An Algorithm for Automatic License Plate Detection from video using corner features

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Abstract*—As the importance of public transit system increases an Automatic License Plate Recognition (ALPR) has turned out to be an important research subject.It is getting hard to preserve track of each vehicle for purposes of law enforcement and traffic management.ALPR equipped with many intelligent surveillance systems like, road traffic management, security management, automatic toll collection system, etc. The basic steps in ALPR were accurate localization of number plate, which bears on the overall system accuracy.A license plate detection method was produced to find number plates from a continuous video stream showing the movement of all the vehicles in various conditions such as, non-uniform illumination, vehicle speed, background and foreground color, different weather condition, occlusion within image, etc. In this composition, the detection of a license plate from an image, corner features based on Harris algorithm is proposed and been simulated.The advantages of the algorithm are high speed, accuracy and less complexity.The License plate(s) was extracted successfully from an input video file. The comparison is made between the wavelet transform based algorithm and Harris corner algorithm on the basis of accuracy of multiple license plate detection.

***Keyword: Discrete Wavelet Transform; Harris corner algorithm; License plate detection; ALPR*.**

I. INTRODUCTION

License Plate Recognition (LPR) is an imaging technology used to identify License plates for their vehicles. With the increasing requirement of anti-terrorism and public security worldwide, the global law enforcement has been deploying automatic vehicle License Plate Recognition (LPR) systems everywhere to fight against criminals. Toll booths are constructed on freeways and parking structures, where the car has to block off to pay the toll or parking fees. Also traffic management arrangements are set up on freeways to go over for vehicles going at speeds not permitted by law. This scheme is widespread, particularly in conditions of security and traffic facilities. The singular advantage of ALPR system is that it can hold an image record of a vehicle for further processes if required. For real time application the speed and accuracy of the systems need to be amended. This job is challenging due to several factors that can contribute to low quality images. Some general problems that should be taken into account for practical applications are as follows:

i. Severe outdoor illumination conditions during image acquisition such as headlight of vehicles and projection or reflection of the sunshine.
ii. Complex backgrounds, including damaged or unclean license plate, non-license plate characters printed on the vehicle and hence along.
iii. Perspective distortion caused by different distance and angles between the standpoint and the vehicle and blur caused by vehicle motion.

The ALPR System is equipped with a video camera which continuously captures the image of all the incoming and outgoing vehicles and with the help of an automatic image processing algorithm, the License plate of vehicle were extracted and stored in the memory which will be useful for identification or logging purpose.

II. RELATED WORK

Generally, license plate recognition system operates in three main steps. 1) Plate detection 2) character segmentation and 3) character recognition. The paper presented detection procedure and give a brief overview of some of the existing techniques used in LP detection in the following with extra knowledge of motion tracking algorithm also. Author [1] proposed the algorithm based on Harris corner detection, which detects the location of the license plate. Author [2] author tried to improve the algorithm for low-contrast image while in [3] multi-scale Harris corner detection based on wavelet is proposed for tracking motion vehicles. Then as the license plate is full of curved character and maybe with broken characters also so most of them can be reckoned as a corner and we can apply the Harris corner detection algorithm to them to find the localization of the license plate.

III. ALGORITHM FOR AUTOMATIC LICENSE PLATE DETECTION:

Automatic license plate recognition is useful in many contexts such as parking control, law enforcement and vehicle background checking. This chapter includes algorithm for real-time automatic license plate detection. In this algorithm the video frames are continuously extracted and transferred to the algorithm. The algorithm works on the frames which shows only four wheelers and rejects all other frames which shows pedestrians, cycles or any two-wheelers. After selecting the frames the pre-processing steps are applied on it for smoothing and noise removal. For detection of any moving objects in the video frames Gaussian Mixture model is used. The detection of license plate operation was done with the help of Harris corner detector.

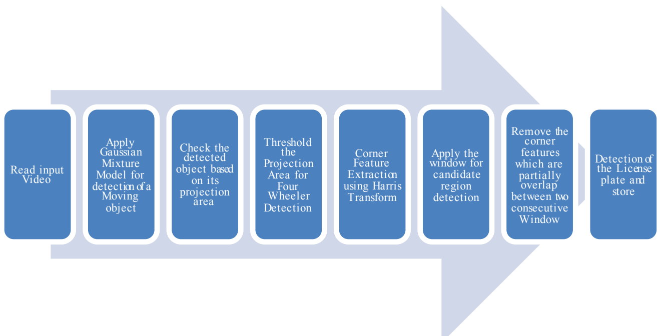


Fig.1: Process Flow for Automatic License Plate Detection System

A. Read Input Video

Video is an electronic medium for the recording of moving visual media. Video are taken by the IP camera situated at the entrance of the institute where the research project is executed. In image processing video is combinations of frames. To extract the license plate from a video, video is given as input to the system. This video is continuously captured and stores the recordings during the entry and exit time of the institute. The entry and exit time is selected based on the no. of vehicles entering or leaving the college entrance.

B. Detection of Moving Vehicle(s) from input video

From an input video stream, each frame is used in the algorithm for estimation of foreground and detection of moving object. For detection of moving objects from incoming video, Gaussian mixture model (GMM) [4]–[6] is used. Gaussian mixture models are often used for data clustering. Clusters are assigned by selecting the component that maximizes the posterior probability. Gaussian mixture modeling uses an iterative algorithm that converges to a local optimum. Gaussian mixture modeling may be more appropriate than k-means clustering when clusters have different sizes and correlation within them. Clustering using Gaussian mixture models is sometimes considered a soft clustering method. The posterior probabilities for each point indicate that each data point has some probability of belonging to each cluster. A pixel at timet is modeled as mixture of K Gaussian [7] distributions. The probability of observing the current pixel value is given by

$$P(X_t) = \sum_{i=1}^{k} w_{i,t} * \varphi(X_t, \mu_{i,t}, C_{i,j}) \quad (1)$$

Where, $w_{i,t}$, $\mu_{i,t}$, and $C_{i,j}$ are the estimate weight, mean value and covariance matrix of i[th] Gaussian in the mixture at time t. $\varphi(X_t, \mu_{i,t}, C_{i,j})$ is the Gaussian probability density function (2).

$$\varphi(X_t, \mu_{i,t}, C_{i,j}) = \frac{1}{(2\pi)^{\frac{n}{2}} |C|^{1/2}} e^{(-\frac{1}{2}(X_t-\mu_t)^T C^{-1}(X_t-\mu_t))} \quad (2)$$

Each input frames are first read and converted into the intensity image. For removal of effect of sudden intensity changes caused by the illumination conditions, shadow and reflection on the window of the vehicles each frames were first subtracted from the mean value of the frame. Gaussian Mixture model is than applied for the detection of the foreground. The result of applying the GMM on the input video is shown in Figure 2.

(a) **(b)**

Fig. 2: (a)Input Frame (b)Foreground Region detected

C. Decision of Detecting Only Four Wheelers from input video

After applying the Gaussian Mixture Modeling on every incoming frame, detected foreground pixels were analyzed for only bigger vehicle, e.g. Car, Van or Bus. As the connected pixel region for bigger object is more, this number is used as a threshold for selecting the four wheelers only from all the incoming frames. The area showing the connected region from the estimated foreground is calculated and compared with the threshold for every video frames. The algorithm then stores the frames which have the connected pixel area higher than the threshold. This step will give the detected object as four wheeler only. The connected pixel area calculated for pedestrian, cycle, bike and car for a sample input video file is listed in Table I. Based on the testing result of the algorithm on

TABLE I AREA COMPUTATION FOR DIFFERENT MOVING OBJECTS IN THE VIDEO FILE

Video Frame#	Connected pixel Area	Object in a video frame
40	1047	Sweeper cleaning a road
52	2615	Scooter
95	2199	Pedestrians (03 no)
112	2779	Group of 10 pedestrians
256	3065	Car

25 video files captured during the peak timings of the institute, the threshold for the connected pixel area is decided to be 3000 pixels. Since the camera distance and road lane is fixed, the tested threshold works accurately on every video files captured at 9:00am in morning and at 5:00pm in evening.

D. Candidate Region Detection using Harris Corner Detector

Corner detection is a technique used in various systems to extract certain kinds of features. A corner can be defined as points for which there are two dominant and different edge directions in a local neighborhood of the point. Corner is the point that gray-scale varies drastically or located at the outline of an image boundary, reflecting important features and information of the image. Differs from other features of straight lines, circles and edges, corners are easy to be extracted from the images. Vehicles license plate is a combination of different characters so they have an intensive and regular corners. The basic principle of Harris corner detector is taking a small window centering on target pixel, moving the window separately along four directions (up, down, left, and right), calculating gradation change of the window in four directions and selecting the minimum value as function value corresponding to the corner point of the target pixel. If the value is bigger than threshold value, it is deemed to be corner point. Assume that the small window with the center of the target pixel (x, y) travels the distance of u in the x-direction, and v in the y direction. The gray-scale function of the image can be derived at the corner using first-order Taylor's expansion. The analytic formula of Harris algorithm could be used as follows:

$$E_{x,y} = \sum w_{x,y}\left(I_{x+u,y+v} - I_{x,y}\right)^2 \qquad (3)$$

Where $I_{x,y}$denotes the gray-scale of the pixel and $w_{x,y}$ is a function for window,

$$X = I \otimes (-1,0,1) \qquad (4)$$

$$Y = I \otimes (-1,0,1)^T \qquad (5)$$

And $\otimes$ is the convolution operator. For small offset of gray-scale:

$$E_{x,y} = Ax^2 + 2Cxy + By^2 \qquad (6)$$

Where $A = X^2 \otimes w, B = Y^2 \otimes w, C = (XY) \otimes w$Transform $E_{x,y}$into quadratic form using (7).

$$E_{x,y} = [uv]M[\frac{u}{v}] \qquad (7)$$

Where, M is real symmetric matrix derived using (8).

$$M = \sum w_{x,y}\begin{bmatrix} I_x^2 & I_x \cdot I_y \\ I_x \cdot I_y & I_y^2 \end{bmatrix} \qquad (8)$$

Consequently, R express, function corresponding to Harris corner point, is calculated using (9).

$$R(x,y) = \det(M) - k(trace(M))^2 \qquad (9)$$

Including, *det(M)* refers to determinant of matrix *M*; and *trace(M)* refers to trace of matrix. As per Harris algorithm, when *R* value of target pixel is more than threshold value, the pixel is deemed to be corner point. The original image and the output of Harris corner detector is shown in Fig 3(b).

E. Windowing Approach for Exact License Plate Detection

License plate has more number of characters compared to other regions. As shown in the Fig. 5, the region of the image having license plate will have more features extracted compared to the other part of the image.

(a) (b)

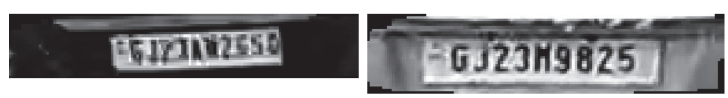
Fig. 3:(a)Detected Car using GMM, (b)Corner Features using Harris Corner Detector

The corners are counted within the sliding window that is W pixels wide and H pixels high. The sliding window is defined as a candidate license plate region if the number of corners inside the window is more than a threshold. After traveling the whole image, all the candidate license plate regions can be found without overlapping windows. The size of the window is decided after observation. And the region having maximum number of corners can be considered as a final license plate region. The number of Harris feature and detected sliding window region is shown in the Fig. 4(a) and Fig. 4(b). From this final extracted license plate region is shown in the figure 4(c).

(a) (b) (c)

Fig. 4: (a) Detected Harris Corners, (b) Result of applying window, (c) Detected License Plates.

The results shown in Fig. 4are having two license plates in the video file. Both the license plates are now detected and separately stored at the destination address after trimming operation on the background. The detected license plates obtained from Fig 4(c) are shown in Fig 5.



(a) (b)

Fig. 5: Detected License Plates.

For the record of detected license plates this output images are stored in to the specific location and next input image will be processed for continuous detection of license plates this makes the algorithm automatic.

IV. EXPERIMENTAL RESULTS

The Automatic License Plate Detection system is developed in the licensed software MATLAB, Version 7, Release, 2011. The Hardware configuration used for the implementation of the algorithm is Intel Core i3-3217U CPU@1.8GHz, 4.00GB RAM, 64-bit Operating System. The Video camera used for capturing the video frames is IP Camera with 1/3" Progressive Scan CMOSSensor, 1280X1024,25/30fps,H.264/MJPEG/MPEG4,Triple stream, 30m IR. The camera is scheduled to record the incoming and outgoing cars during the fixed timings of the institute. The IP Camera is located at the entrance plaza of the A. D. Patel Institute of Technology, where the research project sponsored by GUJCOST, is currently executed. The results of applying the algorithm automatically on a video stream captured continously are shown in this section. The IP Camera is used for capturing the scheduled video files.From the input video frames, each frame is used for estimating the foreground and removal of constant background. Gaussian Mixture Model is used for this purpose. The output of the GMM is the represented as white color in the constant black background. If any movement found in the frames, the GMM gives the output , this output data is checked for the extraction of only frames which contains the car or bus. For this purpose each estimated foregroundis checked for connectivity and connected set area. If the connected area of any region is higher than the predefined threshold, the frame is extracted and treated as an image for subsequent steps. The result of applying GMM on different video frames are shown in Fig 7.

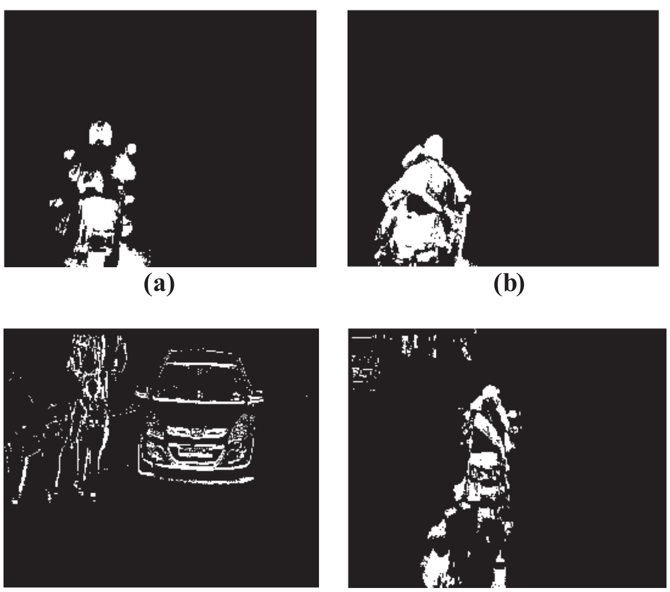


Fig. 6: Foreground estimation of the Two-wheeler, Pedestrials and a Car.

A. *Corner Feature Extraction:*

The detected object (Four wheeler only) is used for applying Harris corner detector and selection of Harris corner points correspond to only the required rectangular window. Corner detection is a technique used in various systems to extract certain kinds of features. A corner can be defined as points for which there are two dominant and different edge directions in a local neighborhood of the point. Corner is the point that gray-scale varies drastically or located at the outline of an image boundary, reflecting important features and information of the image. Differs from other features of straight lines, circles and edges, corners are easy to be extracted from the images. Vehicles license plate is a combination of different characters so they have an intensive and regular corners (Fig 7).

B. *Windowing approach*

License plate has more number of characters compared to other regions. As shown in the Fig 7(b) the region of the image having license plate will have more features extracted compared to the other part of the image. The corners are counted within the sliding window that is W pixels wide and H pixels high. The sliding window is defined as a candidate license plate region if the number of corners inside the window is more than a threshold. After traveling the whole image, all the candidate license plate regions can be found without overlapping windows. The size of the window is decided after observation. And the region having maximum number of corners can be considered as a final license plate region. The number of Harris feature and detected sliding window region is shown in the Fig 7(a).

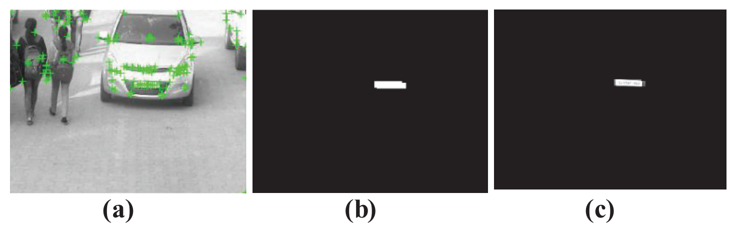


Fig. 7: (a) Corner Detection Result, (b) Result of windowing technique, (c) Detected License plates

a) Slide the W x H window from left top of the image every two pixels. The number of corners inside the window is counted as cornum.

b) If num_of_corners> T, coordinates (i,j) of the top left point of the window and corresponding cornum are put into an array C in which C[n]=[i, j, num_of_corners]. Otherwise, go back to step1 and slide the window to the next.

c) Travel from C[1] to C[n-1], and check if the window C[n] partly overlaps on C[p], p=1…(n-1), if | i- C[p,1]| <= W and |j-C[p,2]| <=H, go to Step4. If C[n] has no overlapping area on C[p], p=1… (n-1), then go back to step1 and slide the window to the next.

d) It shows that the window C[n] partly or totally overlaps on C[p], then compare the number of corners between C[n] and C[p]. If C[n,3]>C[p,3], it proves that the number of corners in C[n] is more than C[p], then replace C[p] with C[n] and delete C[n]. Go back to step1 and slide the window to the next.

e) Scan whole image and all the candidate license plate regions can be found out. Result of these operations is shown in Fig 7(b).

C. Storage of Detected license plate

After the exact license plate is extracted this image will be stored to the specific location for the further use. The detected license plates are used for the entry and exit log (Fig.8).

Fig.8: Input Video frame and Detected License plate images.

D. Comparison with existing Technique

The proposed technique is checked with the existing technique proposed by the author in [8]. As the position of the vehicle and speed of the vehicle is dynamic in the input video used, the technique proposed by author [8] is not able to detect only the license plate, but additional components like black

Fig. 9: (a) Input Image, (b) License plate detection using [8], (c) Result of proposed technique.

iron grill, extra portions around the License plateand backside bumper. The comparison between the proposed technique and the technique suggested by [8] is shown in Fig 9.

CONCLUSION

Depending upon the literature survey and simulation results the conclusion is derived that License Plate detection algorithm based on Harris corner detection and windowing technique works efficiently on an input video file captured during the different timings and with different lighting conditions.Effective results are obtained for images and videos having different challenges such as broken number plate, vehicle in motion, shadow effects and different illumination conditions. Vehicles are detected from a video effectively and license plate detection was accomplished successfully. After testing the algorithm for automatic detection of license plate the proposed technique gives accurate result.

ACKNOWLEDGEMENT

This work was supported by GUJCOST minor research project 2013-14 grant. Authors would like to thank Principal and Head, Electronics and Communication Engineering department of A. D. Patel Institute of Technology for constant motivation, support and encouragement.

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