Real-Time License Plate Recognition and Speed Estimation from Video Sequences

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Abstract – At present videos and image processing methods are being used for traffic surveillance, analysis and monitoring of traffic in many areas. The methods for recognizing license plate of a vehicle and detecting its speed from video sequences is a research hotspot and a computer vision problem. Previous techniques required special hardware, calibration of hardware or failed to identify the vehicle.

In this paper, we propose a novel generic technique for real-time license plate recognition and speed estimation of a vehicle. It accomplishes the task with the application of three successive steps, which are license plate detection, license plate recognition and speed estimation. License plate is detected by using edge filters, horizontal and vertical length thresholds, dilation and averaging methods. It is then followed by license plate recognition, which is based on template matching and Euclidean distance approach. Finally, the speed of the vehicle is estimated by a regression model, which finds the relative position of the vehicle in successive video frames. Experimental results show that the proposed technique achieves 100% accuracy for license plate detection, 92% accuracy for license plate recognition and successfully estimates the speed of the vehicle within ± 8km/hr. of the actual speed.

Index Terms—Computer Vision, License Plate Detection, License Plate Recognition, Vehicle Speed Estimation, Video Sequences

I. INTRODUCTION

Over the last few years, the traffic on roads has increased by leaps and bounds and so have the problems of car theft, over-speeding and jumping the red light. Due to the above-mentioned problems, vehicle tracking, recognition and speed detection have gained immense importance in modern traffic control systems.

The onerousness involved in number plate localization and recognition is very well known in the field of Digital Image Processing and the encumbrance increases as more and more factors are taken into consideration. Each vehicle has a unique license plate number. License plate recognition system makes use of this unique number for variety of applications such as border monitoring, toll management, parking management, car ownership etc.

With the implementation of an efficient security system we can put a curb on the increasing crime rate. Also speed estimation of vehicles from videos has gained importance recently as it can be used in automated driving, detecting over-speeding cars, automatic garages and toll gates operation etc. But the difficulty in adopting a standard procedure, in solving this problem, is mainly due to the characteristic features of the number plate, which vary widely with the region/area to which the vehicle belongs.

II. RELATED WORK

Several approaches [1], [2], [3] and [4] have been proposed for estimation of vehicle speed from videos. Rad et al [1] captured traffic movies with a stationary camera, which is mounted, on a freeway. The camera is calibrated based on geometrical equations that were supported directly by using references. Camera calibration for exact measurements may be possible while accurate speed estimation can still be quite difficult to achieve. Ibrahim et al [2] use a hybrid algorithm based on combining an adaptive background subtraction technique with a three-frame differencing algorithm, which ratifies the major drawback of using only adaptive background subtraction, but the camera still requires calibration before use and if the background changes the camera needed to be calibrated again. Liu et al [3] use an object-based method developed to extract moving vehicles and subsequently detect their speeds from two consecutive images automatically. The vehicle speed detection error was + 3.2 Km/hr. which is quite minimal, but it doesn’t provide any information about the license plate of the car. Pornpanomchais et al [4] intends to develop the vehicle speed detection system using image processing technique. Overall, work in this field includes the software development of a system that requires a video scene, which consists of the following
components: moving vehicle, starting reference point and ending reference point. The system is designed to detect the position of the moving vehicle in the scene and the position of the reference points and calculate the speed of each static image frame from the detected positions. But the system requires background calibration and the time to detect speed from a single video sequence is around 70 seconds.

III. PROPOSED TECHNIQUE

Initially, all the frames are extracted from the video sequence and preprocessed to get the required resolution.

A. License Plate Detection

To detect the car plate region as well as enhancing the characters, we apply the rotationally symmetric Gaussian low pass filter to the whole image and then we apply a 2D median filter [5] to reduce the “salt and pepper” noise. A modified form of Sobel filter [6] is then applied to the gray scale version of the image in combination with thresholds and certain metrics for edge detection and to reduce false positives. The resulting image is then dilated with a mask producing certain areas of possible license plate.

The dilation of A by B is defined by: [7]

\[ A \oplus B = \bigcup_{b \in B} A_b \]

These possible regions are then filtered through a series of steps consisting of metrics like length-to-breadth ratio and area of plate. The final image or region is passed on to next stage for segmentation.

B. License Plate Recognition

1. License Plate Character Segmentation

To extract the characters from the localized number plate, the image obtained from the previous step is complemented. The contents in this image will either be trivial noise components or characters to be identified. A border removal mechanism followed by the approximation of character height is performed to extract the characters. This border removal process considers the unwanted white region around the number plate portion as a single noise component, which can be easily eliminated. Now the image will be left with the number plate characters. Different characters can be separated out by converting the image into binary image using appropriate threshold and then labeling connected components.

2. License Plate Character Recognition

Recognition is done through a template matching approach. The set of templates previously stored in the database are compared with this extracted character set. Correlation [8] is used to define the relationship between the templates and the character in hand. Top 3 matches from the correlation stage are then passed onto the Euclidean Distance stage. 9-dimensional vector for all the templates are computed prior to this stage of algorithm. 9-dimensional vector for test character is then computed by dividing the character into 9 regions and then taking black is to white pixels ratio. The distance b/w test vector and 9-D vector of top 3 matched characters is calculated. The shortest distance corresponds to the best match and the character is extracted.

C. Speed Estimation

Speed Estimation initially involved training of the system based on the Regression Model. A fifth order polynomial function is then obtained to estimate the distance of a vehicle based on height of the detected License Plate. The selection of height of the license plate as a metric reduces miscalculation due to positioning of the video device. Relative distance of the vehicle at various instances of time is, then, calculated by applying the polynomial function on different frames of the video sequence. Finally, speed is calculated by using the frame rate, the difference in frame numbers and the relative distance at various instances of time. The complete technique is diagrammatically represented in figure 1.

FIGURE 1
IV. EXPERIMENTAL RESULTS

The algorithm is validated on an Intel Core 2 Duo, 2GHz system in MATLAB 7.12.0. The step by step implementation of the algorithm is shown in Figure 2. The input frame (Fig. 2(a)) is subjected to Gaussian filter (Fig. 2(b)) and 2D median filter (Fig. 2(c)). The resulting image is subjected to modified Sobel filter (Fig. 2(d)), which is then processed to give Fig. 2(e). This image is dilated with a mask (Fig. 2(f)). Typical license plate characteristics are used to eliminate false positives and the license plate is extracted (Fig. 2(g)). The extracted license plate is then transformed into binary using appropriate thresholds and different connected components are labeled to segment different characters (Fig. 2(i)). Individual characters are then passed to template matching and minimum Euclidean distance stages for character recognition. Speed Estimation procedure is now applied on different frames.

License Plate Detection was tested on more than 200 images and 50 video sequences. 100% accuracy was obtained for license plate detection whereas 92% success was achieved for license plate recognition. The maximum error in speed estimation was +8km/hr. Table 1 depicts the variation in actual v/s estimated speeds.

<table>
<thead>
<tr>
<th>Actual Speed (In Km/hr.)</th>
<th>Estimated Speed (In Km/hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>23.6</td>
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<tr>
<td>30</td>
<td>33.5</td>
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<td>40</td>
<td>41.9</td>
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<td>50</td>
<td>49.8</td>
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<td>60</td>
<td>56</td>
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<td>70</td>
<td>62.3</td>
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<td>80</td>
<td>74.7</td>
</tr>
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TABLE 1
V. CONCLUSION

In this paper we have proposed a novel generic technique for license plate detection, recognition and speed estimation from video sequences. The technique is generic, as it doesn’t require any special hardware or calibration and can work even in complex backgrounds. Experimental results clearly show that the technique is robust and can be used as a basis for future research.

In future, our technique can be extended to replace radar guns. Also new innovative techniques can be developed to make use of object tracking method for speed detection.

VI. REFERENCES


