Discussion on Smart Car Routing Method Based on Gray Image

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Abstract. As the carrier of visual information, image is an important source of information for human beings, and camera has always been one of the most important sensors for smart car line patrol. By using the camera to patrol the line, the smart car can obtain the optimal path and the furthest prospect, so as to achieve the high speed which is difficult to be achieved by using other sensors. However, the camera's acquisition of information is very affected by light. In the case of solar interference, traditional image processing methods can not achieve good results. In this paper, we will discuss the method of dealing with the gray-scale image which is disturbed by sunlight.

1. Introduction
As the traditional sensor of smart car, camera has been used in the tracking direction of smart car. However, the camera has a great impact on the light received by image information collection. If it is not processed further, the collected path will be difficult to meet the requirements of people for the use of intelligent vehicles. In order to extract the edge line of the gray image collected by the camera under the interference of sunlight, three edge line extraction methods are proposed in this paper: Otsu method, Sobel method and adjacent point threshold method. The three methods are not independent of each other. They have their own characteristics and can be mixed to achieve better results.

2. Traditional edge extraction method
The traditional Hawkeye camera adopts the method of hardware binarization. The user adjusts the threshold manually, and the camera returns the binary image. Obviously, in the case of sunlight interference, the effect of binarization of global threshold is not good.

First of all, the camera can only give a threshold value in each operation of the intelligent vehicle, which has poor adaptability to the change of light. As shown in Figure 1, for the images collected in the same operation process with uneven light, the effect is acceptable under one light condition, and the processing effect is not good under another light condition.
Secondly, the camera can't deal with the interference of sunlight. Taking Figure 2 as an example, when there is sunlight reflection, the track edge disappears, and the edge extraction becomes difficult. This is because black-and-white images reduce a lot of information in the acquisition process. It's impossible to deal with the interference of sunlight in such a way.

3. Calculation threshold of Otsu method
One of the problems of the traditional Hawkeye camera is that it can only use the same threshold to binarize all the collected images in one operation. However, in the case of solar interference, the light condition of each image acquisition of intelligent vehicle may be different. It is unreasonable to use the same threshold to binarize each image. If there is a method that can help us to calculate the reasonable threshold value of each image, then the use of gray-scale camera will greatly improve the problem of uneven light during the operation of intelligent vehicle. And Otsu method is such a method to calculate the threshold value.

Otsu method is an algorithm to determine the threshold value of image binary segmentation, which was proposed by Japanese scholar Otsu in 1979. The principle of Otsu method is to make the variance between foreground and background images maximum after image binary segmentation according to the obtained threshold value.

For image I (x, y), the segmentation threshold of foreground and background is recorded as T. The proportion of pixels belonging to foreground to the whole image is recorded as \( \omega_0 \), and the average
gray level is $\mu_0$; the proportion of background pixels to the whole image is $\omega_1$, and the average gray level is $\mu_1$. The total average gray level of the image is recorded as $\mu$, and the variance between classes is recorded as $g$.

If the background of the image is dark and the size of the image is $M \times N$, the number of pixels whose gray value is less than the threshold $T$ is recorded as $N_0$, and the number of pixels whose gray value is greater than the threshold $T$ is recorded as $N_1$, then:

$$\omega_0 = \frac{N_0}{M \times N}$$

$$\omega_1 = \frac{N_1}{M \times N}$$

$$N_0 + N_1 = M \times N$$

$$\omega_0 + \omega_1 = 1$$

$$\mu = \omega_0 \mu_0 + \omega_1 \mu_1$$

$$g = \omega_0 (\mu_0 - \mu)^2 + \omega_1 (\mu_1 - \mu)^2$$

Substituting equation (5) into equation (6), the equivalent formula is obtained:

$$g = \omega_0 \omega_1 (\mu_0 - \mu_1)^2$$

This is the variance between classes.

The threshold $T$, which maximizes the variance $g$ between classes, is obtained by ergodic method.

For the image with two peaks in histogram, the $T$ obtained by Otsu method is approximately equal to the trough between the two peaks. This is the case with the gray histogram on the smart car track, as shown in Figure 3.

![Figure 3. Track gray histogram](image)

After using Otsu method to calculate the threshold value to process the gray image collected by the gray camera, the camera's response to the uneven light environment has been greatly improved. As shown in Figure 4, Otsu method can deal with the problem of uneven light.
4. Sobel operator to extract boundary

In the case of the reflection of sunlight on the side line of the track, although the use of Otsu method is not very good, because the use of Otsu method alone is also a method of overall image binarization, and the gray value of the reflection point will be much higher than the normal track. A small area of reflection will make the edge line disappear, and a large area of reflection will even affect the calculation of the threshold value, resulting in an abnormal binarization of the whole image.

Sobel operator jumps out of the idea of gray image binarization and directly uses gray information. The principle of convolution is to convolute the image pixels. The essence of convolution is to find the gradient value, and then threshold the gray value of the new pixel to determine the edge information.

If $G_x$ is convolution in the X direction of the original image, $G_y$ is convolution in the Y direction of the original image;

$$
G_x = \begin{bmatrix}
-1 & 0 & 1 \\
-2 & 0 & 2 \\
-1 & 0 & 1
\end{bmatrix} \ast A
$$

$$
G_y = \begin{bmatrix}
1 & 2 & 1 \\
0 & 0 & 0 \\
-1 & -2 & -1
\end{bmatrix} \ast A
$$

The pixel value of the active point in the original image after convolution is:

$$
G = \sqrt{G_x^2 + G_y^2}
$$

Given a threshold value, the image edge calculated by Sobel operator can be obtained. As shown in Figure 5:
5. **Adjacent point threshold method**

In order to avoid the disadvantages brought by the global binarization of Otsu method, the threshold value of adjacent points focuses on the gray jump of adjacent points to extract the edge line. In order to reflect the gray jump of adjacent points, calculate the difference between two pixel points divided by the sum of two pixels, namely:

\[ T = \frac{\text{abs}(a - b)}{(a + b)} \]  \hspace{1cm} (10)

In order to improve the calculation speed and facilitate observation and analysis, zoom in 100 times:

\[ T = \frac{\text{abs}(a - b) \times 100}{(a + b)} \]  \hspace{1cm} (11)

The value of T will change obviously when the adjacent two points are black, the adjacent two points are white, and the adjacent two points are black and white. If the gray distribution of a part of the image is shown in Table 1, then the value of T will be 3.08, 15.7 and 1.60 respectively. The black and white jump point can be found. This method can be seen as using a threshold between each two points. In practical use, because the change of gray level may be fuzzy, it can be calculated by two or three pixels apart.

**Table 1. Gray distribution table**

|     | 63 | 67 | 92 | 95 |
|-----|----|----|----|----|

In actual use, in order to facilitate the determination of elements, the effect combined with Dajin method is shown in Figure 6. Obviously, the adjacent point threshold method can avoid the interference of light to a large extent, but in fact, the threshold value that determines whether the color jumps or not needs to be manually selected. Compared with Sobel operator, the final effect is worse in preventing line loss, but it is not easy to find the wrong side line.
Figure 6. The results of comprehensive algorithm processing

6. Conclusion
The above three methods can deal with some problems of edge extraction of gray image of intelligent car camera under light interference. Otsu method can deal with the case of uneven light; Sobel operator has good effect on the interference of direct sunlight and reflection and other local light; adjacent point threshold also gives a scheme to deal with gray-scale image directly.

The algorithm of intelligent vehicle has developed for many years, and its discrimination of elements is basically based on the processing of black and white images. Therefore, in the process of image processing, the appropriate threshold given by Otsu method gives the possibility to continue the previous algorithm, Sobel operator and adjacent point threshold greatly enhance the anti-interference ability of light. The development direction of image processing algorithm is to combine all kinds of algorithms and make the best of the advantages and avoid the disadvantages.

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