A Horizontal Tilt Correction Method for Ship License Numbers Recognition

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Abstract. An automatic ship license numbers (SLNs) recognition system plays a significant role in intelligent waterway transportation systems since it can be used to identify ships by recognizing the characters in SLNs. Tilt occurs frequently in many SLNs because the monitors and the ships usually have great vertical or horizontal angles, which decreases the accuracy and robustness of a SLNs recognition system significantly. In this paper, we present a horizontal tilt correction method for SLNs. For an input tilt SLN image, the proposed method accomplishes the correction task through three main steps. First, a MSER-based characters’ center-points computation algorithm is designed to compute the accurate center-points of the characters contained in the input SLN image. Second, a $L_1 - L_2$ distance-based straight line is fitted to the computed center-points using M-estimator algorithm. The tilt angle is estimated at this stage. Finally, based on the computed tilt angle, an affine transformation rotation is conducted to rotate and to correct the input SLN horizontally. At last, the proposed method is tested on 200 tilt SLN images, the proposed method is proved to be effective with a tilt correction rate of 80.5%.

1. Introduction

An SLN is composed by a sequence of characters. An automatic ship license numbers (SLNs) recognition system plays a significant role in intelligent waterway transportation systems since it can be used to identify ships by recognizing the characters in SLNs [1-2].

SLNs recognition is a brand-new research topic and few related papers have been published. [1] used a transferred deep CNN model in combination with prior features to localize multi-style ship license numbers in nature scenes. Liu et al. [2] presented an effective coarse-to-fine approach for locating various SLNs in the wild.
Figure 1. Some tilt correction results of the proposed method. (a) Some SLN images in our testing dataset. (b) The corresponding tilt correction results.

One related research area of SLNs recognition is automatic license plate recognition (ALPR) [3]. Similar with an ALPR system, an automatic SLNs recognition system mainly consists of image acquisition, SLNs location, tilt correction, character segmentation and character recognition. Ships usually appear in the complicated environments of rivers and canals, while the position-fixed monitors mostly set on the banks. Under this circumstance, most SLNs in the captured images have serious tilt because the monitors on the bank and the ships on the water have a great vertical or horizontal angle [4]. These tilt SLNs will affect the accuracy and robustness of the following character segmentation and character recognition procedures of a SLNs recognition system significantly. Hence, an effective tilt correction method improves the performance of an SLN recognition system.

Tilt correction can be generally categorized into horizontal tilt correction and vertical tilt correction [5]. In this paper, we focus on horizontal tilt correction, and a horizontal tilt correction method of SLNs is presented. For an input tilt SLN, a MSER-based [6] characters center-points computation algorithm is firstly designed to compute the accurate center-points of the characters contained in the input SLN image. Then, a $L_1 - L_2$ distance-based straight line is fitted to these computed center-points using M-estimator algorithm to estimate the tilt angle of the input SLN. Finally, based on the computed tilt angle, an affine transformation rotation is conducted to rotate and to correct the input SLN horizontally.

The proposed method is experimented on 200 tilt SLNs which are collected from the SLNs dataset of ZJUSHIPS950 [2]. The experiment results in Sec. 4 indicate that the proposed approach achieves a horizontal tilt correction rate of 80.5%. The main contribution of this paper is that we present an effective horizontal tilt correction method for SLNs recognition, which, as far as we know, is the first work concerning the SLNs tilt correction problem.

2. Related works

Works that related most with SLNs tilt correction is car license plates tilt correction [4-5, 7-9]. Car license plates tilt correction methods can be roughly classified as detecting line methods [4], orientation image methods [7] and linear fitting algorithms [8]. Detecting line-based methods [4] correct tilt license plates by localizing the four sides of the plates using straight line detection algorithms, e.g., Hough transformation. An important prior of detecting line methods is the characters are always written on plates. However, detecting line methods are not applicable for SLNs tilt correction because the SLNs are usually written directly on the ship bodies rather than on plates. As a kind of orientation image-based tilt correction method, [7] used the local maximum of the direction angle histogram to estimate the horizontal incline angle of a license plate. It is also difficult for orientation image-based car license plates tilt correction methods to correct SLNs because characters contained in one single SLN may have different tilt angles. [8] is a linear fitting-based algorithm, it computes a horizontal rotation angle by fitting a straight line to the license plate using least square
fitting with perpendicular offsets. Linear fitting-based algorithms usually assume that characters from one same car license plate are written in one line. However, the layouts of SLNs from different ships are complicated (Fig. 1(a)). Characters contained in one same SLN may be written in two lines, causing most linear fitting-based algorithms to obtain unreasonable straight lines. Our approach is also linear fitting-based, nevertheless, an extremal regions filtering and merging algorithm is posed in Sec. 3 to reduce the influences of two-line writing and noises. In conclusion, it is complicated to directly use car license plate tilt correction algorithms to perform SLNs tilt correction. To accurately correct tilt SLNs, a tilt correction method taking the characteristics of SLNs into consideration needs to be proposed.

3. The proposed method
Fig. 2 demonstrates the detail processing procedures of the proposed method. It accomplishes the horizontal tilt correction task through three main procedures: 1) MSER-based characters center-points computation. The extremal regions (ERs) of the input SLN image are firstly computed. Then, these ERs are filtered by referring their widths, heights and area sizes. Third, the reserved ERs are merged according to their horizontal distances, the center-points of the remaining ERs are obtained; 2) $L_1 - L_2$ distance-based straight line fitting. An $L_1 - L_2$ distance-based straight line is fitted to the computed center-points by using M-estimator algorithm. The tilt angle can be also computed at this stage; 3) Horizontal tilt correction. Based on the computed tilt angle, an affine transformation rotation is proceeded to rotate and correct the input SLN horizontally.

3.1 MSER-based characters center-points computation
The SLN image in Fig. 2 is a Chinese cargo ship SLN, some characters of that SLN are written in one line while others are in two lines. Actually, the English characters below the Chinese characters are phonetic transcriptions, they are not required to be recognition. Moreover, the existence of those smaller phonetic transcription-characters may decrease the accuracy of the straight lines fitted to the characters need to be recognized. To improve the center-points computation accuracy, it is necessary to remove these small phonetic transcription-characters and other non-character regions. The details of our MSER-based characters center-points computation algorithm are summarized as follows:

(1) MSER-based character regions computing. The MSER [6] method is primarily used to compute the ERs of each input SLN image.

(2) ERs filtering. The obtained ERs are then filtered by referring the geometrical characteristics of characters. Specifically, for each obtained ER, an axis-oriented minimum bounding box is estimated, the ratios between the width, height and area size of the estimated bounding box and the width, height and area size of the corresponding input SLN image are computed, respectively. If one of these computed ratios is too small or too great to a certain range, this ER will be filtered.

(3) ERs merging and center-points computing. In this step, the intersected ERs are horizontally merged. All bounding boxes are sorted by the values of their Coordinate X in ascending order. Then, if a bounding box and its previous adjacent bounding box are intersected with each other and the area size of the intersected region is greater than one-third the area size of the previous bounding box, these two bounding boxes will be merged as a new one. At last, the center-points of the remaining bounding boxes are computed.
3.2 $L_1 - L_2$ distance-based straight line fitting

In order to compute the rotation angle, a straight line is fitted to the center-points computed in Sec. 3.1 by referring [2]. Assume that $P_c = \{(x_1, y_1), (x_2, y_2), \ldots, (x_i, y_i)\}$ is the set of the center-points computed from an SLN image. A line $f(x)$ is fitted to $P_c$ using the M-estimator algorithm [10], where $f(x)$ needs to meet the condition of minimizing $\sum \rho(r_i)$. $r_i$ is the distance between the $i^{th}$ point in $P_c$ and the fitting line $f(x)$. $\rho(r)$ is the $L_1 - L_2$ distance function of the M-estimator, which is defined as

$$\rho(r) = 2 \cdot \left( \frac{2}{1 + \frac{r^2}{2}} - 1 \right).$$

Finally, the slope of the fitted straight line $f(x)$ is used as the rotation angle.

3.3 Affine transformation-based horizontal tilt correction

Since the rotation angle has already been computed in the previous step, the input SLN image is rotated by conducting an affine transformation by referring the estimated rotation angle. The affine transformation function in OpenCV (https://opencv.org/) is used here.

4. Experimental results and analysis

4.1 Testing dataset

The effectiveness of the proposed approach was verified on 200 tilt SLN images. These tilt SLN images were captured from different ship images in ZJUSIPS950 SLNs dataset [2]. These tilt SLN images are of the characteristics of complex backgrounds, random photographing angles, different illuminations and various layouts. Fig. 1 shows some testing SLN images.

4.2 Experiment results

The proposed method was implemented using C++ and was tested on a computer with an Intel 3.30 GHz CPU configured. An output SLN image is considered as a successfully corrected one if the characters contained in that SLN are observed to be in a fairly horizontal line, otherwise it will be treated as a failure. The quantitative experiment results are listed in Table 1. Table 1 tells that the proposed approach achieves a horizontal tilt correction rate of 80.5%, suggesting the proposed method has good tilt SLNs correcting ability. Table 1 also demonstrates that the proposed algorithm achieves a very fast time efficiency of 3.6 milliseconds per SLN image. One can also recognize the good tilt SLNs correcting performances of the proposed approach from Fig. 1. In addition, the tilt correction results in Fig. 3(a)-3(c) suggest that our method can still achieve fine results even when occlusion, blur or poor image quality occur.
Figure 3. Some sample tilt correction results of SLN images with occlusion (a), poor quality (b) and blur (c). (d) and (e) demonstrate some failure correction results.

Table 1. Horizontal tilt correction results of SLNs

| Number of SLN images | Number of valid corrections | Number of failures | Tilt correction rate | Time (ms/SLN image) |
|----------------------|-----------------------------|--------------------|---------------------|---------------------|
| 200                  | 161                         | 39                 | 80.5%               | 3.6                 |

4.3 Discussion and failures

Our approach computes rotation angles by fitting a straight line to all detected characters regions, thus, if a few characters are occluded, the remaining characters could provide clues to fit a fairly reasonable straight line. Fig. 3(a) gives some correction results of SLNs with occlusion, showing that our approach has good ability to correct SLN images with occlusion.

Blur weakens the edge features of characters, causing the MSER method to compute many overlapping ERs. Fortunately, the ERs filtering algorithm in Sec. 3 is helpful to alleviate this. After ERs filtering, a more accurate straight line can be obtained since the redundant and interrupted ERs are removed. From Fig. 3(c) one can conclude that our method is capable of accurately correcting SLNs images with blur in many cases. However, as shown in Fig. 3(d), failures may appear when serious blur occurred.

The experimental results in Fig. 3(b) show that our approach is fairly robust to poor-quality images, it can correct tilt SLNs even when some strokes of the characters are missing or interfered. Notwithstanding, if the resolutions of SLN images are extremely poor or too much noise information existed, the proposed approach may fail to correct SLNs (Fig. 3(e)). The reason is that it is hard for MSER algorithm to detect poor-resolution scripts as maximally stable extremal regions.

5. Conclusion

We have proposed an effective horizontal tilt correction method of SLNs in this paper. The proposed method was tested on 200 tilt SLNs images from ZJUSHIPS950 dataset, as the first work concerning the SLNs tilt correction problem, the proposed method is proved to be effective with a tilt correction rate of 80.5%. More SLNs prior features will be exploited in the future work to accurately correct tilt SLNs.

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