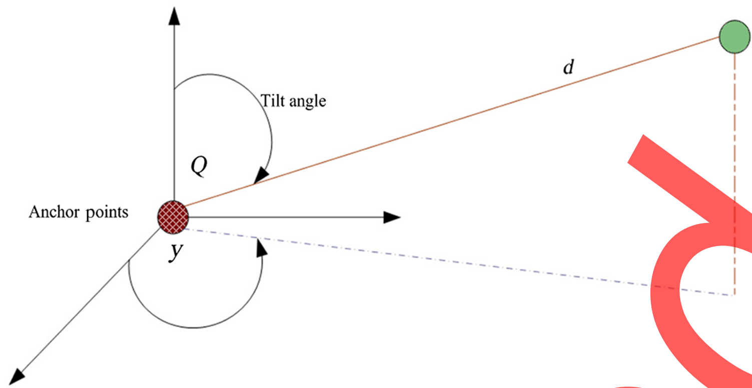

Fig. 4 Angle and distance.

$$\phi = \arccos\ c - c_1/b. \tag{11}$$

If there is interference in the external environment when measuring the distance, we change the calculation method:

$$g_1(a,b,c) = \sqrt{(a-a_1)^2 + (b-b_1)^2 + (c-c_1)^2}, \tag{12}$$

$$g_2(a,b,c) = \arctan\ b - b_1/a - a_1, \tag{13}$$

$$g_3(a,b,c) = \arccos\ c - c_1/b. \tag{14}$$

Assuming that the errors are independent random variables, the conditional probability function expression is as follows:

$$w = \frac{1}{\sqrt{(3\pi)^{2.7}\prod_1^{2.7}\beta_j}}\exp\left(-\sum_1^{2.7}\frac{1}{2\beta_j^2}(d-j)^2\right). \tag{15}$$

3.3 *Overview of Camera Calibration*

For the research of CV technology, it is necessary to understand the camera model, and the camera that obtains the internal and external parameters is the camera that has been calibrated. If there is no relative displacement in the position of the target, the positions of the target and the camera remain unchanged.[21,22] Figure 5 shows a relatively common coordinate system structure.

The coordinate system of the two-dimensional image is relatively simple; we usually use the rectangular coordinate system. The specific structure is shown in Fig. 6.

According to Fig. 6, the physical size of the sensor on different axes of the coordinate system is different. According to the data representation in the coordinate axis, we can exchange pixel values and coordinates.[23] In this way, the conversion relationship between the space and the camera is established. For the mathematical expression of the model, a suitable world coordinate system can simplify and optimize the operation speed

$$\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 1/di & 0 & a_i \\ 0 & 1/du & b_i \\ 0 & 0 & 1 \end{bmatrix}. \tag{16}$$

The camera coordinate system has its own characteristics. The optical center of the lens is the origin, and X and Y are parallel to the x axis and y axis of the image plane, respectively. The XY plane of its construction is parallel to the image plane, and the Z axis is perpendicular to the image plane. Let the coordinate of the intersection between the Z axis and the image plane be c.[24,25] In general, the principal point of the camera is located at the center of the image plane,

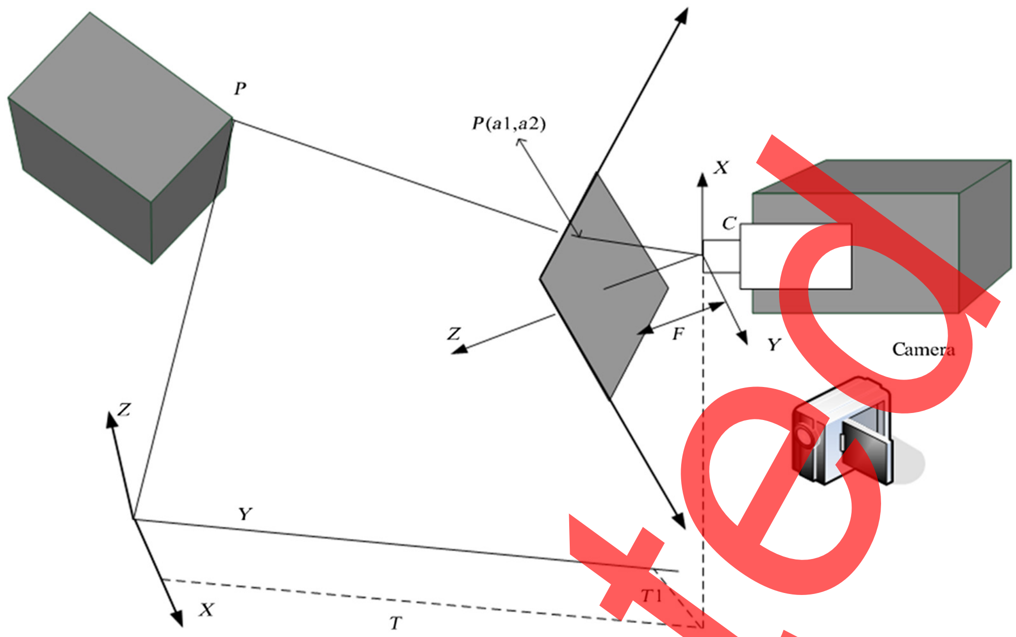

Fig. 5 Camera model coordinate system.

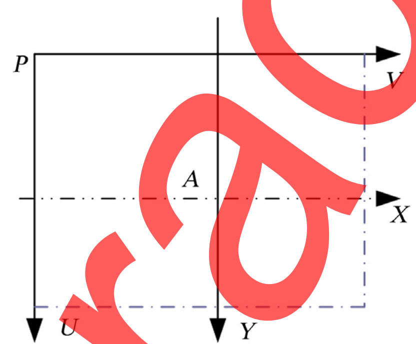

Fig. 6 Simple structure of image coordinate system.

but deviations also exist. Therefore, the principal point coordinates are not known parameters, and their values need to be obtained through calibration. The focal length d is the distance between the main point of the camera and its optical center,[26] as shown in Fig. 7.

In practical situations, the lens of the camera will have errors due to various reasons, such as the distortion of the lens of the camera, the error in the position of the optical center, etc., so the final image will be distorted. At this time, we say that there is a complex nonlinear relationship between the points in space and the corresponding points on the image captured by the camera[27,28]

$$\bar{a} = a + \varphi_a(a, b), \tag{17}$$

$$\bar{b} = b + \varphi_b(a, b), \tag{18}$$

where (a, b) represents the ideal position of the image, $(\bar{a}, \bar{b})$ is the actual position of the image, and φ represents the nonlinear deformation.

$$\varphi_{ai} = h_1\varepsilon^2 + h_2\varepsilon^4 + h_3\varepsilon^6 + \cdots + h_n\varepsilon^{2n}, \tag{19}$$

$$\varepsilon = \sqrt{a^2 + b^2}, \tag{20}$$

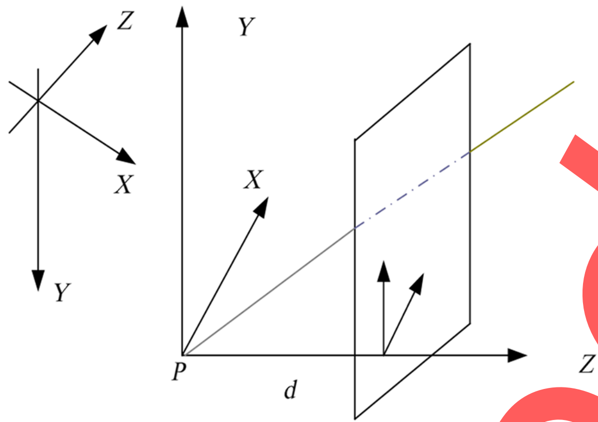

Fig. 7 Camera coordinate system and world coordinate system.

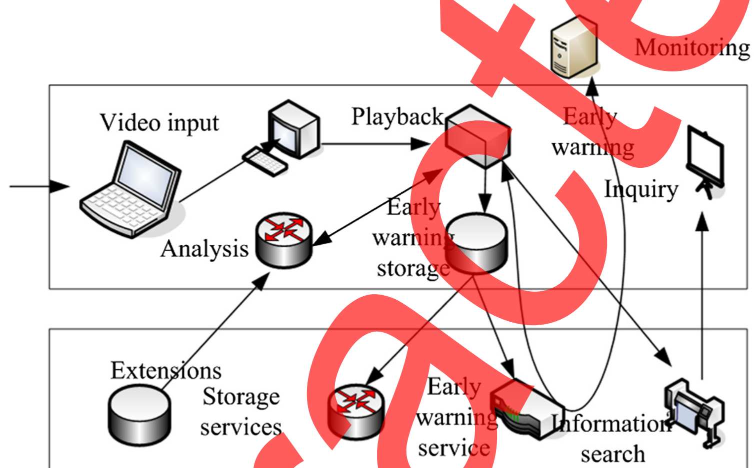

Fig. 8 Underwater machine vision monitoring system.

where ε represents the distance from the image to the focus point, and h represents the radial distortion coefficient. Figure 8 shows the underwater machine vision monitoring system.

4 Experiment of Swimming Pool Safety Detection Device Based on Computer Vision

4.1 *Main Control Unit Hardware Test*

With the continuous advancement of science and technology, people's leisure and entertainment methods are becoming more and more diversified. When people enjoy a variety of leisure projects, they also have high requirements for experience, and swimming is a typical example. In recent years, swimming has been sought after by people because of its advantages. However, swimming comes with certain risks, so we must provide services while keeping clients safe. The swimming pool monitoring main control unit is the core of the entire swimming pool monitoring platform, where various modules can be monitored, problems can be detected quickly, and risks can be prevented.[29,30]

The main control unit is the center of the entire security monitoring, and we must ensure that it works normally. To ensure the normal operation of each module, we must ensure the normal input and output of the voltage.[31] As shown in the data in Table 1, we tested different voltage conditions. The first group of power supply voltage is +4 V, its resistance requirement is 14 kΩ, the test result is 14.7 kΩ, the voltage output of this power supply is +4 V, and the test result is

Table 1 Power test conditions.

Voltage category	+4 V	+3 V	+2.4 V	+1.3 V
Resistance requirement	14 kΩ	6 kΩ	3.5 kΩ	330 Ω
Result	14.7 kΩ	6.3 kΩ	3.3 kΩ	335 Ω
Output requirements	+4 V	+3 V	+2.4 V	+1.3 V
Result	+4.02 V	+2.98 V	+2.45 V	+1.37 V

Table 2 Filtering module test situation.

Current category	6 ma	8.3 ma	12.9 ma	17 ma
Output requirements	6 ± 0.04 ma	8.3 ± 0.04 ma	12.9 ± 0.04 ma	17 ± 0.04 ma
Channel 1 output	5.99 ma	8.32 ma	13.02 ma	18.01 ma
Channel 2 output	6 ma	8.33 ma	13 ma	18.03 ma
Channel 3 output	6 ma	8.35 ma	13 ma	18 ma

+4.02 V. The second group of power supply voltage is +3 V, its resistance requirement is 6 kΩ, the test result is 6.3 kΩ, the voltage output of this power supply is +3 V, and the test result is +2.98 V. The third group of power supply voltage is +2.4 V, its resistance requirement is 3.5 kΩ, the test result is 3.3 kΩ, the voltage output of this power supply is +2.4 V, and the test result is +2.45 V. The fourth group of power supply voltage is +1.3 V, its resistance requirement is 330 Ω, the test result is 335 Ω, the voltage output of this power supply is +1.3 V, and the test result is +1.37 V. According to the actual test value, the output value of the power supply is relatively stable, and the change of the resistance maintains a normal range, indicating that the voltage of the device is relatively stable and can operate normally.

In the monitoring system of swimming pools, we usually use current for data transmission. During the data transmission process, the AC component must be filtered out to obtain accurate data. As shown in the data in Table 2, we tested different currents. The first group's current is 6ma, the output current required by the device is 6 ± 0.04 ma, the output current of channel 1 is 5.99 ma, the output current of channel 2 is 6 ma, and the output current of channel 3 is 6 ma. The current of the second group is 8.3 ma, the output current required by the device is 8.3 ± 0.04 ma, the output current of channel 1 is 8.32 ma, the output current of channel 2 is 8.33 ma, and the output current of channel 3 is 8.35 ma. The current of the third group is 12.9 ma, the output current required by the device is 12.9 ± 0.04 ma, the output current of channel 1 is 13.02 ma, the output current of channel 2 is 13 ma, and the output current of channel 3 is 13 ma. The fourth group current is 17 ma, the output current required by the device is 17 ± 0.04 ma, the output current of channel 1 is 18.01 ma, the output current of channel 2 is 18.03 ma, and the output current of channel 3 is 18 ma. According to the data, the currents of the three channels meet the transmission requirements.

4.2 *Test Situation of Functional Modules*

There are many different service modules in the swimming pool. In this experiment, we take the touch screen as the research object and explore the operation of the touch screen by collecting the touch voltage of the touch screen.

As shown in the data in Table 3, we tested the voltage of the touch screen. The voltage of the first group is 100mv, the equipment requirement is 100 ± 4 mv, and the actual output voltage is 102.4 mv. The voltage of the second group is 200 mv, the requirement of the equipment is 200 ± 4 mv, and the actual output voltage is 201.6 mv. The voltage of the third group is 300 mv,

Table 3 Functional module test situation.

Input voltage (mv)	Voltage requirements (mv)	Voltage measurement (mv)
100	100 ± 4	102.4
200	200 ± 4	201.6
300	300 ± 4	303.7

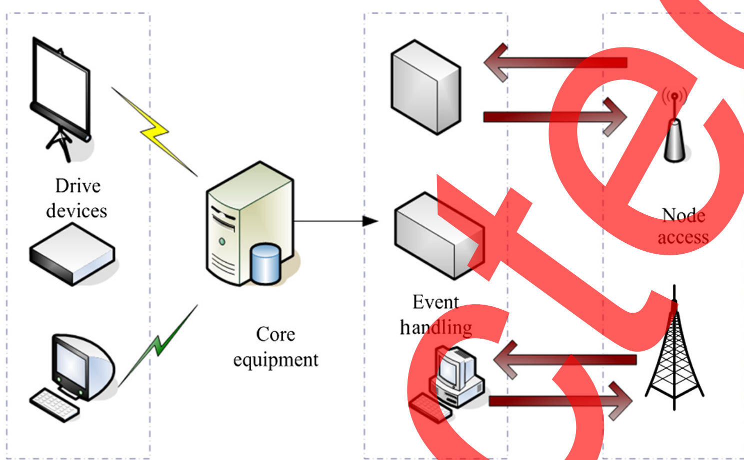

Fig. 9 Input system structure diagram.

the requirement of the equipment is 300 ± 4 mv, and the actual output voltage is 303.7 mv. According to the data, the actual output voltage is within the error range of the device, indicating that the touch screen can operate normally and will not affect the meaning of the signal transmitted by the input voltage. Figure 9 shows a structural diagram of the input system.

4.3 *Communication Test Result Analysis*

As shown in the data in Table 4, we tested the transmission of the communication module of the main control unit. In the first set of experiments, the actual number of bytes transmitted is 1200 bytes, the acceptance range of the device is 1200 ± 2 bytes, and the actual number of bytes received is 1200 bytes. In the second set of experiments, the actual number of bytes transmitted is 2200 bytes, the acceptance range of the device is 2200 ± 2 bytes, and the actual number of bytes received is 2200 bytes. In the third group of experiments, the actual number of bytes transmitted is 3200 bytes, the acceptance range of the device is 3200 ± 2 bytes, and the actual number of bytes received is 3200 bytes. According to the data, when the device transmits a large amount of data, the module can still work normally and stably, which can ensure that the data of the entire system arrives quickly.

Table 4 Analysis of communication test results.

Actual number of bytes transferred (byte)	Receiving standard (byte)	Number of bytes received (byte)
1200	1200 ± 2	1200
2200	2200 ± 2	2200
3200	3200 ± 2	3200

5 Swimming Pool Safety Detection Device Based on Computer Vision

5.1 *Swimming Pool Hardware Management Analysis*

Professional swimming places must have professional swimming equipment, and scientific protection measures can reduce risks. The complete hardware equipment of the swimming pool not only deals with emergency first aid but also brings a sense of security to the user. To explore the hardware situation of the local swimming pool, we visited its users. The details are as follows.

As shown in the data in Fig. 10, there are five people who are very dissatisfied with the hardware equipment of the local swimming pool, accounting for 6.25% of the total number of respondents, we visited its users, a total of 81 people. There are seven people who are dissatisfied with the hardware equipment of the local swimming pool, accounting for 8% of the total surveyed. There are 34 people who think that the hardware equipment of the local swimming pool is general, accounting for 42% of the total number of respondents. There are 28 people who are satisfied with the hardware equipment of the local swimming pool, accounting for 35% of the total surveyed. There are seven people who are very satisfied with the hardware equipment of the local swimming pool, accounting for 8.75% of the total number of respondents. According to the data, the proportion of people who consider local hardware equipment important is the largest. From the overall situation, a large number of people think that the local swimming hardware equipment is relatively complete, but there is still room for improvement.

In addition to hardware facilities, the water quality of the swimming pool is also the focus of users' attention. With the gradual improvement of living standards, people's safety awareness is getting increasing, and the water quality requirement of swimming pools is increasingly important. According to the survey data, 23 people believe that water quality is the most important

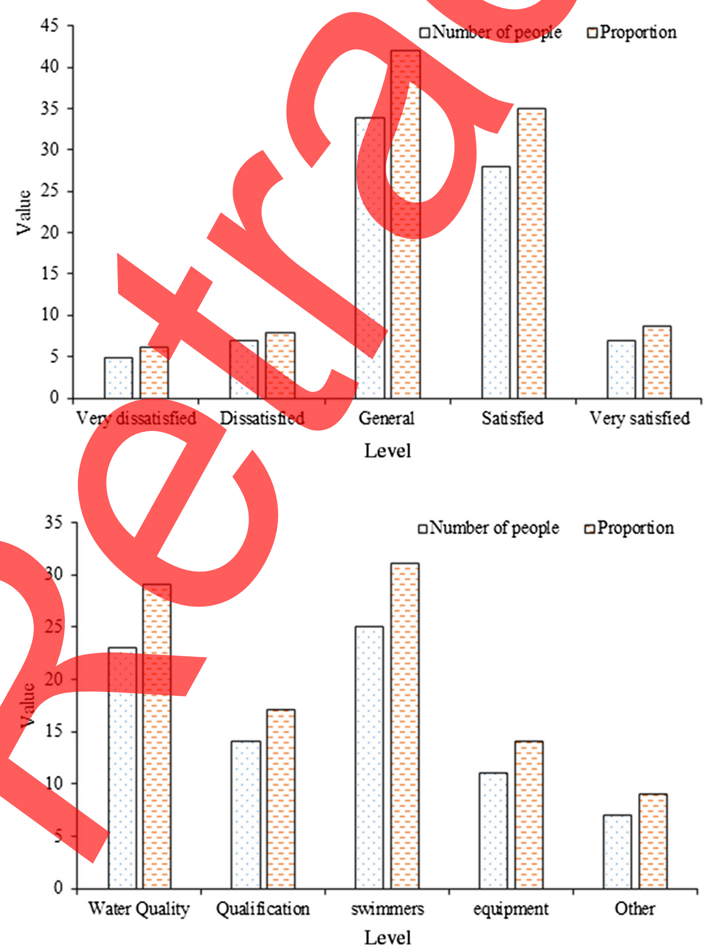

Fig. 10 Hardware safety satisfaction survey analysis of swimming venues.

aspect in swimming safety, accounting for 29% of the total number of respondents. There are 14 people who think the qualification of staff is the most important aspect in swimming safety, accounting for 17% of the total number of respondents. There are 25 people who think the number of swimmers is the most important aspect in swimming safety, accounting for 31% of the total number of respondents. There are 11 people who identified equipment as the most concerning issue in swimming safety, accounting for 14% of the total surveyed. There are seven people who think other factors are more important, accounting for 9% of the total number of respondents. According to the data, the proportion of people who are concerned about water quality and swimming is the largest. It can be seen that it is essential to provide a good water quality environment for swimmers.

In the previous analysis, we found that users are more concerned about water quality, so we investigated the local water quality. According to the data in Fig. 11, six people are very dissatisfied with the water quality of the local swimming pool, accounting for 7% of the total surveyed. There are 22 people who are dissatisfied with the water quality of local swimming pools, accounting for 28% of the total surveyed. There are 26 people who think the water quality of the local swimming pool is very average, accounting for 33% of the total surveyed. There are 19 people who are satisfied with the water quality of local swimming pools, accounting for 24% of the total surveyed. There are seven people who are very satisfied with the water quality of local swimming pools, accounting for 8% of the total surveyed. According to the data, most people think that the local water quality is not very good, and relevant departments need to take more precautions.

The risks of swimming in the pool vary from person to person. According to the survey data, there are two people who are pessimistic about the risks that occur during swimming, accounting for 2.5% of the total number of respondents. There are four people who are more afraid of the

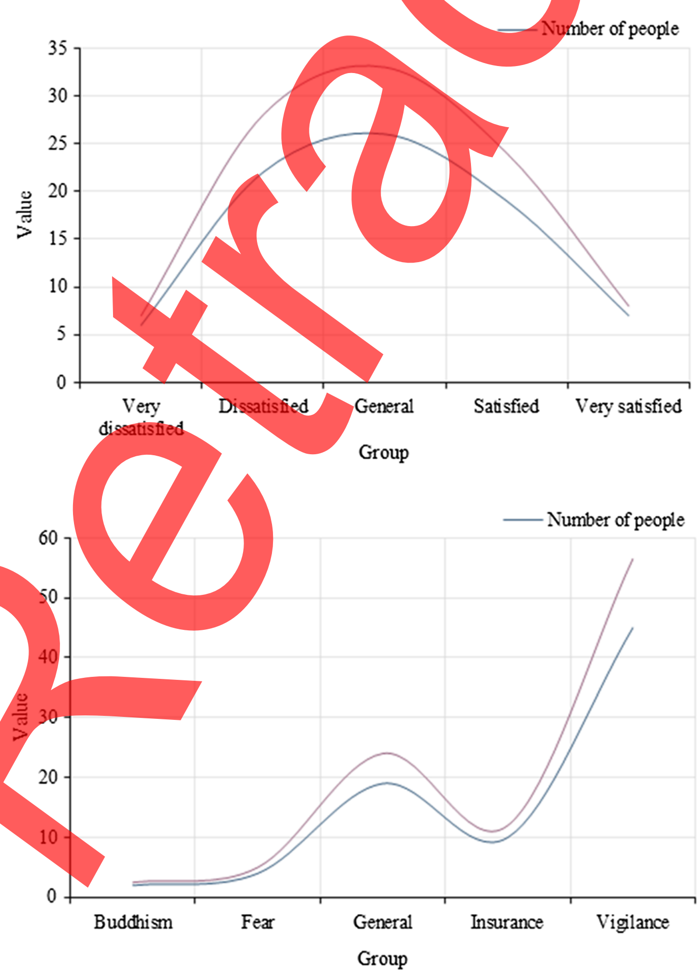

Fig. 11 Analysis of the results of the survey on the safety of swimming pools.

risks during swimming, accounting for 5% of the total surveyed. There are 19 people who can cope with the risks that appear during swimming, accounting for 24% of the total surveyed. There are 10 people who have an negative attitude to the risks that appear during swimming, accounting for 12% of the total number of respondents. There are 45 people who are cautious about the risks that occur during swimming, accounting for 56.5% of the total surveyed. According to the data, most people are worried about the risks encountered by swimming, so swimming pools need to be equipped with complete rescue equipment.

5.2 *Types of Security Incidents*

In fact, safety accidents cannot be avoided; we can only try to reduce the risk probability through human measures. Swimming also has some unexpected events. From an academic point of view, a swimming accident refers to an act or event that occurs in swimming activities involving personal injury, disability, or casualty and can lead to legal consequences.

We conducted accident investigations on local swimming pools. According to the data in Fig. 12, there were four deaths due to alcoholism, accounting for 28.6% of the total investigation population. There were six people who caused accidents, accounting for 42.9% of the total number of people investigated. There were three people who had accidents due to the sudden onset of an invisible disease, accounting for 21.4% of the total number of people surveyed. There was one person who was involved in an accident due to an infectious disease, accounting for 7.1% of the total number of people investigated. In all above cases, a total of 14 people had accidents. According to the data, individuals need to pay attention to their physical condition before swimming to ensure that they have enough resilience. In addition, the management of the swimming pool needs to be effective to reduce the occurrence of accidents.

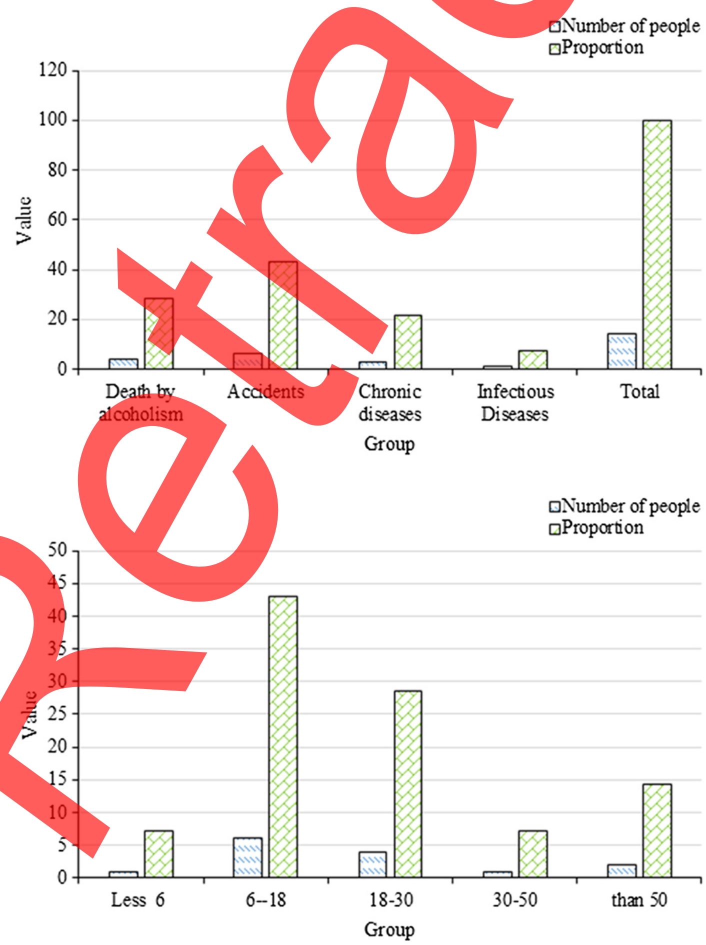

Fig. 12 Pool safety accident analysis.

According to the data, we examined the individuals involved in the accidents. According to the survey data, among the accidents that occurred, there was one person younger than 6-years-old, accounting for 7.1% of the total number of people investigated. Among the 6-year-olds to 18-year-olds, six people had accidents, accounting for 42.9% of the total surveyed. Among the 18-year-olds to 30-year-olds, four people had accidents, accounting for 28.6% of the total surveyed. Among the 30-year-olds to 50-year-olds, one person had an accident, accounting for 7.1% of the total surveyed. Among the over 50-year-old group, two people had accidents, accounting for 14.3% of the total surveyed. According to the data, there are many accidents among the 6-year-old to 18-year-old group. This group is in the stage of physical growth and development, and they do not have the ability to protect themself or the ability of adults to predict and judge the consequences of behavior, making them vulnerable to injury.

5.3 *Swimming Pool Lifeguard Situation*

Lifeguards are an important guarantee for the safety of swimming pools. The skills and sense of responsibility of lifeguards have a significant impact on the safety of swimming pools. To this end, we investigated the lifeguards in the local swimming pool. According to the data in Fig. 13, there are two lifeguards with a junior high school education, accounting for 4.9% of the total surveyed. There are 11 people with a high school education, accounting for 16.9% of the total number of respondents. There are 25 people with a college education, accounting for 61% of the total number of respondents. There are four people with a bachelor's degree or above, accounting for 9.8% of the total number of respondents. The data show that swimming pool lifeguards have higher educations, which helps them to develop good habits.

Fig. 13 Pool lifeguard situation analysis.

The proficiency of a lifeguard is the most important skill for a lifeguard position. According to the survey data, there are four people who are very skilled in ambulance skills, accounting for 9.8% of the total number of people surveyed. There are 12 people with relatively skilled ambulance skills, accounting for 29.3% of the total surveyed. There are 18 people with general ambulance skills, accounting for 44% of the total number of people surveyed. There are seven people with less skilled ambulance skills, accounting for 17.1% of the total surveyed. According to the data, rescuers are generally average in lifesaving skills.

6 Conclusions

With the continuous improvement of living standards, people's standards for daily leisure and entertainment activities are increasing, especially the elements of human health. In terms of swimming, people's enthusiasm has not diminished, but the safety hazards brought by swimming have never been solved. This paper aims to study the research on the safety detection device of swimming pools based on CV and expects to use the current popular CV technology to monitor the safety problems of swimming pools. Although this article has certain conclusions, there are still shortcomings: the data on swimming areas is relatively concentrated and there is no exploration of multiple regions. The data have certain limitations and cannot represent the general situation.

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Code, Data, and Materials Availability

Data sharing was not applicable to this article as no datasets were generated or analyzed during the current study.

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