

REAL TIME LOCALIZATION, TRACKING AND RECOGNITION OF VEHICLE LICENSE PLATE

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Keywords: License plate localization, License plate recognition

Abstract: Real time license plate localization, tracking and recognition are reasonably tackled problems with many successful solutions. Though most of these solutions are plausibly fast and efficient, however, almost all of the existing real time systems either deal with only a single problem at a time; detection, tracking, recognition or they are not efficient enough to work well for low quality surveillance videos. The aim of this paper is to address all three tasks for low quality videos in real time. A novel approach is proposed for efficient localization of license plate in video sequence and slightly adapted existing techniques have been applied for tracking and recognition. The implemented system is intelligent enough to automatically adjust for varying camera distances and diverse lighting conditions.

1 INTRODUCTION

Many different systems and techniques have already been devised that can detect, track or recognize vehicle license plates in real time. However, most or all of them are not capable of performing all three operations in real time with adequate efficiency. Also, most of previously proposed methods are specific to conditional constraints like camera angle, height, distance and lighting conditions or they are unable to detect and track multiple plates at a time.

This paper presents an efficient and robust frame work that can perform localization, tracking and recognition of multiple vehicle license plates in real time scenario (i.e. incoming video stream from low resolution surveillance cameras). The major aim of carrying out this work is to make significant contribution for the efficacy improvement of video indexing applications. The system is robust enough to learn any scenario and adjust itself according to any camera angle, height and distance from the road.

The main contribution of this paper is a novel technique of detecting license plates in real time from low quality surveillance video. The method

detects the license plate of moving vehicle based on the geometry of its contours present in the foreground. The detection procedure is supplemented by nearest mean classifier to eliminate false candidate regions. The algorithm automatically learns and adjusts itself to the plate size in the initial few frames. The detected plate is tracked by using dynamic displacement method and finally the characters of license plate are recognized by using a simple nearest neighbour classifier. The main intention of tracking a vehicle's license plate throughout the video stream is to enhance the efficiency of license plate character recognition by using majority voting on a set of detected samples of same license plate, and to eliminate the fallaciously detected license plates by continuous assessment of tracked plates. The rest of this paper is organized as follows. After a review of related works, the main frame work is described in three sections, license plate localization, tracking and recognition. The experimental results are provided in section 4 followed by the discussion and conclusion in section 5.

2 RELATED WORK

(Donoser et al., 2007) addressed the issues of detection, tracking and recognition altogether. They introduced a real-time framework that enables detection, tracking and recognition of license plates from video sequences. (Chang et al., 2004) proposed a license plate detection algorithm using colour edge and fuzzy logic. However, their algorithm can only be used to detect the license plates with specific colours. Techniques based on learning such as Adaboost (Zhang et al., 2006) are also used for license plate detection. Simplicity and speed are the attractive features for Adaboost learning with respect to other classifiers. However, in comparison to edge based methods Adaboost is slow. Adaboost method fails to detect license plate when the range of variations for distance or viewing angle increases. One of the earlier prominent works has been done by (Koller et al., 1994) who proposed a deformable contour based vehicle tracking algorithm.

3 PROPOSED FRAMEWORK

The section describes the proposed framework comprising of detection/localization, tracking and recognition of license plates in CCTV surveillance videos. As a first step, license plate is localized in the incoming frames. This requires some background learning and pre-processing to differentiate between license plates and other plate like regions. The located plate is further tracked in each frame by continuous up-gradation of background and finding the new location of license plate. The detected plate(s) is/are enhanced and character recognition procedure is applied to recognize the characters of the license plate in each frame.

3.1 Background Learning

Background learning is performed by using exponential forgetting algorithm (Tan. X. et al., 2007). The system begins its background computation by considering the very first frame as background and updates it by impending frames.

Every updated background is a weighted sum of previous background and new frame. In this way, the background dynamically adapts the changes in the movement of objects or luminance conditions in the frame. The background learning procedure is mathematically described as:

$$B_{n+1} = (1 - \mu)B_n + \mu F_n \quad (1)$$

Where, 'Fn' is the current frame, 'B' is the background and 'μ' is the background learning coefficient.

3.2 License Plate Localization

After pre-processing, candidate regions (for license plate) are detected by finding the contours and boundaries of connected components in the frame. These connected components are filtered on the bases of geometry of the component. Since, geometry of the license plate follows criteria of being rectangle with certain 'width to height' ratio, so it is very helpful to minimize the regions of interest. ROI selection is done in two steps.

First, the identified candidate regions are judged on the basis of their size and aspect ratio. The final selection of license plate/plates is achieved by extracting relevant features and classification. Since we target the application of our approach to existing CCTV infrastructure, it is imperative that the method must cope the varying camera distances and the angle. In order to achieve this we propose a new initial learning mechanism that learn the size of the license plate in the subject video and adjust the selection window to minimize the false candidates.

3.3.1 Initial Learning

The initial learning is performed on few initial frames of the video. Starting with a wider geometric window where size of window means the 'width' and the 'width to height' ratio. The upper limit is set to 20% of frame size considering the application requirements that the camera view should be at least as wide as the width of a single lane on road and if the detected plate is less than 5% of frame size, it is almost impossible to extract the characters with acceptable accuracy. However, this threshold is automatically updated to narrow down the range on the basis of learning performed by the system. The implemented technique is robust enough that it automatically decides the threshold for size of license plate in a video with respect to the overall frame size on the basis of initial learning. Figure 2 illustrates the effect of learning procedure.

3.3.2 Feature Extraction and Classification

We used histogram of oriented gradients (HOG) as feature descriptor. The HOG is extracted for selected candidates from first stage of detection.

Each candidate region is divided into 16 non-overlapping blocks and for each block 9 bin histogram of gradient magnitudes over gradient orientation is computed. Finally a 144 dimension feature vector for each candidate region is generated. A simple and computation efficient nearest mean classifier is used to classify the region as true or false license plate. Figure 3 illustrates the two steps of detection process.

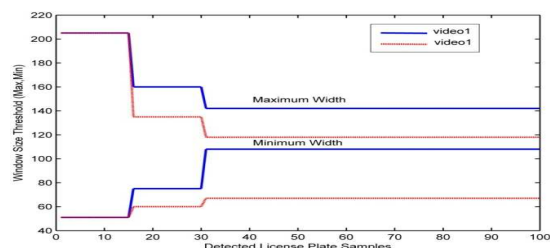


Figure 2: Threshold learning in various videos. In video 1, camera was mounted quite closer to the passing vehicles on the road. In video 2, camera was mounted far away from on road vehicles.

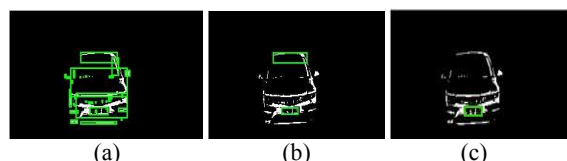


Figure 3: False Candidate Regions Rejection. (a) shows that a number of false candidate regions are indicated. (b) are obtained by applying the criteria of window sizes. (c) are finalized true candidate regions after applying correlation criteria.

3.4 License Plate Tracking

The real idea of applying a tracker is to provide supplement resource for localization and number extraction process. When a new car appears in the frame, its license plate is detected and passed on to modified Lucas Kanade's tracker (Baker. S. et al., 2004) that predicts the position of respective license plate in the next frame by computing the displacement using a constant acceleration dynamic model as follows:

$$I(x, y, t + \tau) = I(x - \xi, y - \eta, t) \quad (2)$$

where, 'I' is a window of pixels, 'x' and 'y' are new x and y coordinates of the object (license plate), ' ξ ' and ' η ' are the displacement values for previous x, y coordinates respectively.

The later image taken at time $t + \tau$ can be obtained by moving every point in the current image, taken at time t , by a suitable amount. The

amount of motion $d = (\xi, \eta)$ is called the displacement of the point at $X = (x, y)$ between time instants t and $t + \tau$.

3.5 License Plate Recognition

The final step of the frame work is to recognize the characters of detected plates. The localized plate is pre-processed for noise removal, de-skewing and enhancement of edge information. After pre-processing, connected regions are identified in the enhanced image and characters are segmented by using MBR (Minimum Boundary Rectangle).

This way, each character is separately enclosed by a bounding box. Each separated character is then classified using a simple nearest neighbour classifier. Note that the classifier requires the binary maps of the segmented characters. The recognition process is illustrated in figure 4. To reduce probability of error, each license plate is recognized in every frame and result is finalized by majority voting of results from all the instances of the license plate images. Figure 4 shows majority voting for a detected license plate. As stated earlier, license plate recognition is helpful for video indexing applications. Even if only few characters of the license plate are recognized due to poor conditions or quality of video, it can be really helpful for indexing of video sequences.

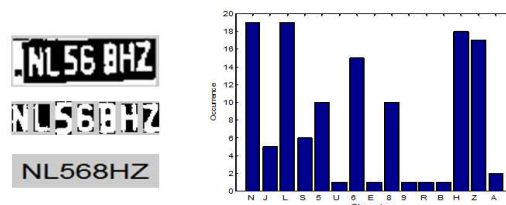


Figure 4: Effect of majority voting. Various characters are recognized in 30 consecutive frames, the recognition result is finalized depending upon the occurrence of each character.

4 EXPERIMENTS AND RESULTS

The proposed frame work is evaluated on a set of road surveillance videos from different CCTV camera. The resolution varies from maximum (1024x768) to minimum (360x288). The framework processes the specified videos for all three operations (detection, tracking and recognition of license plates) in maximum of 35 milliseconds per frame which means approximately 28 frames per second on Intel 2.1GHz Core2 Duo.

The results achieved are significantly better when compared with the results presented by other authors. For instance, if we compare our framework's execution times with (Donoser et al., 2007) who reports minimal detection, tracking and recognition time; it can be seen that the execution time for tracking and recognition are almost identical but the localization performed by our proposed framework is significantly faster.

The comparison of execution time with contemporary methods is presented in Table 1.

Table 1: Comparison of proposed frame work with various methods.

Method	Localization	Tracking	Recognition
(Donoser et al., 2007)	0.070 s	0.005 s	0.006 s
(Zhang et al., 2007)	0.05 s	-	-
(Rastegar et al., 2009)	2.3 s	-	0.4 s
(Zheng et al., 2005)	5.03 s	-	-
(C. Arth et al., 2006)	-	0.039 s	0.0198 s
Our proposed method	0.025 s	0.006 s	0.0045 s



Figure 5: License plate detection from different CCTV

4.1 Detection Results

Figure 5 shows the some of the detection results taken from different CCTV videos. The results show the detection accuracy for different camera angles, height and distances. The detection results without tracking are noted as 92% and while supplemented with tracking the proposed framework proved 100% detection accuracy.

4.1 Recognition Results

In order to evaluate the performance of our framework, we executed it for more than 20 good to worst quality videos with more than 400 vehicles

passed through them. For good quality videos, the license plate recognition results are 98% which is really promising. For extremely low quality videos with high blur factor, the recognition procedure has showed 91% efficiency.

5 CONCLUSIONS

An intelligent license plate localization, tracking and recognition method is implemented for real time video streams from road surveillance cameras by keeping applications of traffic monitoring and efficient video indexing under consideration. We have addressed these issues for a range of low to high resolution video streams with variant conditions and motion blur. The realized system intelligently performs all three operations in 35 milliseconds per frame with exceptional accuracy. This is due to its capability to learn and adjust itself with different camera positions and distances.

REFERENCES

- Arth, C., Limberger, F., Bishof, H. (2006). Real-Time License Plate Recognition on an Embedded DSP-Platform. *Institute for Computer Graphics and Vision, Graz University, Austria*
- Baker, S., Matthews, I. (2004). Lucas-Kanade 20 years On: A unifying framework. In *International Journal of Computer Vision*, volume 3, pages 221–255.
- Chang, S. L. et al. (2004). Automatic License Plate Recognition. In *IEEE Transactions on Intelligent Transportation Systems*, Volume 5, pages 42-53
- Zheng, D., Zhao, Y., Wang, J. (2005). An efficient method of license plate location. In *Pattern Recognition Letters Volume 26*, pages 2431–2438
- Donoser, M., Arth, C., Bischof, H. (2007). Detecting, Tracking and Recognizing License Plates. In *ACCV 2007, Part II, LNCS 4844* 447–456
- Zhang, H. et al. (2006). Real-Time License Plate Detection under Various Conditions. In *LNCS Volume 4159/2006*, pages 192-199, Springer Verlag
- Koller, D., Weber, J., Malik, J. (1994). Robust multiple car tracking with occlusion reasoning. In *European Conference on Computer Vision. Proceedings*
- Tan, X., Li, J., and Liu, C. (2007). A video-based real-time vehicle detection method by classified background learning. In *World Transactions on Engineering and Technology Education*.
- Rastegar, S., Ghaderi, R., Ardeshir, J., Asadi, N. (2009). An intelligent control system using an efficient license plate location and recognition approach. In *International Journal of Image Processing (IJIP)*, Volume 3, Issue 5, pages 252-264