Research on Automatic Color Scale Optimization Based Canny Identification Strategy for Underwater Fish

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Abstract. In order to solve the problem of the traditional Canny edge detection algorithm, due to the inaccurate selection of the threshold value, the recognition rate is low in the fish edge detection process. This paper proposes an adaptive Canny edge detection algorithm. The image enhancement is carried out by using automatic color scale, and the optimal recognition of underwater fish target is completed. The experimental results show that the improved algorithm and edge contour are more complete, which proves the effectiveness of the fish density recognition method.

1. Introduction

With the development of science and technology, the application of computer vision technology has been of great importance in the monitoring of fish stocks. Due to the rapid growth of aquaculture, the scale of the fishing facilities has been enlarged further so that the culture density of the fish stocks increases. Water quality changes rapidly to carry out the temporal monitoring and management of the density and state of fish stocks. By using computer vision to monitor fish stocks in real-time, we can reduce labor input, labor costs, and effectively improve the ability of farmed fish to achieve full-day automated management. It is therefore, one of the most effective and intuitive ways to understand the distribution of fishery resources when recognizing images of underwater fish. However, due to the color cast phenomenon of underwater images and the scattering effect of water suspended objects, there are problems such as low contrast and blurred details in underwater images, which make it difficult to identify the density of underwater fish [1]. Therefore, before the recognition, it is very important to enhance the fish image. Zhang et al analyzed the practicality of underwater images and used the Retinex algorithm to achieve good enhancement results [2]. Chiang et al propose a novel systematic approach to enhance underwater images by a dehazing algorithm [3]. He et al propose a simple but effective image prior-dark channel prior to remove haze from a single input image approach to acquire a high-quality haze-free image [4]. Hitam et al propose a new method called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color models specifically developed for underwater image enhancement [5]. The image is enhanced to make the image clearer.
The above method achieves image enhancement to a certain extent, but the details of the enhanced image are not significant enough, and there is some noise. For the traditional Canny edge detection algorithm applied to the image segmentation of fish, there are some problems, such as low-density recognition rate and missing edge contour due to inaccurate threshold selection [6]. This paper proposes an underwater fish density Canny identification strategy based on automatic color scale optimization. The automatic color scale to enhance the details of the fish and the image texture of the fish, to sharpen the edge of the fish, then the adaptive Canny edge detection algorithm, to achieve the automatic selection of double thresholds. The experiments show that the algorithm a more complete edge profile of the fish, which effectively improves the density of the fish.

2. Canny adaptive edge detection algorithm

Canny Edge Detection Calculator is a multi-stage algorithm fused edge detection algorithm, which follows 3 standards for precise extraction of edges [7]. Canny edge detection algorithm, as the basic algorithm of image edge extraction, can obtain a continuous and clear edge image. However, the traditional Canny edge detection algorithm is sensitive to noise after filtering, it is easy to get a more blurred edge image, and can only passively extract edges by artificially set threshold parameters for different image environments, it is difficult to achieve good edge extraction effect [8].

2.1. Traditional Canny algorithm

2.1.1. Image of Gaussian filtering. The main purpose of Gaussian filtering image $f_{(x,y)}$ is to smooth the image, to a certain extent to remove noise reduce the recognition of pseudo-edges, and effectively improve the accuracy of edge detection. The one-dimensional Gaussian filter function is:

$$G(x) = (2\pi\sigma)^{\frac{1}{2}} \exp(-x^2(2\sigma)^{-2})$$

(1)

The two-dimensional Gauss function is:

$$G(x, y) = (2\pi\sigma)^2 \exp(-(x^2 + y^2)(2\sigma)^{-2})$$

(2)

$$I(x, y) = G(x, y, \sigma) * f(x, y)$$

(3)

2.1.2. Calculate the magnitude and direction of the gradient. Soble calculators are generally used for calculations, and $d_x$ and $d_y$ are calculated using Soble calculators and input image cobbles. Take the Soble solver as an example:

$$d_x = f(x, y) * Soble_x(x, y)$$

(4)

$$d_y = f(x, y) * Soble_y(x, y)$$

(5)

In order to minimize the effect of noise on the results, the image is through gaussian function, and each pixel on the image matrix is weighted in a certain range of fields, so as to effectively eliminate noise [9]. $f_{(x,y)}$ is the input image and $I_{(x,y)}$ is the filtered image.

In this way, the magnitude and position are:

$$M(x, y) = (d_x^2(x, y) + d_y^2(x, y))^{\frac{1}{2}}$$

(6)

$$\theta_M = \arctan\left(\frac{d_y}{d_x}\right)$$

(7)

$M_{(x,y)}$ represents the point amplitude, which is used to determine whether it is an edge point, the size of the amplitude, indicating the rate of grayscale change in the current pixel region. $\theta_M$ represents
the direction of the gradient to determine the contrast direction when the non-maximum value is suppressed.

2.1.3. Non-maximum suppression processing. After the gradient calculation of the current image, the edge information selected by the gradient value is not accurate, the non-maximum value suppression, the maximum gradient is retained to suppress other gradient values, so that all gradient values other than the local maximum value can be suppressed to 0, to achieve edge refinement. The steps are: (1) compare the gradient strength of the current point with the gradient strength in the horizontal vertical direction. (2) If the gradient value of the current point is greater than the gradient value of the gradient point adjacent to the gradient direction, its value is preserved. Otherwise, it is suppressed and set to 0. This suppresses the processing of the sharpest part of the retained edge by means of a non-maximum value.

2.1.4. Double threshold extraction edge. After non-maximum suppression, there are still some edge pixels caused by noise and other reasons, in order to solve these interference responses, the use of double threshold filter edge pixels, and retain edge pixels with high gradient values. Traditional Canny achieves edge extraction by applying manually set double threshold parameters, including a high threshold and a low threshold [10]. If the gradient value of the current edge pixel is greater than the high threshold, it will be regarded as a strong edge point; if the gradient value of the current edge pixel is between the two thresholds, it will be regarded as a weak edge point. When connected to a strong edge point, if Less than the low threshold, the dual threshold manually entered depends on the content of the given input image.

2.1.5. Analysis of defects of the traditional Canny algorithm. In the traditional Canny edge detection algorithm, the high threshold TH1 and the low threshold TH2 need to be set manually. The manually set double threshold directly determines the efficiency and edge extraction quality of the Canary Edge Detection Algorithm. On the choice of double threshold, if you choose a high threshold, you can effectively remove the pseudo-edge, but will lose important details; if you set too low threshold, the detail information will be too prominent, so that the edge is not clear, so how to choose a more accurate double threshold is very critical.

2.2. Adaptive Canny edge detection
For the traditional Canny algorithm, the artificial threshold is not accurate. when applied to different scenes, it is easy to lead to low edge detection effect, cannot get a more complete edge image [11]. This paper proposes an adaptive Canny edge detection method, which improves the traditional Canny edge detection algorithm in the problem of threshold selection. The first is the introduction of the parameter \( I_\sigma = 0.33 \), which is used to change the percentage threshold based on simple statistics and apply the value of \( I_\sigma = 0.33 \) [12] to the entire image data set. The median pixel strength \( M \) of the image is then calculated and high and low thresholds are constructed from the median \( M \).

\[
\text{lower} = (1.0 - I_\sigma) \ast M \tag{8}
\]

\[
\text{upper} = (1.0 + I_\sigma) \ast M \tag{9}
\]

In the calculation, the upper threshold and the lower threshold are composed of the median. The result of judging the upper limit of the high threshold value and the lower limit of the low threshold value, when the required lower limit is less than 0, the lower limit is set to 0, and when the required upper limit is greater than 255, the upper limit is set to 255. In order to achieve the threshold solution in different scenarios, the adaptive Canny edge detection is realized.

By introducing the parameter \( I_\sigma \) and constructing the double-threshold function, this method can realize Canny edge detection in different scenes, improve the edge detection effect, obtain a clear edge contour, and improve the accuracy and continuity of edge extraction.
3. Automatic level fish density Canny identification strategy

3.1. Algorithmic principle
Due to low visibility and excessive suspension, underwater images are often blurred, and due to the absorption and scattering of light by the water body, the water body presents a clear blue-green color. Through the automatic color scale algorithm to adjust the light and dark degree of the fish image, in order to adjust the color details of the fish image to enhance the image. Then mainly by stretching the gray histogram of the fish image. The final enhanced image is obtained through linear quantization, and the contrast of the fish image is improved [13]. Through this algorithm, the accuracy of fish density identification is improved, and the accurate analysis of fish populations is realized.

3.2. Algorithmic flow
The overall process of the algorithm: First, the channel is split, the image is divided into blue component part, green component part, red component part, and then the histogram of each color channel is counted [14]. and then the upper and lower limits of R, G and B channels are calculated separately, the purpose of which is to eliminate the limit value of the current image pixels, and then the remaining pixels are linearly mapped. The algorithm flow is shown in figure 1.

![Figure 1. Automatic level algorithm flowchart.](image)

3.3. Image enhancement processing
Color recovery is carried out by using automatic color scale algorithm to improve the color difference of the image and enhance the image [15]. Firstly, the automatic level performs the gray histogram statistics of the three-channel image, and then the cross-border pixel division is carried out, setting the pixels above the threshold \( T_{\text{max}} \) to 255 and the pixels below the threshold \( T_{\text{min}} \) to 0.

\[
T_{\text{min}} = \max(u), u < 0
\]

\[
T_{\text{max}} = \max(u), u > 0
\]

In the calculation, the parameter \( u \) is the value after logarithmic function operation. The image is then linearly quantified, a segmented linear stretch table is established for each channel, and a segmented linear extension is used for each channel using the corresponding table [16].

\[
f(g) = 0, g \leq \min
\]

\[
f(g) = 255, g \geq \max
\]

\[
f(g) = ((g - \min) / (\max - \min)) \times 255, \min < g < \max
\]

In the calculation, \( \max \) is the maximum gray value of each channel and \( \min \) is the minimum gray value of each channel [17]. Segmented linear stretching is performed on the R, G, and B channels using the corresponding tables. Figure 2 is an automatic color scale algorithm to enhance the front and rear
contrast map, you can see that the original image contrast is not high, the image outline is not clear, the image is foggy. After enhancement, the brightness of the image is enhanced, the key features of the image are highlighted, the outer contour of the contrast of the foggy image is enhanced, and the difference between the foreground and the background is highlighted, so that the image has a better visual effect, which is conducive to the next step of recognition.

**Algorithm 1:** automatic color scale

**Input:** RGB Image

**Output:** New pixel

**Result:** Enhanced Image

1. Initialize a 256 by 3 matrix.
2. Statistical R, G, B grayscale histogram.
3. Use LowCut to calculate the lower threshold.
4. Use HighCut to calculate the upper threshold.
5. for y=0 to 256 do
6. if y less than or equal to the lower threshold then
7. Update the current pixel value to 0
8. else
9. if y more than the upper threshold
10. Update the current pixel value to 255;
11. else
12. Use Equation 7 to get the current pixel value;
13. end if
14. end if
15. end for

(a)Comparison Chart 1

(b)Comparison Chart 2
4. Experimental results and analysis

In order to test the effectiveness of the underwater fish density Canny identification strategy based on automatic color scale optimization, the subjective and objective evaluation of the recognition effect is mainly the sensory evaluation of image sharpness, contrast, and detail contours by human eyes. However, this kind of evaluation method is prone to subjective color. Therefore, objective evaluation is added on the basis of subjective evaluation. Through quantitative analysis of the image, the number of fish in the image before and after the algorithm is compared, and the experimental data is analyzed to obtain more information. Obtain objective and accurate experimental results.

4.1. Subjective evaluation

Subjective evaluation is mainly by comparing the recognition effect before and after the enhancement of fish video. The data source is that the underwater robot captures a video of the waters under natural conditions. In the simulation experiment on Visual Studio 2017, it can be seen from figure 3(a), (b) that the image of the unexplained fish is obviously foggy, and the contrast is not high and the edge details are blurred, which makes it impossible to accurately identify the foreground and background after applying the foreground segmentation algorithm, which makes the fish image part missing. After the fish image is enhanced, the image contrast is obviously enhanced, after the application of the foreground segmentation algorithm, the foreground and background distinction is obvious, the fish image is complete, the fish profile is clear, and the recognition effect of the fish density is improved. By enhancing the image comparison before and after the fish, the detail blurring of the edges of the fish image can be solved by automatic color scale optimization, and the recognition efficiency can be improved.
4.2. Objective evaluation

In order to more accurately verify the Canny recognition strategy of underwater fish based on automatic color scale optimization, the image enhancement effect is objectively evaluated by quantitative analysis. The quality evaluation of the image is mainly carried out by the image means, standard deviation and entropy. Compare this article's image enhancement algorithm with the dark channel algorithm, MSRCR (Multi-Scale Retinex with Color Restore). The image average reflects the average brightness of the image, and the closer the average is to the middle, the better the quality of the image. The standard deviation reflects the degree of discreteness of the image pixels, which can be understood as contrast, the larger the standard deviation, the higher the image contrast. Entropy is the average information entropy of the image, the greater the entropy, the more information the image contains, the better the image quality. According to figure 4, figure 5, figure 6, Table 1, select two groups of fish images for experiments, the experimental results show that the contrast of the dark channel method is higher than the automatic color scale method on the parameter of standard deviation. The image distortion exposure enhanced by the dark channel is obvious, which is not conducive to the later fish identification. After automatic color scale enhancement, the image performs well on the three image parameters of mean, standard deviation and entropy, indicating that the image contrast is obvious and the texture details are clear.
Figure 4. Image enhancement algorithm effect contrasts with Figure 1

Figure 5. Image enhancement algorithm effect contrasts with Figure 2

Table 1. Comparison of quantitative evaluation indicators of fish images

| The first group      | The average | Standard deviation | Entropy  |
|----------------------|-------------|--------------------|----------|
| Original Figure      | 134.942     | 31.5881            | 7.0221   |
| MSRCR                | 154.388     | 32.3203            | 6.9311   |
| Dark channel         | 113.153     | 69.3937            | 7.5683   |
| auto levels          | 133.936     | 58.2396            | 7.8461   |

| The second group     | The average | Standard deviation | Entropy  |
|----------------------|-------------|--------------------|----------|
| Original Figure      | 129.645     | 34.8782            | 7.2362   |
| MSRCR                | 126.238     | 22.4181            | 6.5131   |
| Dark channel         | 108.377     | 67.3867            | 7.5746   |
| auto levels          | 129.061     | 57.7670            | 7.8337   |
In order to verify the ability of the algorithm in this paper to improve the recognition rate of fish, the number of fish in the image is compared before and after the use of this algorithm. Every 5s, count the number of fish in the video. The experimental results are shown in figure 6. After using the algorithm in this paper, the number of identifiable fish is significantly higher than that of the optimized algorithm. Experimental results show that the algorithm's recognition rate of fish is significantly improved, which proves the effectiveness of the algorithm.

![Figure 6. Comparison of fish populations before and after the algorithm](image)

5. Conclusions

In view of the problem of underwater fish density identification, this paper puts forward a study on the underwater fish density Canny identification strategy based on automatic color scale optimization. Conclusions include:

1. The automatic color scale algorithm effectively improves the contrast of the image, enhances the color difference, and highlights the key features of the image.
2. Compared with the traditional Canny algorithm, adaptive Canny edge detection algorithm obtains high and low threshold, which can be applied to edge extraction in different scenes, and is more efficient and practical.
3. The experimental results show that the edge information of fish density is extracted by using this algorithm, and the recognition rate of fish density is improved to a certain extent. The validity of the algorithm in this paper is proved.

Due to the possibility of pixel distortion in images optimized with automatic level enhancement, further optimization can be made in conjunction with image repair techniques.

6. References

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