Ship Draft Detection Based on Machine Vision

RAN Xin  SHI Chaojian  XIAO Baojia
Department of Navigation, Merchant Marine College
Shanghai Maritime University
Shanghai, P.R. China

Abstract—Ship draft detection is the first and significant step for ship draft survey, usually determined by visual observation manually. In order to overcome the man-made error, an automatic ship draft detection method based on machine vision and image process is proposed in this paper. Firstly, the flow chart of processing is introduced and each step is described individually, and then a draft line detection algorithm is proposed in detail. After the image containing ship draft is obtained and preprocessed, the contours including draft line are extracted from the image by edge detection operator, and then the draft line is detected by Hough transform. The experimental results show that the proposed method is effective to detect the draft line and helpful to improve the accuracy of ship survey.

Keywords—draft survey; edge detection; hough transform; machine vision

I. INTRODUCTION

Water-borne vessels, such as ships and barges, are commonly used to transport cargo utilizing oceans, navigable rivers, canals and lakes. Their ability to carry large amounts of cargo economically makes them particularly suitable for transporting dry bulk cargo, liquid cargo and other similar type cargo that can be loaded by clamshell buckets, conveyors or pumped into the vessel holds. However, to improve the transportation economics, as well as to be able to determine the amount of cargo that has been loaded onto the vessel, it is important to obtain accurate readings of the vessel draft. Burness Corlett & Ptns (IOM) Ltd. presented a technical report to analyze the various factors that may cause measurement errors of ship draft survey, and concluded that the accumulated errors will result in 0.5%~1% deviation of the final ship survey [1].

The ship draft marks are located at 6 specific positions around the freeboard, the marine surveyors will observe the draft lines and read the numbers before and after unloading cargoes, then use them to calculate the weight of cargoes. However, this is simply a visual estimate and can vary a number of centimeters depending on the surveyor and wave conditions. Conditions typically produce waves in excess of tens of centimeters down to one centimeter in amplitude. Conditions on oceans and rivers can drastically affect the draft line measurements when compared to readings taken within an area such as a protected port. Furthermore the exact point along the curve of the wave being measured is currently determined by the surveyor which leads to differences amongst surveyor practices. In addition, the poor visibility at the time the surveyor read the draft line can also cause problems. This is particularly true if the position or visual angle of surveyor is inappropriate. In such instance the poor condition may impair the surveyor's ability to make visual observations.

In order to overcome the disadvantages of manual observation, many researchers proposed new measurement devices or method to replace human eyes. David Ray et al. designed a portable draft measurement device to obtain the distance from the top of the ship deck to the level of the water in which the ship is floating [2]. Huayao Zheng et al. proposed a new level sensor system for ship stability analysis and monitor, which positioned double pressure sensors below the water surface of the ship [3]. P. E. Morton et al. proposed an improved portable device with a laser emitter and receiver to obtain data to determine a certifiable vessel draft [4]. J. Wu and R. Cai studied the factors in vessel draft survey, and analyzed the reasons of errors, thus provided the countermeasure to increase precious of draft survey [5].

In this paper an automated ship draft detection method based on machine vision is proposed. The flow chart of the processing is introduced firstly, and then a draft line detection algorithm is proposed in detail. Finally the experimental results and the discussion are presented.

II. SHIP DRAFT DETECTION METHOD

The proposed method is composed of a series of image processing algorithm including image preprocessing, draft line detection and ship draft measurement. The flowchart is shown as Fig.1. The original images are taken by surveyor around the ship with digital camera, and transferred to notebook computer with video capture card. Then the image data will be processed in the computer and the final results will be shown on the computer screen.

The original images are usually not suitable for direct detection of draft line due to inappropriate position or view angle of surveyor, and also due to the influence of sunshine or wave conditions. Thus the preprocessing should be adopted so that the draft line signal in the images can be enhanced. If the ship draft line can be detected with edge detectors in the preprocessed images, the following draft measurement will be implemented to find and recognize the ship draft mark and to determine the exact ship draft value by compute the length between the ship draft mark and the draft line. If no draft line can be detected in the image, it
means that not enough information is contained in the image and the next image should be processed all over again.

By repeating the process described above, each image in the acquired video will be processed and a series of ship draft values can be obtained. The ship draft values will be used to estimate the final ship draft by some statistic methods or by means of surveyor’s expertise.

![Flowchart](image)

**Figure 1. The flowchart of the proposed method**

### III. DRAFT LINE DETECTION

Draft line detection is the first and also the important step for ship draft survey, which has significant influence in ship draft measurement. An automated draft line detection method based on image process is proposed in this section, which composed of a series of image processing algorithm, from image preprocessing, geometry transform to edge detection.

Fig.2 shows one of the draft line images the surveyor obtained. It can be seen that the image is sideling and a fake water line appears on the real draft line due to the shipboard flushing of sea wave. An affine transform algorithm is used to adjust the image making the draft line horizontal, which will be discussed later. At preprocessing stage, the red, green and blue channel are divided from the original image, each channel and its histogram are shown in Fig.2. It is noticed that the draft line is more distinct in red channel than in other channels. The peak distribution of pixel grey scales in each channel’s histogram also gives the same judgment. So the red channel will be split from the original image and used at the subsequently step.

Because the ship draft line is exactly the consecutive contour edge in the image, the edge detection algorithm is used to extract the line feature in the image. The effect of several edge detection methods is verified through the practical experiments for the original image and its three channels, including Laplace, Sobel and Canny detection operator. The results shown in Fig.3 illustrate that the best way to extracting draft line is Canny operator adopted in red image channel.

However, the edge image result from edge detection method contains a lot of lines, including draft mark, watermark on the shipboard, wave crests and other noises, and obviously the draft line. Then the mission at the next step is to pick out the draft line from the edge image. From Fig.3 it can be seen that most of the detected edge is short, but the draft line and the upper fake watermark line are relatively long. Therefore, the Hough transform is adopted to detect the long lines and exclude other short lines in the image. Depending on the common sense that the watermark line is always at upper position than draft line, the lower and true draft line will be picked out at the final step.

In the flowchart of the proposed method, there are two important problems need to solve, one is geometry adjustment, and the other is Hough transform, which will be discussed in detail as follows.

#### A. Geometry adjustment

Let’s define the proper edge image as \( f \), the coordinates of pixel in the image as \((x, y)\), and the distorted image of \( f \) as \( f' \), the coordinates of pixel as \((x', y')\), and then the distortion transform can be defined as:

\[
x' = r(x, y) \\
y' = s(x, y)
\]

where \( r(x, y) \) and \( s(x, y) \) are the spatial transform. In the situation discussed here, the image taken by surveyor should be adjusted by rotation and translation, and the affine transform will be a good choice. The rotation degree can be defined by computing the inclination of the draft line or the draft mark. The affine transform can be defined as:

\[
\begin{bmatrix}
\tilde{x} \\
\tilde{y}
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{bmatrix}
\begin{bmatrix}
r \\
s \\
1
\end{bmatrix}
\]

\[(2)\]

#### B. Hough transform

The Hough transform is a technique that can be used to isolate features of a particular shape within an image. The classical Hough transform is most commonly used for the detection of lines because it can be defined in a specific parametric form[6]. In the image space, the straight line can be described as \( y = ax + b \), where \( a \) is the slope of the line and \( b \) is the \( y \)-intercept and can be graphically plotted for each pair of image points \((x, y)\). However, a convenient
equation for describing a set of lines uses parametric or normal notion:

\[ r \cos \theta + y \sin \theta = \rho \]  \hspace{1cm} (3)

where \( \rho \) is the length of a normal from the origin to this line and \( \theta \) is the orientation of this line with respect to the X-axis.

Therefore, a set of points that form a straight line will produce sinusoids which cross at the parameters for that line. Thus, the problem of detecting collinear points can be converted to the problem of finding concurrent curves.

The edge description is already obtained from the previous Canny edge detector, and the Hough transform can be used to identify the parameter(s) of a curve which best fits a set of given edge points.

IV. EXPERIMENT AND DISCUSSION

The practical experiment and results in different steps are presented to illustrate the effect of the proposed method. Fig.2 is the image of ship draft line obtained by surveyor from the port with the red, green and blue channel of the original image and their histogram. The image is sideling due to the inappropriate position or view angle of surveyor and a fake water line appears on the real draft line due to the shipboard flushing of sea wave. Fig.3 shows the different experimental results to detect the draft line with Laplace, Sobel and Canny detector, from the results it can be seen that Canny detector with red channel of the original image can achieve the best result. Fig.4 shows the result of geometry adjustment by affine transform, the draft line is horizontal and the draft mark is adjusted. Fig.5 (a) shows the draft line detection result, the two longer lines, the draft line and the upper waterline, are detected and illustrated in green. The final result is shown in Fig.5 (b); the draft line is extracted exactly according to the position relationship between the draft line and waterline.

V. CONCLUSION

A ship draft line detection method is presented in this paper, which can extract the draft line exactly through a serious of image processing techniques. The experimental results show that the proposed method is effect and can be used instead of visual observation. After detecting the draft line successfully, an automatic ship draft mark reading method can be developed, then the ship draft survey system can be developed, which will be our future work.

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REFERENCES

Figure 3. The experimental results to detect the draft line with Laplace, Sobel and Canny detector

Figure 4. The result of geometry adjustment by affine transform

Figure 5. The draft line detection result, (a) the draft line and waterline, (b) the final result