A Novel Multiple License Plate Extraction Technique for Complex Background in Indian Traffic Conditions

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Abstract

License plate recognition (LPR) is one of the most important applications of applying computer techniques towards intelligent transportation systems (ITS). In order to recognize a license plate efficiently, location and extraction of the license plate is the key step. Hence finding the position of a license plate in a vehicle image is considered to be the most crucial step of an LPR system, and this in turn greatly affects the recognition rate and overall speed of the whole system. This paper mainly deals with the detecting license plate location issues in Indian traffic conditions. The vehicles in India sometimes bare extra textual regions, such as owner's name, symbols, popular sayings and advertisement boards in addition to license plate. Situation insists for accurate discrimination of text class and fine aspect ratio analysis. In addition to this additional care taken up in this paper is to extract license plate of motorcycle (size of plate is small and double row plate), car (single as well as double row type), transport system such as bus, truck, (dirty plates) as well as multiple license plates present in an image frame under consideration. Disparity of aspect ratios is a typical feature of Indian traffic. Proposed method aims at identifying region of interest by performing a sequence of directional segmentation and morphological processing. Always the first step is of contrast enhancement, which is accomplished by using sigmoid function. In the subsequent steps, connected component analysis followed by different filtering techniques like aspect ratio analysis and plate compatible filter technique is used to find exact license plate. The proposed method is tested on large database consisting of 750 images taken in different conditions. The algorithm could detect the license plate in 742 images with success rate of 99.2%.

Keywords: License plate recognition, sigmoid function, Horizontal projection, Mathematical morphology, Aspect ratio analysis, Plate compatible filter.

1. INTRODUCTION

License plate recognition (LPR) applies image processing and character recognition technology to identify vehicles by automatically reading their license plates. Automated license plate reading is a particularly useful and practical approach because, apart from the existing and legally required license plate, it assumes no additional means of vehicle identity. Although human observation seems the easiest way to read vehicle license plate, the reading error due to tiredness is main drawback for manual systems. This is the main motivation for research in area of automatic license plate recognition. Since there are problems such as poor image quality, image perspective distortion, other disturbance characters or reflection on vehicle surface, and the color similarity between the license plate and background vehicle body, the license plate is often difficult to be located accurately and efficiently. Security control of restricted areas, traffic law enforcements, surveillance systems, toll collection and parking management systems are some applications for a license plate recognition system.

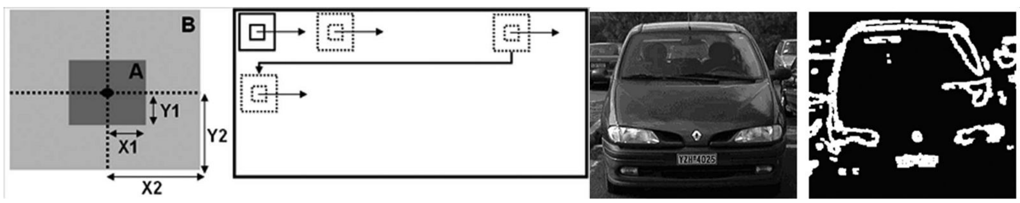
Main goal of this research paper is to implement a method efficient in recognizing license plates in Indian conditions because in Indian scenario vehicles carry extra information such as owner's name, symbols, design along with different standardization of license plate. Our work is not restricted to car but is expanded to many types of vehicles like motor cycle (in which size of license plate is small), transport vehicles which carry extra text and soiled license plate. Our proposed algorithm is robust to detect vehicle license plate in both day and night conditions as well as multiple license plates contained in an image or frame without finding candidate region.

The flow of paper is as follows: section 2 discusses about the previous works in the field of LPR. Section 3 is about the implementation of algorithm. Section 4 talks about the experimentation results of the proposed algorithm. Section 5 and 6 are about conclusion and references.

2. PREVIOUS WORK

Techniques based upon combinations of edge statistics and mathematical morphology [1]–[4] featured very good results. A disadvantage is that edge based methods alone can hardly be applied to complex images, since they are too sensitive to unwanted edges, which may also show a high edge magnitude or variance (e.g., the radiator region in the front view of the vehicle). When combined with morphological steps that eliminate unwanted edges in the processed images, the LP extraction rate becomes relatively high and fast. In [1], the conceptual model underneath the algorithm is based on the morphological operation called "top-hat transformation", which is able to locate small objects of significantly different brightness [5]. This algorithm, however, with a detection rate of 80%, is highly dependent on the distance between the camera and the vehicle, as the morphological operations relate to the dimensions of the binary objects. The similar approach was described in [2] with some modifications and achieved an accuracy around 93%. In [3], candidate region was extracted with the combination of edge statistics and top hat transformations and final extraction was achieved using wavelet analysis, with the success rate of 98.61%. In [4], a hybrid license plate detection algorithm from complex background based on histogramming and mathematical morphology was undergone which consists of vertical gradient analysis and its horizontal projection for finding out candidate region; horizontal gradient, its vertical projection and morphological deal of candidate region is used to extract exact license plate (LP) location. In [6], a hybrid algorithm based on edge statistics and morphology is proposed which uses vertical edge detection, edge statistical analysis, hierarchical-based LP location, and morphology for extracting the license plate. This prior knowledge based algorithm achieves very good detection rate for image acquired from a fixed distance and angle, and therefore, candidate regions in a specific position are given priority, which certainly boost the results to a high level of accuracy. But it will not work on frames with plates of different size and license plate more in number. In [7][8], technique was used that scans and labels pixels into components based on pixel connectivity. Then after with the help of some measurement features used to detect the region of interest. In [9] the vehicle image was scanned with pre-defined row distance. If the number of the edges is greater than a threshold value, the presence of a plate can be assumed.

In [10], a block based recognition system is proposed to extract and recognize license plates of motorcycles and vehicles on highways only. In the first stage, a block-difference method was used to detect moving objects. According to the variance and the similarity of the MxN blocks defined on two diagonal lines, the blocks are categorized into three classes: low-contrast, stationary and moving blocks. In the second stage, a screening method based on the projection of edge magnitudes is used to find two peaks in the projection histograms to find license plates. But main shortcoming of this method is detection of false region or unwanted non text region because of projection of edges. In [11], a method using the statistics like mean and variance for two sliding concentric windows (SCW) was used as shown in Figure (1). This method encounters a problem when the borders of the license plate do not exhibit much variation from the surrounding pixels, same as edge based methods. Also, edge detection uses a threshold that needs to be determined which cannot be uniquely obtained under various conditions like illuminations. Same authors report a success rate of 96.5% for plate localization with proper parameterization of the method in conjunction with CCA measurements and the Sauvola binarization method [12].



(a) (b)

FIGURE 1: (a) SCW Method, (b) Resulting Image after SCW Execution [11].

In Hough transform (HT) based method for license plate extraction, edges in the input image are detected first. Then, HT is applied to detect the LP regions. In [13], a combination of Hough transform and contour algorithm was applied on the edge image. Then the lines that cross the plate frame were determined and a rectangular-shaped object that matched the license plate was extracted. In [14] scan and check algorithm was used followed by radon transform for skew correction. In [15] proposed method applies HL subband feature of 2D Discrete Wavelet Transform (DWT) twice to significantly highlight the vertical edges of license plates and suppress the surrounding background noise. Then, several promising candidates of license plates can easily be extracted by first-order local recursive Otsu segmentation [16] and orthogonal projection histogram analysis. Finally, the most probable candidate was selected by edge density verification and aspect ratio constraint.

In [17,18], color of the plate was used as a feature, the image was fed to a color filter, and the output was tested in terms of whether the candidate area had the plate's shape or not. In [19, 20] the technique based on mean-shift estimate of the gradient of a density function and the associated iterative procedure of mode seeking was presented and based on the same, authors of [21] applied a mean-shift procedure for color segmentation of the vehicle images to directly obtain candidate regions that may include LP regions. In [22], concept of enhancing the low resolution image was used for better extraction of characters.

None of the above discussed algorithms focused on multiple plate extraction with different possible aspect ratio.

3. PROPOSED MULTIPLE LICENSE PLATE EXTRACTION METHOD

Figure (2) shows the flow chart of the proposed algorithm, which shows the step by step implementation of proposed multiple license plate extraction method in Indian traffic conditions.

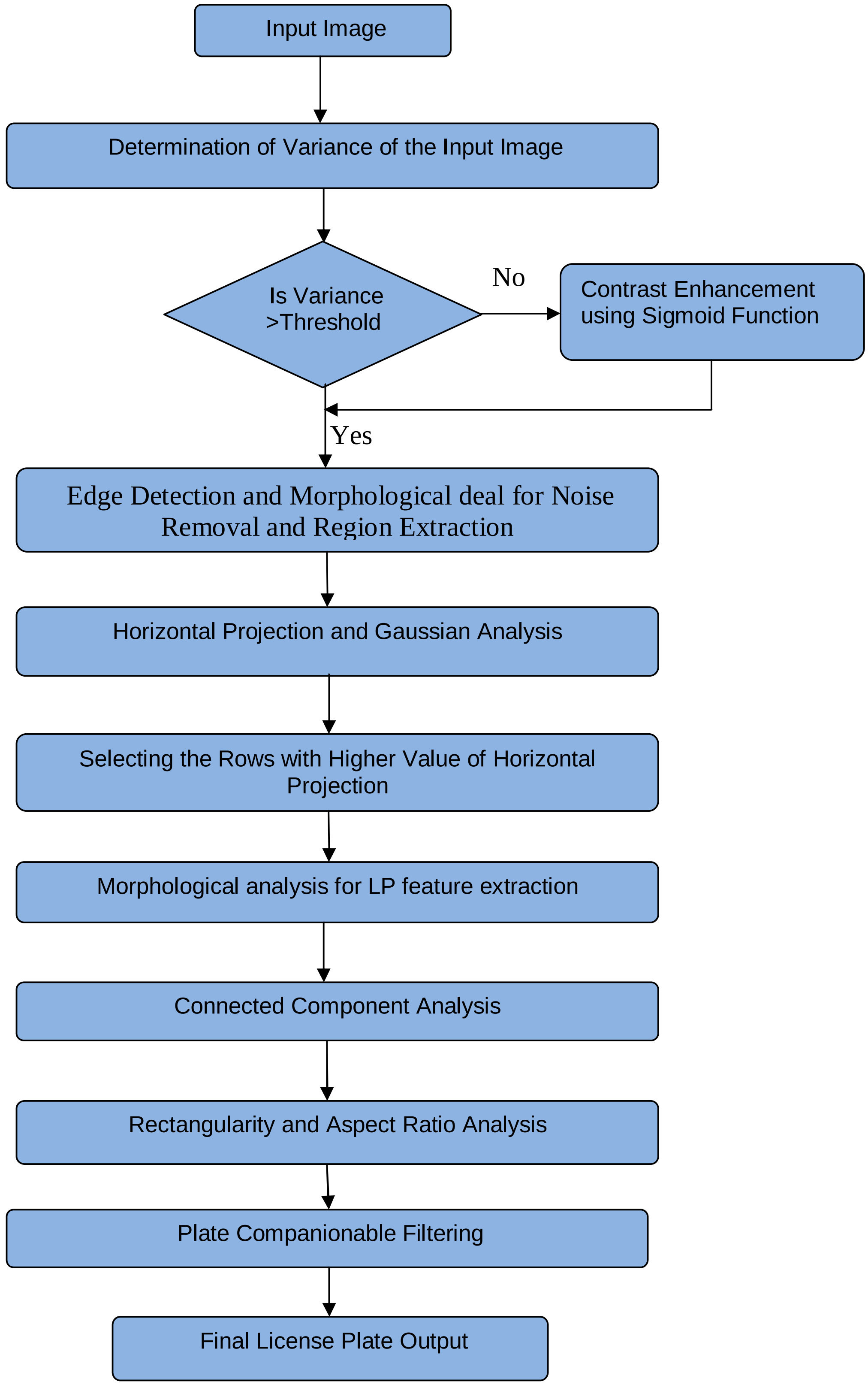


FIGURE 2: Flow Chart of Proposed Method

3.1 Preprocessing

This work aims on gray intensity based license plate extraction and hence begins with color to gay conversion using (1).

$$I(i,j) = 0.114 * A(i,j,1) + 0.587 * A(i,j,2) + 0.299 * A(i,j,3) \tag{1}$$

where, *I(i,j)* is the array of gray image, *A(i,j,1), A(i,j,2), A(i,j,3)* are the R,G,B value of original image respectively. For accurate location of the license plate the vehicle must be perfectly visible irrespective of whether the image is captured during day or night or non homogenous illumination. Sometimes the image may be too dark, contain blur, thereby making the task of extracting the license plate difficult. In order to recognize the license plate even in night condition, contrast enhancement is important before further processing. One of the important statistical parameter which provides information about the visual properties of the image is variance. Based on this parameter, condition for contrast enhancement is employed. First of all variance of the image is computed. With an aim to reduce computationally complexity the proposed implementation begins with the thresholding of variance as a selection criterion for frames aspiring contrast enhancement. If the value is greater than the threshold then it implies that the corresponding image possesses good contrast. While if the variance is below threshold, then the image is considered to have low contrast and therefore contrast enhancement is applied to it. This method of contrast enhancement based on variance helps the system to automatically recognize whether the image is taken in daylight or in night condition.

In this work, first step towards contrast enhancement is to apply unsharp masking on original image and then applying the sigmoid function for contrast enhancement. Sigmoid function which is also known as logistic function is a continuous nonlinear activation function. The name, sigmoid, obtained from the fact that the function is "S" shaped. The sigmoid has the property of being similar to the step function, but with the addition of a region of uncertainty [23]. It is a range mapping approach with soft thresholding. Using *f(x)* for input, and with α as a gain term, the sigmoid function is given by:

$$f(x) = \frac{1}{1+e^{-\alpha x}} \tag{2}$$

For faultless license plate extraction, identification of edges is very important as license plate region consists of edges of definite size and shape. In blurry images identification of edges are indecent, so for the same sharpening of edges are must. By using the unsharp masking, sharpening of areas which have edges or lots of details can be easily highlighted. This can be done by generating the blurred copy of the original image by using laplacian filter and then subtracting it from the original image as shown in (3).

$$I(i,j)_{sharpe} = I(i,j)_{original} - I(i,j)_{blur} \tag{3}$$

The resultant image, obtained from (3) is then multiplied with some constant c and then added it to the original image as shown in (4). This step highlights or enhances the finer details but at the same time larger details will remain undamaged. The value of *c* chosen is 0.7 from experimentaiton.

$$I(i,j)_{output} = I(i,j)_{orignal} + c * I(i,j)_{sharpe} \tag{4}$$

In the next step, smoothing average window size of *MxM* is apply on the output image obtain from (4). Since we are going for edge detection, value of *M* is equal to 3. After that finding out the mean at each location, it is compared with some pre defined threshold *t.* If the value of pixel at that location is higher than predefined threshold it remains unchanged else that pixel value will be change by using sigmoid function of (2).

$$I(i,j)_{enhance} = \begin{cases} p & if\ \ p > t \\ p + (\dfrac{b}{1+e^{-p}}) & if\ \ p < t \end{cases} \tag{5}$$

Where *p* is the pixel value of enhanced image *I(i,j).* Here value of *b*, which determines the degree of contrast needed, varies in the range of 1.2 to 2.6 based on experimentation. Figure (3) shows the results of contrast enhancement using sigmoid function. As shown in Figure, after applying the contrast enhancement algorithm details can be easily viewed from the given input image.

Original Image	Contrast Enhanced Image
	
	
	

FIGURE 3: Original Low Contrast Image and Enhanced Image using Sigmoid Function.

3.2 Vertical Edge Analysis and Morphological Deal

The license plate region mainly consists of vertical edges and therefore by calculating the average gradient variance and comparing with each other, the bigger intense of variations can be determined which represents the position of license plate region. So we can roughly locate the horizontal position candidate of license plate from the gradient value using (6).

$$g_V(i, j) = \left| f(i, j+1) - f(i, j) \right| \tag{6}$$

Figure 4 shows the original gray scale image and the image after finding out vertical edges from the original.

FIGURE 4: Original Gray Scale Image and Vertical Gradient of Same

Mathematical morphology [6] is a non-linear filtering operation, with an objective of restraining noises, extract features and segment objects etc. Its characteristic is that it can decompose complex image and extract the meaningful features. Two morphological operations opening and closing are useful for same. In opening operation erosion followed by dilation with the same structuring element (SE) is used as shown in (7). This operation can erase white holes on dark objects or can remove small white objects in a dark background. An object will be erased if the SE does not fit within it. In closing operation dilation followed by erosion with the same SE as shown in (8). This operation removes black holes on white objects. A hole will be erased if the SE does not fit within it.

$$A \circ B = \left(A \Theta B \right) \oplus B \tag{7}$$

$$A \bullet B = \left(A \oplus B \right) \Theta B \tag{8}$$

In general scenario, license plate is white or yellow (for public transport in India) with black characters, therefore we have to begin with the closing operation as shown in Figure 5(a). Now, to erase white pixels that are not characters, an opening operation with a vertical SE whose height is less than minimum license plate character height is used as shown in Figure 5(b).

FIGURE 5: (a) Result after closing operation (b) Opening operation.

3.3 Horizontal Projection and Gaussian Analysis

From last step, it is observe that the region with bigger value of vertical gradient can roughly represent the region of license plate. So the license plate region tends to have a big value for horizontal projection of vertical gradient variance. According to this feature of license plate, we calculate the horizontal projection of gradient variance using (9).

$$T_H(i) = \sum_{i=1}^{n} g_V(i, j) \tag{9}$$

There may be many burrs in the horizontal projection and to reduce or smoothen out these burrs in discrete curve Gaussian filter has to apply as shown in (10).

$$T'_H(i) = \frac{1}{k}\left\{T_H(i) + \sum_{j=1}^{w}\begin{bmatrix} T_H(i-j)h(j,\sigma) + \\ T_H(i+j)h(j,\sigma) \end{bmatrix}\right\}$$

$$\text{where} \qquad h(j,\sigma) = e^{-(j\sigma^2)/2}; \qquad k = 2\sum_{j=1}^{w} h(j,\sigma) + 1 \tag{10}$$

In (10), $T_H(i)$ represents the original projection value, $T'_H(i)$ shows the filtered projection value, and i changes from 1 to n, where n is number of rows. w is the width of the Gaussian operator; $h(j,\sigma)$ is the Gauss filter and σ represents the standard deviation. After many experiments, the practicable values of Gauss filter parameters have been chosen w = 6 and σ = 0.05. The result of smoothening of horizontal projection by Gauss Filter is shown in Figure 6.

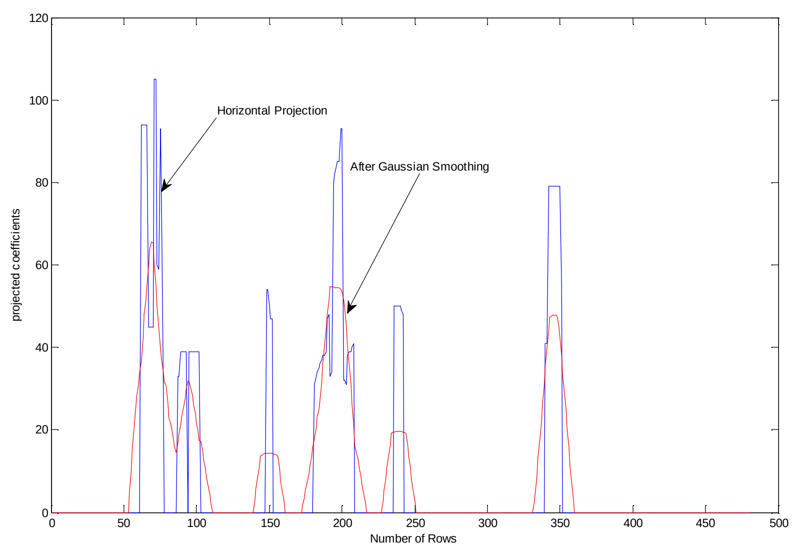


FIGURE 6: Horizontal Projection Before and After Smoothing

As shown in the Figure 6, some rows and columns from the top and bottom are discarded from the main image on the assumption that license plate is not part of that region and thereby reducing computationally complexity. One of wave ridges in Figure 6 must represent the horizontal position of license plate. So the apices and vales should be checked and identified. For many vehicles may have poster signs in the back window or other parts of the vehicle that would deceive the algorithm. Therefore, we have used a threshold T to locate the candidates of the horizontal position of the license plate. The threshold is calculated by (11) where m represents the mean of the filtered projection value and w_t represents weight parameter.

$$T = w_t * m \tag{11}$$

Where w_t = 1.2. If $T'_H(i)$ is larger than or equal to T, it considers as a probable region of interest. Figure 7 (a) shows the image containing rows which have higher value of horizontal projection. We apply sequence of morphological operations to this particular image to connect the edge pixels and filter out the non-license plate regions. The result after this operation is shown in Figure 7 (b).

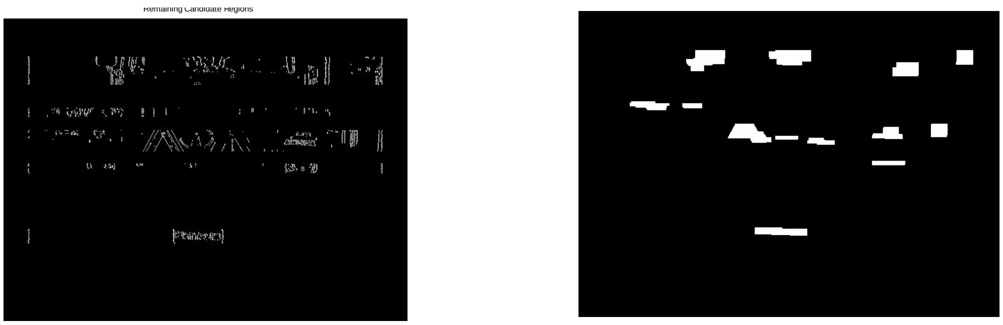


FIGURE 7: (a) Remaining Regions after Thresholding (b) After Sequence of Morphological Deal

In subsequent step, the algorithm of connected component analysis is used to locate the coordinates of the 8-connected components. The minimum rectangle, which encloses the connected components, stands as a candidate for vehicle license plate. The result of connected component analysis is shown in Figure 8.

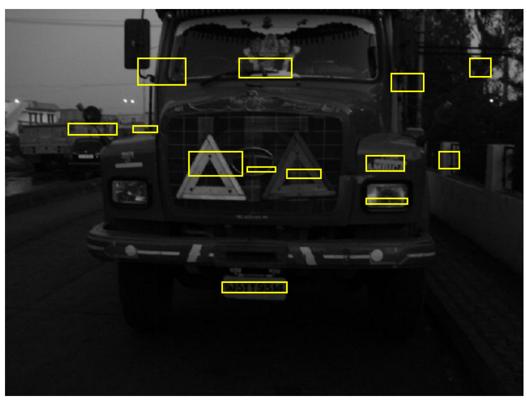


FIGURE 8: Connected Component Analysis

3.4 Filtration of non License Plate Region

Once the probable candidates using connected component analysis obtained, features of each component are examined in order to correctly filter out the non-license plate components. Various features such as the size, width, height, orientation of the characters, edge intensity, etc can be helpful in filtering of non-license plate regions. In this algorithm, rectangularity, aspect ratio analysis and plate companionable filter are defined in order to decide if a component is a license plate or not. Even though these features are not scale-invariant, luminance-invariant, rotation-invariant, but they are insensitive to changes like contrast blurriness and noise.

3.4.1 Rectangularity and Aspect Ratio Analysis

The license plate takes a rectangular shape with a predetermined height to width ratio in each kind of vehicles. Under limited distortion, however, license plates in vehicle images can still be viewed approximately as rectangle shape with a certain aspect ratio. This is the most important shape feature of license plates. The aspect ratio is defined as the ratio of the height to the width of the region's rectangle. From experimentations, (1) components have height less than 7 pixels and width less than 60 pixels, (2) components have height greater than 60 or width greater than 260 pixels (3) components for which difference between the width and height is less than 30 and (4) components having height to width ratio less than 0.2 and greater than 0.7 are discarded from the eligible license plate regions. In transportation vehicle and vehicles consisting of two row license plate aspect ratio varies nearer to 0.6. In aspect ratio analysis third parameter is very crucial as it helps to discard the component which satisfying first two conditions.

3.4.2 Plate Companionable Filter

Some components may be misrecognized as candidates even after aspect ratio analysis as it satisfies all above mentioned conditions. To avoid this simple concept is employed, which is known as plate companionable filtering. According to the license plates characteristics, plate characters possess a definite size and shape and are arranged in a sequence. The variations between plate background and characters, such as the ones shown in Figure 9, are used to make the distinction. If the count value at the prescribed scanning positions which are H/3, H/2 and (H-H/3) correspondingly, where H is the height of the component, is more than desired threshold then it is considered as a license plate else it is discarded from the promising region of interest. A desirable threshold is around 30 in average from experimentation. Table 1 show some examples based on this concept. Because of this feature program is more robust for the multiple license plate detection. Our proposed algorithm will simultaneously search out the multiple license plates without filtering out the non-license plate regions. Figure 10 shows the final extracted license plate from an input image.

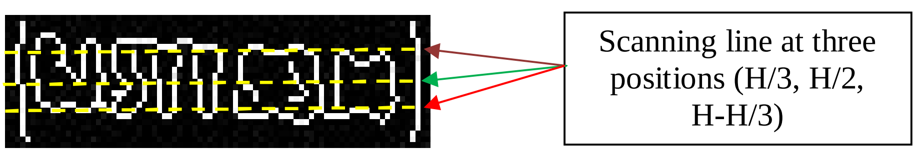


Figure 9: Concept of Plate Companionable Filter

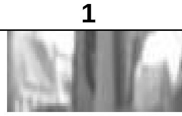
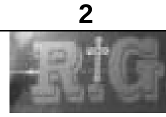
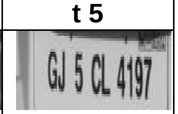
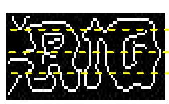
Parameters	**Component 1**	**Component 2**	**Component 3**	**Component 4**	**Component 5**
Candidates					
Vertical Edges with scanning line					
Count at (H/3,H/2, H-H/3)	12,18,10	15,14,20	12,11,16	44,46,42	39,42,45
comments	Non LP component	Non LP component	Non LP component	Accepted as LP	Accepted as LP

TABLE 1: Analysis of Plate Companionable Filter.

Figure 10: Final Extracted License Plate

4. EXPERIMENTATION RESULTS

We have divided the vehicles in the following categories: Images consists of (1) single vehicle (2) more than one vehicle. Both the above two categories are further subdivided in day and night conditions; soiled license plate; plates consist of shadows and blurry condition.

As the first step toward this goal, a large image data set of license plates has been collected and grouped according to several criteria such as type and color of plates, illumination conditions, various angles of vision, and indoor or outdoor images. The proposed algorithm is tested on a large database consisting of 1000 vehicle images of Indian condition as well as database received from [24].

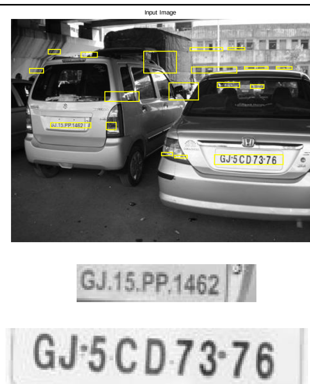
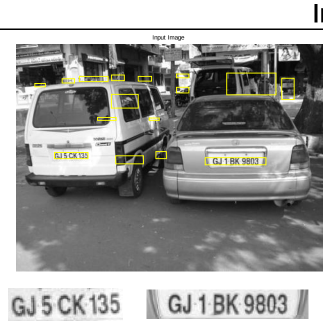
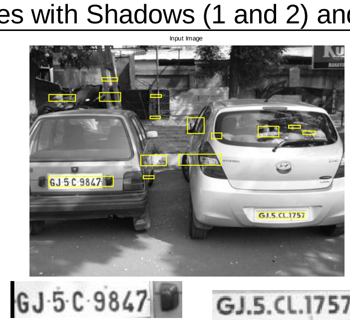
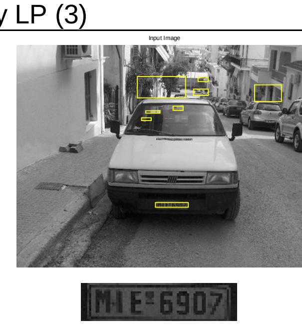
<table>
<tr><td colspan="3">Images consisting of License Plate with different AR</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Images consisting of multiple License Plates</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Images with Shadows (1 and 2) and Dirty LP (3)</td></tr>
<tr><td>
(1)</td><td>
(2)</td><td>
(3)</td></tr>
<tr><td colspan="3">Images in Night Condition with different AR</td></tr>
</table>

Figure 11: Experimentation Results in Different Conditions

The proposed algorithm is able to detect the license plate successfully with 99.1% accuracy from various conditions. Table 2 and Table 3 show the comparison of proposed algorithm with some existing algorithms. The proposed method is implemented on a personal computer with an Intel Pentium Dual-Core processor-1.73GHz CPU/1 GB DDR2 RAM using Matlab v.7.6.

Image set	Proposed Method	Method proposed in [7]
Day	250/250	242/250
Night	148/150	140/150
Success rate	99.5%	95.5%

TABLE 2: Comparison of proposed method for single LP detection in different conditions

Image set	Proposed Method	Method proposed in [25]
Day	198/200	190/200
Night	148/150	130/150
Success rate	98.9%	91.4%

TABLE 3: Comparison of proposed method for multiple LP detection in different conditions

5. CONCLUSION & FUTURE WORK

The proposed algorithm uses edge analysis and morphological operations, which easily highlights the number of probable candidate regions in an image. However, with the help of connected component analysis and then using different filtering conditions along with plate companionable filter, exact location of license plate is easily determined. As contrast enhancement is employed using sigmoid function, the algorithm is able to extract the license plates from the images taken in dark conditions as well as images with complex background like shadows on plate region, dirty plates, night vision with flash. The advantage of the proposed algorithm is that it is able to extract the multiple license plates contained in the image without any human interface. Our proposed algorithm is also able to detect plate if the vehicle is too far or too near from camera position as well as if contrast between plate and background is not clear enough. Moreover the algorithm works for all types of license plates having either white or black back-ground with black or white characters. The proposed work can be extended to identify plates from video sequence in which removal of motion blur is an important issue associated with fast moving vehicles.

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