Construction Method of Swimming Pool Intelligent Assisted Drowning Detection Model Based on Computer Feature Pyramid Networks

Keshi Li*
School of information, North China University of Technology, Beijing, 100144, China
*Corresponding Author’s Email: 1209972319@qq.com

Abstract. Swimming pool intelligent assisted drowning detection is an important research content in the field of drowning rescue. A large number of scholars track drowning targets in real time through underwater intelligent monitoring system, and use it to build a reliable swimming pool intelligent assisted drowning detection model to reduce the risk of drowning. For the complex underwater environment of the swimming pool, the previous detection model has been difficult to adapt to the practical demand. In this regard, based on the summary of the previous swimming pool intelligent assisted drowning detection models and the computer feature pyramid networks, the feature stratification of the swimming pool intelligent assisted drowning detection image is completed, and then the final swimming pool intelligent assisted drowning detection results are obtained through the YOLO principle. After analysis, it is confirmed that the accuracy rate of swimming pool intelligent assisted drowning detection of this method is significantly improved, which can provide effective data theoretical guidance for swimming pool intelligent assisted drowning rescue and has significant practical advantages.

1. Introduction
Drowning in the swimming pool is common due to various sudden events and uncertainties, and the growing number of accidents has drawn the focus of the World Health Organization. The high-risk nature of drowning rescue work in the swimming pool has put high demands on its timeliness and professionalism, so the swimming pool intelligent assisted drowning detection model was born. The construction of traditional swimming pool intelligent assisted drowning detection model is mainly achieved by the computer recognition, but the model has the problem of low sensitivity in practical application and cannot meet the high standard requirements of swimming pool intelligent assisted drowning detection. Among them, the traditional machine learning has obvious problems. The traditional model has low processing ability for swimming pool intelligent assisted drowning detection image, and easily affected by the underwater ripples in the swimming pool, resulting in its high false alarm rate. Although traditional machine learning can extract swimming pool intelligent assisted drowning features by computer and judge swimming pool intelligent assisted drowning detection images, a large number of calculations are required in its training process, and it takes a long response time to achieve swimming pool intelligent assisted drowning detection. In this regard, after summarizing the previous traditional machine learning in this paper, a new swimming pool intelligent assisted drowning detection model is constructed based on the computer feature pyramid networks. The computer feature pyramid networks can stratify the swimming pool intelligent assisted drowning features by feature stratification. Each layer predicts the swimming pool intelligent assisted drowning
detection results of the corresponding scale resolution respectively, which can detect the changes of the moving target more clearly and capture more details of the swimming pool intelligent assisted drowning features. It can be seen that the construction method of the swimming pool intelligent assisted drowning detection model based on computer feature pyramid networks has strong flexibility and accuracy. The development of computer feature pyramid networks has formed a whole set of basic logic system. Among them, the representative ones include: no background modeling is required in the multi-scale training and testing process, which can further improve the efficiency of swimming pool intelligent assisted drowning detection. This study adds the processing of reflection of swimming pool wall to the basic construction of swimming pool intelligent assisted drowning detection model to further improve the clarity of swimming pool intelligent assisted drowning detection images, and reduces the image noise of swimming pool intelligent assisted drowning detection through image adaptive binarization. Based on computer feature pyramid networks, layered features extraction of detection image is performed, using the YOLO principle to achieve swimming pool intelligent assisted drowning detection. After analysis, it is confirmed that the accuracy of swimming pool intelligent assisted drowning detection of this method is significantly improved and has obvious practical advantages.

2. Traditional Machine Learning
In the process of machine learning, considering that most learners have no formal knowledge background, further understanding of the learning target features is required by background modeling. Taking high-resolution remote sensing image ship target detection as an example, in motion detection based on traditional machine learning, pre-processing must be performed for high-resolution remote sensing image ship target detection to reduce interference factors in high-resolution remote sensing image ship target detection. The advantage of using traditional machine learning to detect high-resolution remote sensing image ship targets is that it can detect objects at a long distance from the target and there is no excessive limitation on the size of the detected targets. However, it also has certain disadvantages, which are mainly manifested in its detection for feature extraction in a single way, so it is more difficult to achieve for the rectangular detection environment and multiple detection targets, its detection accuracy is low. At the same time, when using traditional machine learning to recognize facial expressions, the texture features in facial expressions need to be extracted, and the recognition rate is low because of the excessive number of feature dimensions of facial expression recognition. When traditional machine learning is used for the feature description of facial expression recognition, it is difficult to extract this feature effectively by only relying on linear or non-linear algorithms. To address this problem, some scholars have described the facial expression recognition features by introducing a local binary algorithm with the two-dimensional order relation as a means to improve the facial expression recognition rate, which can achieve certain results in practical applications, but it is never able to avoid the dimensional disaster and cannot be applied in the swimming pool intelligent assisted drowning detection. Combined with the real demand of facial expression recognition, some scholars use feature tracking method in traditional machine learning to extract facial expression recognition features, it can realize the classification of multiple features, which is what can be learned in this paper to build swimming pool intelligent assisted drowning detection model. Therefore, the classification accuracy of swimming pool intelligent assisted drowning detection features has improved by computer feature pyramid networks in this paper.

3. Deep Learning
Deep learning is the extended content of traditional machine learning. In each level of learning, it is able to represent the input data as abstract and composite data to improve the description accuracy of the data. Especially applied in the field of facial image recognition, the original input based on deep learning is a pixel matrix, which is divided into four layers. Among them: the first layer serves to extract the image pixels and encode the edge information in them to capture their detailed parts; the second layer serves to sort the edge information in a certain order; the third layer serves to encode the
important feature parts of the nose and eyes in the face; the fourth layer serves to recognize the features in the facial image. In this process, deep learning can effectively classify the features contained in different facial images and automatically adjust the classification levels of facial image features for different levels. In the deep learning, it is crucial to determine the number of layers of data transformation to specify the specific depth of learning. Connecting the number of layers of data transformation can obtain a transformation chain from input to output, which describes the causality between input and output, and explores its present valuable information. For feedforward neural networks in the deep learning, since the output layer is parameterized, the number of layers of data transformation is the depth of the network, which can be obtained by adding one to the number of hidden layers. For recurrent neural networks in the deep learning, the number of layers of data transformation cannot be calculated because the data transformation information is repeatedly propagated between multiple layers. After discovering this phenomenon, previous scholars in this area have simulated any function by a universal approximator that the number of layers of data transformation in a recurrent neural network is greater than 2. In the study, it was found that as the number of layers of data transformation continues to stack, it does not increase the function approximation ability of the recurrent neural network, but only improves the learning ability of the features. Considering that the sample set in the swimming pool intelligent assisted drowning detection is not labeled by classification and is an unsupervised learning task. Based on the deep learning, the deep structures are trained, traverse each layer and calculate the probability of each output to obtain a highly accurate output solution. Therefore, the deep learning is applicable in the field of computer vision. Based on this, this paper proposes a construction method of swimming pool intelligent assisted drowning detection model based on computer feature pyramid networks by drawing on the advantages of deep learning.

4. Construction Method of Swimming Pool Intelligent Assisted Drowning Detection Model Based on Computer Feature Pyramid Networks

In the construction method of swimming pool intelligent assisted drowning detection model based on computer feature pyramid networks designed in this paper, the processing of swimming pool wall reflection must be executed in advance, the swimming pool intelligent assisted drowning detection image is obtained by background difference, a binarization frame is obtained after adaptive binarization processing, the boundary is searched based on computer feature pyramid networks, and the detection image features are extracted in a hierarchical manner by boundary image to achieve swimming pool intelligent assisted drowning detection. In this paper, the design flow of the model construction method is shown in Figure 1.

![Figure 1. Flow of Construction Method of Swimming Pool Intelligent Assisted Drowning Detection Model Based on Computer Feature Pyramid Networks](image-url)

---

3
Combined with Figure 1, the following will describe the key steps in the figure in detail, the specific contents are as follows.

**4.1. Processing of Swimming Pool Wall Reflection**

Since the swimming pool intelligent assisted drowning detection is based on binarized foreground images, and the phenomenon of swimming pool wall reflection will inevitably interfere with the accuracy of swimming pool intelligent assisted drowning detection, making it generate false alarms when no one is drowning. Therefore, it is necessary to segment both of them by processing the swimming pool wall reflection, and then enhance its segmentation effect [1]. First, the original image of swimming pool intelligent assisted drowning detection is intelligently acquired by the background difference, and let the number of pixels in the image be $N$, then there is formula (1).

$$N = \sum_{i=0}^{L-1} n_i$$

In the formula (1), $L$ expresses the highest luminance of the original image of swimming pool intelligent assisted drowning detection; $i$ expresses the luminance value in the image; $n_i$ expresses the number of pixels in the image with luminance value $i$. By the formula (1), the number of pixels in the image is obtained, and assuming the probability of gray value within each gray interval segment is $p_i$, then there is formula (2).

$$p_i = \frac{n_i}{N}$$

In the formula (2), set the superposition of $p_i$ is 1, then there is formula (3).

$$\sum_{i=0}^{L-1} p_i = 1$$

Divide the superposition $p_i$, divide the original image of swimming pool intelligent assisted drowning detection into different grayscale intervals, and form Area $C_0$ and $C_1$, then its calculation formulas are shown as formula (4) and formula (5).

$$C_0 = \sum_{i=0}^{T-1} p_i$$

$$C_1 = \sum_{i=T}^{L-1} p_i$$

In the formula (4) and formula (5), $T$ expresses the dynamic division threshold. Among them, set the average grayscale of $C_0$ and $C_1$ are $\mu_0$ and $\mu_1$, then its calculation formulas are shown as formula (6) and formula (7).

$$\mu_0 = \frac{1}{W_0} \sum_{i=0}^{T-1} i p_i$$

$$\mu_1 = \frac{1}{W_1} \sum_{i=T}^{L-1} i p_i$$

In the formula (6) and formula (7), $W$ expresses the grayscale frequency of the image. Formula (6) and formula (7) are integrated to obtain the average grayscale of the whole swimming pool intelligent assisted drowning detection image, which is set as $\mu$, then there is formula (8).

$$\mu = W_0 \times \mu_0 + W_1 \times \mu_1$$

On the basis of formula (8), let the maximum inter-class variance of the intelligent processing division of swimming pool wall reflection is $\sigma^2$, then there is formula (9).
\[ \delta^2 = w_x \times w_t \times (\mu_x - \mu_t) \quad (9) \]

Calculated by the formula (9), when the value of \( \delta^2 \) is the largest, then the parameter at this point is the binarized threshold parameter for the reflection processing of swimming pool wall.

4.2. Adaptive Binarization of Swimming Pool Intelligent Assisted Drowning Detection Image

After the processing of swimming pool wall reflection, since the overall brightness of the swimming pool wall reflection is closer to the brightness of the swimming pool wall, this paper divides the swimming pool wall reflection into a class with the swimming pool wall by adaptive binarization of the swimming pool intelligent assisted drowning detection image, thus making it completely distinguishable from the drowning human body [2]. In the actual scene, assume that the reflection phenomenon of swimming pool wall and the dummy at the bottom of swimming pool exist at the same time, the actual effect is shown in Figure 2.

![Figure 2. Actual Scene Image](image)

Combined with Figure 2, the probability density distribution of grayscale values in the swimming pool intelligent assisted drowning detection image is intelligently described by drawing a grayscale frequency histogram, as shown in Figure 3.

![Figure 3. Probability Density Distribution of Grayscale Values in Image](image)

As can be seen from Figure 3, the dummy at the bottom of swimming pool and the background cannot be described independently. Therefore, this paper adopt the adaptive binarization threshold to segment the dummy at the bottom of swimming pool and the background based on big data, as shown in Figure 4.
Figure 4. Binarization Threshold Segmentation Detection

Combined with Figure 4, through the intelligent binarization threshold segmentation detection, independent dummy at the bottom of swimming pool and the background can be obtained to suppress underwater interference.

4.3. Intelligent Hierarchical Extraction of Detection Image Features Based on Computer Feature Pyramid Networks

On the basis of completing the adaptive binarization processing of swimming pool intelligent assisted drowning detection images, in order to further improve the accuracy of swimming pool intelligent assisted drowning detection, the detection image features are extracted in a hierarchical manner based on the computer feature pyramid networks. The structure of the computer feature pyramid networks constructed in this paper is shown in Figure 5.

Figure 5. Computer Feature Pyramid Network Structure

As shown in Figure 5, the detection image processed by adaptive binarization is used as input, and 2 is used as the nearest upsampling factor to obtain two inverse feature pyramids, and the 1*1 convolution is used instead of the fully connected layer to form the spatial structure corresponding to it [3-4]. On this basis, the Sigmoid function with the computer feature pyramid networks is used to map the feature data in the detection image, and the interval is set to [0,1], and let the functional expression of the hierarchical extraction of the detection image features be $S$, then there is formula (10) [5].

$$S = \frac{1}{k} \sum_{i \in I} (g \log(p_i) + (1 - g) \log(1 - p_i))$$

(10)

In the formula (10), $k$ is the total number of features of swimming pool intelligent assisted drowning detection image; $g_i$ is the label of pixel $i$ on the true-value image. With formula (10), output the hierarchical extraction results of detection image features based on the computer feature pyramid networks, and this is used as an important basis for the swimming pool intelligent assisted drowning detection.
4.4. YOLO Swimming Pool Intelligent Assisted Drowning Detection

With the computer feature pyramid networks as the key point, detect image features. In order to improve the detection rate, the YOLO principle is applied to add batch normalization after each convolutional layer to normalize the detection image feature data, and let the input data of the convolutional layer after BN operation be $y_i$, then there is formula (11) [6].

$$y_i = \gamma * \frac{x_i - \mu}{\sqrt{\delta^2 + \varepsilon}} + \beta \quad (11)$$

In the formula (11), $\gamma$ is the offset; $x_i$ is the input feature data of the ith pixel; $\varepsilon$ expresses a small positive number whose existence is to prevent the formula from being meaningless; $\beta$ expresses the scale factor. After processing by formula (10), in order to improve the accuracy of swimming pool intelligent assisted drowning detection, it is also necessary to intelligently correct the bounding box, taking the swimming pool as a rectangle, and setting the four bounding box parameters of the swimming pool as $b_x$, $b_y$, $b_w$ and $b_h$, then its formula is obtained:

$$b_x = \delta(t) + c \quad (12)$$
$$b_y = \delta(t) + c \quad (13)$$
$$b_w = p \cdot e^n \quad (14)$$
$$b_h = p \cdot e^n \quad (15)$$

In the above formula, $t$ expresses the center in the bounding box; $c$ expresses the predicted value; $e$ expresses the confidence degree. By integrating the above formulas, the complete swimming pool intelligent assisted drowning detection model based on computer feature pyramid networks is obtained, set its expression as $b$, then there is formula (16).

$$b = \delta(t) + c + c \times p \cdot e^n \times p \cdot e^n \quad (16)$$

The YOLO swimming pool intelligent assisted drowning detection is achieved by formula (16).

5. Conclusion

According to the latest statistics in 2021, more than 400,000 people die from drowning around the world every year, and more than 120,000 people drown in China every year, of which more than 80% are children under the age of 14. Although most swimming places are equipped with cameras, their surveillance effectiveness is uneven, and some are even unsupervised. Even with a well-staffed workforce, there are factors such as fatigue. So intelligent drowning monitoring equipment is of great significance in ensuring life safety. In this context, this paper builds an intelligent pool assisted drowning detection model based on the computer feature pyramid network, and completes the innovation of pool-assisted drowning detection method. Through the reflective treatment of the swimming pool wall, the environmental interference in the process of intelligently assisted drowning detection can be reduced. The computer feature pyramid network is used to extract and detect the image features, and the YOLO principle is used to detect the drowning phenomenon in the swimming pool. It has been proved that the computer feature pyramid network has higher accuracy due to the optimization of the feature extraction process of pool intelligently assisted drowning detection.

The intelligent monitoring method in this study can realize drowning monitoring and alarm and meets the expected requirements from the real data, but there are still shortcomings. Firstly, due to site limitations, the monitoring effect of large swimming pools is still unknown. In addition, when there are a lot of swimmers, once the light passes through the complexity, the monitoring quality may be affected. In the future, the monitoring will be upgraded from these two aspects.

References

[1] Huang Jiaying, Zhan Jie. Automatic Alarm System for Swimming Pool Drowning Based on ZigBee Wireless Positioning [J]. Scientific and Technological Innovation, 2019(13):74-77.
[2] Zou Xu, Liao Zhonghao, Wang Tingjun, et al. Research on Swimming Pool Anti-drowning Intelligent Swimming Cap Based on ZigBee Communication Module [J]. Technology Wind, 2018, 366(34):70.

[3] Gao Zhiyong, Huang Jinzhen, Du Chenggang. Pulmonary Nodule Detection Based on Feature Pyramid Networks [J]. Computer Applications, 2020, 40 (09):99-104.

[4] Zhang Jianming, Liu Xuanhe, Wu Honglin, et al. SSD Improved Model for Small Target Detection Combined with Feature Pyramid Networks [J]. Journal of Zhengzhou University (Engineering Science), 2019, 51(03):61-66, 72.

[5] Lin Li, Wang Bin. Moving Target Detection Algorithm Based on Feature Pyramid Networks [J]. Industrial Control Computer, 2019, 032(008):112-113,115.

[6] Lu Di, Ma Wenqiang. Hand Gesture Recognition Based on Improved YOLOv4-tiny Algorithm [J]. Journal of Electronics & Information Technology, 2021:1-9.