A Ship Draft Line Detection Method Based on Image Processing and Deep Learning

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Abstract. The traditional ship draft detection method mainly adopts the method of the human eye observation, which has the problems of large precision error and slow detection speed. Aiming at this problem, this paper proposes a ship draft line detection method based on image processing and deep learning. The color image is first transformed into a grayscale image, and the corner detection is carried out by Harris operator. Contour map is obtained using Canny operator for edge detection, and line segment detection is performed using Hough algorithm. The water surface is determined by calculating the lowest position of the corner point. Then the grayscale image is binarized to increase the contrast of the image, the digital area is determined by the corner positions of the highest and lowest points, and finally the convolutional neural network is used to perform character recognition and calculate the draft of the ship. Tested on videos of various scenes, the error of the proposed method is less than 1cm.

1. Introduction
With the advancement of port automation, the demand for intelligent port measurement is becoming more and more urgent [1]. The traditional ship draft detection method uses an artificial observation method. This method is to obtain the ship's draft value by observing the waterline floating situation for a period of time. Although this method is simple, it is greatly affected by objective factors such as visibility, weather, and water waves, so the measurement error is large, and the accuracy and reliability are reduced. In order to improve the accuracy of ship waterline detection, there have been many ship waterline detection methods, such as sensor-based methods [2] and machine vision-based methods. There are many limitations to using sensor-based measurement methods. For example, the pressure sensor [3] is not easy to install and requires frequent maintenance, so it has little engineering application value. The measurement accuracy of the ultrasonic [4] and laser [5] sensors is greatly affected by the natural environment and is not universally applicable.

The method based on machine vision mainly uses the image processing method to extract the ship's draft and calculate the draft depth. This method has low maintenance cost and convenient automatic operation, so it has high application value [6]. For example, Takahiro et al. [7] proposed an automatic draft line detection method that uses morphology to detect draft line and performs template matching on the extracted characters. The water ruler of the ship mainly has 11 characters, 0-9 and M. The traditional method mainly uses the template matching method. Most of the images selected by this
method are clear and easy to segment. Due to corrosion or pollution, the above methods cannot effectively extract and identify numbers.

Based on the above problems, this paper combines the advantages of image processing and deep learning, and proposes a ship draft line detection method based on image processing and deep learning. Image processing is used to obtain draft line marks, and convolutional neural networks are used for character recognition. The color image is first converted into a grayscale image, and corner points are detected using Harris operator. Then contour maps are obtained using Canny operator for edge detection, and line segment detection is performed using Hough algorithm. The water surface is determined by calculating the lowest position of the corner point. Then, the grayscale image is binarized to increase the contrast of the image, and the digital area is determined by the height of the corners. Finally, CNN [8] performs character recognition and calculates the draught of the ship.

2. Methods

Figure 1 gives the overall framework of the proposed method. First, the test image is converted into a grayscale image, and Harris corner detection, Canny edge detection, and Hough transform operations are respectively performed to obtain a water surface straight line figure and a digital area, and then CNN is used for character recognition, and finally the draft depth is calculated.

![Figure 1. The framework of the proposed method](image)

2.1. Face Detection

Color image is transformed into grayscale image in Figure 2 and the formula of transforming RGB color space into grayscale image is:

\[
g_{\text{gray}} = 0.299 \times r + 0.587 \times g + 0.114 \times b
\]

![Figure 2. The grayscale Image](image)

Harris corner detection is performed on the grayscale image, and the detection result is displayed on the color image, as shown in Figure. 3. The basic idea of Harris corner detection algorithm is to use a fixed window to slide on the image in any direction. Compare the degree of change in the gray level of the pixel in the window before and after sliding. If there is any sliding in any direction, there is a large gray level change, then we can think that there are corner points in the window. When the \([u, v]\)
movement of the window occurs, the grayscale changes of the pixels in the window before and after the sliding are described as follows:

\[ E(u, v) = \sum_{(x, y) \in W} w(x, y)(I(x + u, y + v) - I(x, y))^2 \]

It can be seen from the figure that all characters can be detected correctly.

Figure 3. Result of Harris corner detection

Canny operator is performed on the grayscale image for edge detection, and the detection result is shown in Figure 4. The main steps of edge detection are to first Gaussian smooth the input image to reduce the error rate, then calculate the gradient, amplitude and direction to estimate the edge strength and direction of each point, and then non-maximally suppress the gradient amplitude according to the gradient direction. Finally, double thresholds are used to process and connect the edges.

Figure 4. Result of Canny edge detection.

We use Hough transform on the contour map, use the lowest corner point to determine the exact height of the water surface, and then display the water surface straight line on the color map. The result is shown in Figure 5.
Due to the hull markings, the positioning of the digital contour has a greater impact. So we first binarize the grayscale image, assign pixels with a brightness below 180 to 0, and assign points above 180 to 250, which can increase the contrast of the image and effectively remove the contours next to the number. Disturbance improves the accuracy of digital contour positioning. After locating the contour map of the digital area, we use the highest and lowest points in corner detection to determine the digital area, as shown in Figure 6.

2.2. Deep Learning

The traditional method uses template matching for character recognition, and its detection accuracy is affected in complex environments. To this end, this paper adopts convolutional neural networks for character recognition. We collected a large number of ship digital pictures, combined with the MNIST handwritten data set to form a new data set for training and testing. The algorithm model was tested using the TensorFlow framework, with an accuracy rate of 99.5%.

3. Experimental Results

In order to further verify the effectiveness of the proposed method, we randomly select 50 videos in various scenarios, use the method proposed in the paper to automatically detect the draft line of the ship, and then compare it with artificial observations. All samples are obtained after multiple statistical analysis. The average error is 0.852cm, which is less than 1cm. Table 1 shows the results of the algorithm detection of some samples and the recognition results of professional metrological personnel. It can be seen that in most cases, the error of the method and manual recognition results within 0.5cm, and occasionally the processing error exceeds 1cm. This situation only occurs in the case of large waves, and it is impossible to confirm which result is correct. Even the results of manual observation are not labeled results, so the error is within a reasonable range.
Table 1. Detection Results of the proposed method

| ID | Automatic detection results (m) | Artificial observation results (m) | Error (m) |
|----|--------------------------------|-----------------------------------|-----------|
| 1  | 6.482                          | 6.486                             | 0.004     |
| 2  | 12.562                         | 12.57                             | 0.008     |
| 3  | 9.768                          | 9.78                              | 0.012     |
| 4  | 10.218                         | 10.22                             | 0.002     |
| 5  | 6.642                          | 6.65                              | 0.008     |
| 6  | 12.748                         | 12.75                             | 0.002     |
| 7  | 8.524                          | 8.53                              | 0.006     |
| 8  | 4.265                          | 4.27                              | 0.005     |
| 9  | 11.452                         | 11.45                             | 0.002     |
| 10 | 7.365                          | 7.362                             | 0.003     |

4. Conclusions
This paper proposes a fatigue driving detection algorithm based on deep learning and image processing. Face detection using MTCNN model in deep learning. The image processing method includes three steps of grayscale processing, binarization, and human eye detection. The driver's fatigue status is estimated from the PERCLOS values of multiple videos. Experimental results verify that the proposed algorithm is informative.

This paper proposes a ship draft line detection algorithm based on image processing and deep learning. The image processing method is used to determine the straight line on the water surface, which includes steps such as grayscale processing, Harris corner detection, Canny edge detection, and Hough transform. Character recognition uses convolutional neural networks. The experimental results show that the proposed method has high accuracy and small error.

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