

# An Algorithm of Freight Train Number Locating Based on Template Matching and Morphological Operations

**Liu Ningning, Ma Yuehui, Wang Yuran and Wang Na**

*Department of Electrical Engineering, Shijiazhuang TieDao University,  
Shijiazhuang, Hebei, 050043, P.R.China*

## Abstract

In view of the status of the present railway wagon number mainly adopts the RFID technology, the paper presents a railway wagon number positioning method based on template matching and morphological operations. This method should first pretreatment and morphological filtering for the carriage image, then using the projection method to locate the license plate number region contains railway logo, finally, through the method of establishing the railway logo templates and removing the minimum connected domain area, to position precisely of the license plate number area. The experiment results show that, the method is not affected by the train modles, train colours, the railway logo spraying position and the license plate number spraying interval, make it the high locating accuracy and good adaptability.

Keywords: WAGON NUMBER POSITIONING, MORPHOLOGICAL FILTERING, TEMPLATE MATCH

## 1. Introduction

Wagon number administration plays an important role in the railway transport organization. Nowadays the ATIS mainly adopt the millimeter wave reflection technology , installing an electronic label in the centre sill bridge on the bottom of the wagon .When a train passes by one station ,the surface recognition system would read the information like the wagon number or so by the electronic label. And transfer the wagon number to the centralize control and management system of railway station .Then report level by level through computer network to serve the related apartment[1] .But two problems exist in this method .1.installing the electronic label is a huge workload. If adding 40000 new wagons, sift out 10000 ever year ,to equip the electronic label would be an extreme task[2].2.When renovating the old cars if only re-spray the wagon number without updating the electronic label and the wagon number would cause errors in the car number statistics[3].

Therefore the ATIS based on the image is urgently needed. After collecting the wagon number painted on the carriage use the carriage image to recognize the wagon number automatically to lighten the workload of fitting electronic labels and lower the probabilities of misidentification .It is the wagon number positioning system that plays a critical role in wagon number recognition system. Its purpose is to find the wagon number area in the original image for the next wagon number recognition .

Nowadays exciting lots of wagon number positioning based on the image, but the vast majority is the vehicle license plate location, for example, Guangqi Liu[4] orients an algorithm of license plate location on the basis of texture characteristic of license plate binary image combined with line scanning. In recent years there has been some research in the wagon's number positioning, such as Juhua Yang [5]offers three are combined to locate the region accurately which are the edge detection technique with

modified Sobel operator, projection method and prior knowledge of railway train number. Yiliang Xing[6] raises a train number positioning method based on integral projection combining statistics. Peiming Du[7] presents an algorithm that based on basic operations of mathematical morphology and connected regions. All these theories have reference signification to the car number positioning. However the wagon's number area does not have obvious border feature and has no fixed position or character pitch or fixed aspect ratio when painting. The above methods in the wagon number positioning, positioning effect is susceptible to image capture time illumination intensity, cars dirty and other external factors, so there are the shortcomings of large amount and long recognition time.

This paper presents a railway wagon number positioning method on template matching and morphological operations. In the pre-processing stage, in order to reduce the impact of external factors on the image, adopt Ostu threshold segmentation algorithm and the use of regional characteristics descriptors for the minimum rectangular positioning, simplify the identification algorithm, improve the recognition speed.

## 2. The image pretreatment

### 2.1. Image Gray

The collected carriage images are colorful images, one pixel has  $255 \times 255 \times 255$  colors to range from. As shown in Fig. (1). In order to reduce the image's follow-up computation, easy to locate and improve the handle speed, image gray is needed, thus every point's component can transfer to gray information. Take the use of weighted average, the three components with different weights for the weighted average. Because human eyes are most sensitive to green and least sensitive to blue, so the gray processing formula as follows:

$$Gray = 0.299 \times R + 0.587 \times G + 0.114 \times B \quad (1)$$

Gray stands for gray information, R, G and B corresponding to Red, Green and Blue information.



Fig. (1). Image of Freight Train

### 2.2. Binarization

To reduce computation, easy to do further analysis to the image, Binarization is needed. To avoid weather, flash, stain and other objective reasons influence the binarization, the Ostu threshold segmentation algorithm is needed.

In Ostu algorithm to the threshold  $K$  all the pixels are divided into two types of background  $C_0$  and target  $C_1$ . Wherein the pixel gray level class  $C_0$  is  $[0, K-1]$ , the pixel gray level  $C_1$  category is  $[K, L-1]$ . Class  $C_0$  of pixels accounted of the area for  $\omega_0$ , Class  $C_1$  ratio of the area occupied by the pixel is  $\omega_1$ , the average gray level of the  $C_0$  types of pixels is  $\mu_0$ , the average gray level of the  $C_1$  types of pixels is  $\mu_1$ , the overall mean is  $\mu_G$ , The formula for the variance of the class is  $\delta^2(K)$ . Some of them can be expressed by equations, as follows:

$$\omega_0 = \sum_{i=0}^{K-1} P_i \quad (2)$$

$$\omega_1 = 1 - \omega_0 \quad (3)$$

$$\mu_0 = \frac{\mu_0(K)}{\omega_0} \quad (4)$$

$$\mu_1 = \frac{\mu_1(K)}{\omega_1} \quad (5)$$

$$\mu_G = \omega_0 \mu_0 + \omega_1 \mu_1 \quad (6)$$

$$\mu_0(K) = \sum_{i=0}^{K-1} iP_i \quad (7)$$

$$\mu_1(K) = \sum_{i=K}^{L-1} iP_i = 1 - \mu_0(K) \quad (8)$$

$$\delta^2(K) = \omega_0 (\mu_0 - \mu_G)^2 + \omega_1 (\mu_1 - \mu_G)^2 \quad (9)$$

Let  $K$  from 0 to change between  $L-1$ ,  $\delta^2(K)$  of different  $K$  values were calculate respectively. When  $\delta^2(K)$  gets the maximum value, the  $K$  value is the best threshold. Binarized image shown in Fig. (2).

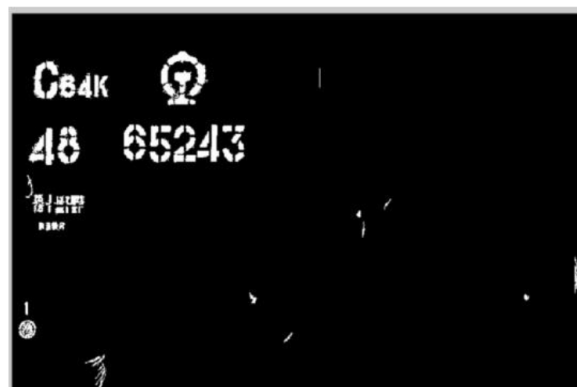


Fig. (2). Image After Binarization

### 2.3. Morphology Filtering

Deal the binary image with open operation, namely a dilation followed by an erosion in order to make the edge smooth, cut off the burr around the numbers or railway logo. Meanwhile remove the small things in the detail image. When smoothing the edge do not change its square, position or shape. Thus the image can be filtered. It is illustrated in Fig. (3).



Fig. (3). Image After Morphology Filtering

### 3. To position wagon number

Wagon number, at the front edge of the body side, as well as the railway logo needs spraying. The number is painted in standard large-size boldface. It contains two parts: one is small script, as 'C64K' in Fig. (1). Following the small figures, the other part written in large size consists of 7 figures. The set screens in photographing, various types of wagons (box wagon, open wagon and special vehicles, etc.), differences in wagon structure, the position of the figures and the spacing distance make the positioning more difficult.

#### 3.1. Position the Wagon Number Area With Railway Logo

##### 3.1.1. Get the Projection Drawings in Lines and Rows

After the morphological filtering, binary image has to be projected in line and row. In the line projection, for the above binary image array  $I$ , Progressive scan of the image, add value for each row.

That is, the number of non zero elements of each row of the image matrix is obtained, and the one-dimensional function is stored in the vector  $C$ , so that the two-dimensional function is transformed into a one-dimensional function, as shown in the formula (10).

$$c(y_i) = \sum_{j=1}^N I(x_j, y_i) \quad (10)$$

The same method makes the column projection, and the number of non-zero elements in each column of the image matrix is statistically stored in the vec-

tor  $D$ . Projection results are shown in Fig. (4) and Fig. (5).

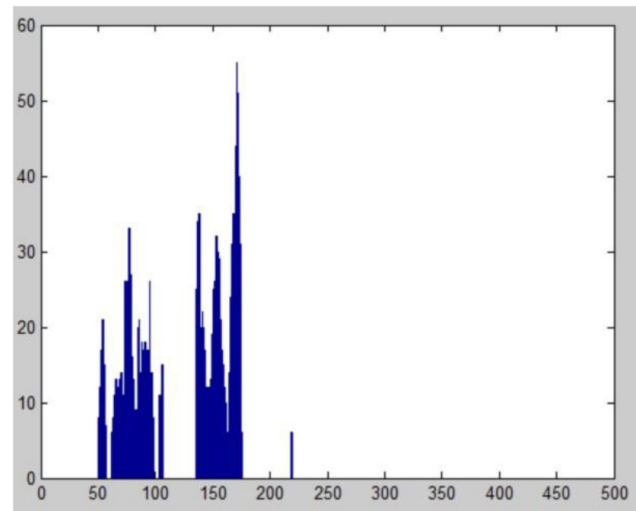


Fig. (4). Projection Drawing in Lines

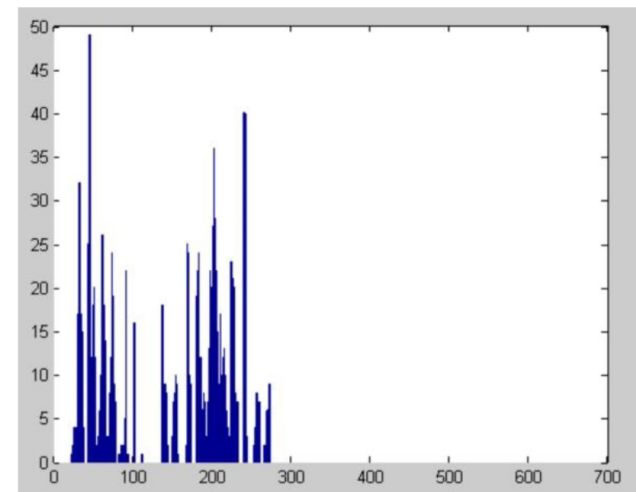


Fig. (5). Projection Drawing in Rows

##### 3.1.2. Gain Orientation Coordinate

Carries on the analysis to the data of vector  $c$  and  $d$ , the duty to 1, corresponding to the license plate number areas; where a value of 0, corresponding to the background or noise region. Considering the background, defaced, small marked effect of figures and so on to locate the license plate number, reduce noise interference and the array of data analysis, only later two adjacent data for 1, is considered to be the effective license plate region, otherwise recognize it as interference. Mark the start and end position coordinates of the white areas, this coordinate will act as positioning coordinates.

##### 3.1.3. Withdraw the Wagon Number Region Containing Railway Logo

Zone containing wagon number and railway signs results from the encircled zone in the positioning coordinates that incepted from the binary drawing. Wip-

ing out the setting of original pictures, the image with railway logo is shown in Fig. (6).



Fig. (6). Image with Railway Logo

### 3.2. to Remove the Railway Logo

After processing, the image consists of 4 parts, including large-sized, small sized script, and railway logos. If wiping out the railway sign, we get the wagon type and 7 effective figures in the image. So, it has to be removed. Here we employ template matching and morphology to remove the logo.

#### 3.2.1. to Get Railway Logo Template

To establish template, we need switched tailor for the binarized image from the wagon box picture, and fetch the railway logo. As the template of railway logo, the data from railway signs graphic will store in the form of matrix. And then coordinate the location of railway logo in the image with railway logo. When the wagon image size is  $682 \times 450$ , after tailoring, the pixel of the rail logo template is about  $80 \times 80$ .

#### 3.2.2. to Position Railway Logo

An important property of the Fourier transform is a convolution of two function in the spatial domain equal to their product in the frequency domain, convolution and correlation is a specific form[8]. So it can be used to calculate the similarity of the image with the fast Fourier transform. The template  $T$  and wagon image  $S$ , respectively for DFT, the discrete Fourier transform can be related to:

$$\Phi(u, v) = X(u, v)Y^*(u, v) \quad (11)$$

Wherein,  $X$  and  $Y$  are respectively the  $T$  and  $S$  Fourier transform,  $*$  is the symbol of the conjugate operation.

For  $\Phi(u, v)$ , the correlation function of the spatial domain is obtained by inverse Fourier transform. The Fourier transform of the image is made up of real and imaginary parts:

$$F(u, v) = R(u, v) + jI(u, v) = |F(u, v)|e^{j\Phi(u, v)} \quad (12)$$

The translation of the 2 images is the difference between the angle of Fourier transform

We need to rotate the Golden Image 180 degree, and use FFT to estimate the degree of correlation between the undetermined railway logo image and The Golden Image. In the end, the maximum correlation value multiplies by 0.9 is threshold value. It shows the railway logo's position in the image. And we get the position coordinates in the lower right corner on the logo.

#### 3.2.3. Wipe out Sectional Railway Logo

In the process of railway logo spraying, there is no settled position or size. So it is hard to remove the logo precisely at a time. In the binarized image of the unpositioning wagon number, it sets up the positioning coordinates on the bottom right corner of the logo. The  $50 \times 50$  pixel matrix on the left and upward is set as 0. Then most of the railway logo can be removed, see Fig. (7). It lays foundation for the number precise positioning.



Fig. (7). Image Wiped Out Sectional Railway Logo

### 3.3. Fetch Sectional Wagon Number

With morphological operation, we pick up orbicular structure element from the above binary image to go on expansive working circulatively. Until the number and the logo region have been in integrity, can we mark the 4 parts and orientate the minimum rectangle of image region with the use of regional feature descriptor. In analysis of the wagon pictures, we find that the area of partly removed railway logo is the smallest. So, with the smallest part removed, the left 3 connected region is information in value, see Fig. (8).



Fig. (8). the Valid Image

#### 4. Result analysis

Train number algorithm is presented in this paper, using MATLAB language test. Fixed camera angle and distance to the truck, collect the car image. In the freight railway station collect 100 pieces of wagon image, positioning test license number on them, which has 90 successful positioning, positioning accuracy is up to 90%, and achieved good positioning effect, the positioning results as in Figure 8, as shown in Figure 9. When tested in the environment of 2.66Hz CPU and 2.00GB of memory, the wagon image for 682 x 450, the longest processing time for 226ms, shortest processing time 135ms, the average processing time 185ms and fast response. It is illustrated in Fig. (9) to Fig. (12).

#### 5. Conclusions

In this paper presents the localization algorithm based on morphological operation and template matching. According to the experimental, this algorithm has the following advantages:

1. Not affected by the position of railway mark and spraying interval of the number.
2. Not affected by size or color.
3. Fast and precisely positioning.

The fast, precise and Strong robustness positioning method will lay a foundation for the wagon number division and recognition, which has huge social and economic benefit and broad application prospects.

#### Conflict of interest

The author confirms that this article content has no conflict of interest.

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Fig. (9). Image of Caravan License Plate Number



Fig. (10). Location Result of Caravan License Plate Number



Fig. (11). Image of Convertible Train License Plate Number



Fig. (12). Location Result of Convertible Train License Plate Number

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