AN EXPANDED-HAAR WAVELET TRANSFORM AND MORPHOLOGICAL DEAL BASED APPROACH FOR VEHICLE LICENSE PLATE LOCALIZATION IN INDIAN CONDITIONS

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Abstract

Automatic License Plate Recognition System (ALPR) is an important and challenging area of research because of its wide range of applications. In any ALPR system the first and the most important stage is the accurate localization of the License Plate. This paper presents a Mathematical Morphology based approach for detecting license plate present in the captured video frame. To start the method makes use of Expanded-Haar Wavelet Transform to detect the minute edges in the captured frame. After this a series of morphological operations are applied on the processed image to highlight the regions that can serve as candidate containing the license plate. Once the correct candidate region is selected edge profile and stack analysis is used to detect the exact license plate. The method is tested on a database comprising of 580 images captured considering diverse angles and different lightening conditions from India and abroad.

Keywords: *Automatic License Plate Recognition System, Discrete Wavelet Transform, Expanded-Haar Wavelet Transform, Horizontal Projection, Mathematical Morphology, Stack Analysis, and Vertical Projection.*

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1. INTRODUCTION

In the current information technology era, the use of automations and intelligent systems is becoming more and more widespread. The Intelligent Transport System (ITS) technology has attracted so much attention that many systems are being developed and applied all over the world [1]. Automatic License Plate Recognition system has turned out to be an important research issue. ALPR has many applications in traffic monitoring system, including controlling the traffic volume, ticketing vehicles without the human control, vehicle tracking, policing, security, and so on [2]-[3]. License plate recognition (LPR) is an image-processing technology used to identify vehicles by their license plates. This technology is gaining popularity in security and traffic installations. Much research has already been done for the recognition of Korean, Chinese, European, American and other license plates, however very less work has been done for Indian license plates. The area is challenging because it requires an integration of many computer vision problem solvers, which include Object Detection and Character Recognition. The most vital and the most difficult part of any VNPR system is the detection and extraction of the vehicle number plate, which directly affects the system's overall accuracy. The presence of noise, blurring in the image, uneven illumination, dim light and foggy conditions make the task even more difficult. In this paper we propose a novel method for accurate localization of exact license plate based on Expanded-Haar Wavelet Transform and Mathematical Morphology.

2. LITERATURE SURVEY

A number of techniques have been proposed in literature for automatic localization and recognition of license plates. Reference [4] describes a method for locating license plate in complex background based on 2nd level 2-D Haar Wavelet Transform and Edge Density Verification. The method is able to detect the vertical edges in the license plate region even with complex background. The work proposed in [5] makes use of Run-Length smearing algorithm to connect the vertical edges in the license plate region. After this connected component analysis and component filtering is applied to extract the exact license plate. In reference [6] the authors have presented a Morphology based approach for localization of license plate. To start the method uses Sobel's operator to detect the vertical edges in the image followed by histogram analysis to detect the candidate regions. Candidate regions are further verified by compact factor for further processing. Compact factor is used to search the regions having dense vertical edges at regularly spaced intervals, which is one of the characteristic feature of a license plate region.

3. METHODOLOGY

Generally speaking, vehicle license plate recognition system consists of three chief modules: vehicle image acquisition, vehicle license plate localization and segmentation, and character recognition as shown in Fig-1. Since the license plate region comprises of regularly spaced characters oriented vertically, the first task is to highlight the regions in the vehicle image containing vertical edges. To do this we make use of 2-dimensional Discrete Wavelet Transform (DWT) as described below.

Fig-1: General Steps in VLPR Systems

3.1 Wavelet Transform

Wavelets provide a convenient way to obtain a multi-resolution representation, which provides directional information in Horizontal, Vertical and Diagonal directions respectively [7]. The 2-D discrete wavelet transform is computed by applying a separable filter bank to the image as follows:

$$L_n(b_i,b_j)=[H_x*[H_y*L_{n-1}]_{\downarrow 2,1}]_{\downarrow 1,2}(b_i,b_j) \quad (3)$$

$$D_{n1}(b_i,b_j)=[H_x*[G_y*L_{n-1}]_{\downarrow 2,1}]_{\downarrow 1,2}(b_i,b_j) \quad (4)$$

$$D_{n2}(b_i,b_j)=[G_x*[H_y*L_{n-1}]_{\downarrow 2,1}]_{\downarrow 1,2}(b_i,b_j) \quad (5)$$

$$D_{n3}(b_i,b_j)=[G_x*[G_y*L_{n-1}]_{\downarrow 2,1}]_{\downarrow 1,2}(b_i,b_j) \quad (6)$$

Where, * denotes convolution operator, $\downarrow 2,1$ $(\downarrow 1,2)$ denotes sub-sampling along the rows (columns), and $L_0 = I(\vec{x})$ is the original image. H and G represent low pass and band pass filters respectively. L_n is obtained by low-pass filtering and is therefore referred to as low resolution image at scale n. The detail images D_{ni} are obtained by band-pass filtering in specific direction. Hence these images contain directional detail information at a given scale n. Thus the original image I can be represented by a set of sub-images at several scales: $\{L_d, D_{ni}\}_{i=1,2,3/n=1....d}$ which is a multi-scale representation of image I at a depth d. We have considered Haar Wavelet in this approach. However Haar wavelet suffers from a limitation. The reason is that the Haar Wavelet Transform performs an average and difference on a pair of values and then calculates another average and difference on next pair. Because of this if a big change takes place from an even index values to an odd index value the conventional Haar Wavelet Transform is unable to detect the corresponding change [8]. For an example consider a one-dimensional signal that has 20 elements as shown in Fig-2(a). Application of conventional Haar wavelet transform is unable to detect the large change that occurs between the elements 14 and 15. However the drop between index locations 7 and 8 is detected as shown in Fig-2(b). The above problem can be corrected by extending the lengths of filter coefficients to three instead of two as in case of conventional Haar Wavelet Transform. Now the coefficients of high pass filter become [0.5 0 -0.5]. Using these coefficients helps in detecting the large changes in the signal as shown in Fig-2(c).

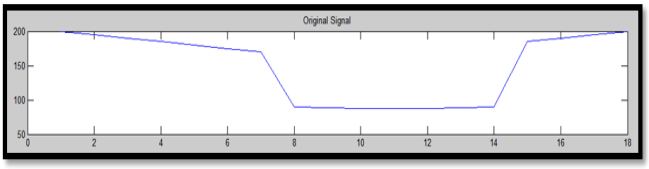


Fig-2(a): Original Signal

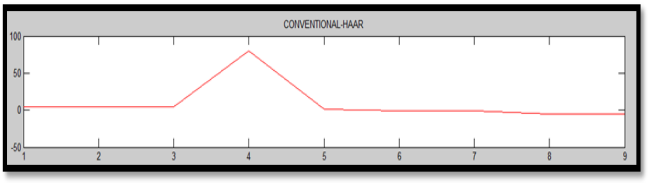


Fig-2(b): Result of applying Conventional Haar Wavelet Transform

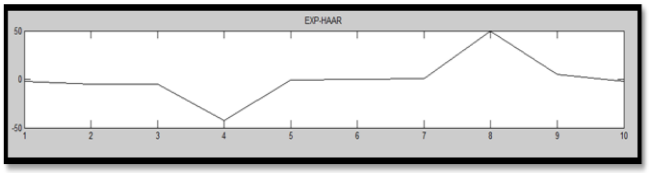


Fig-2(c): Result of applying Expanded-Haar Wavelet Transform

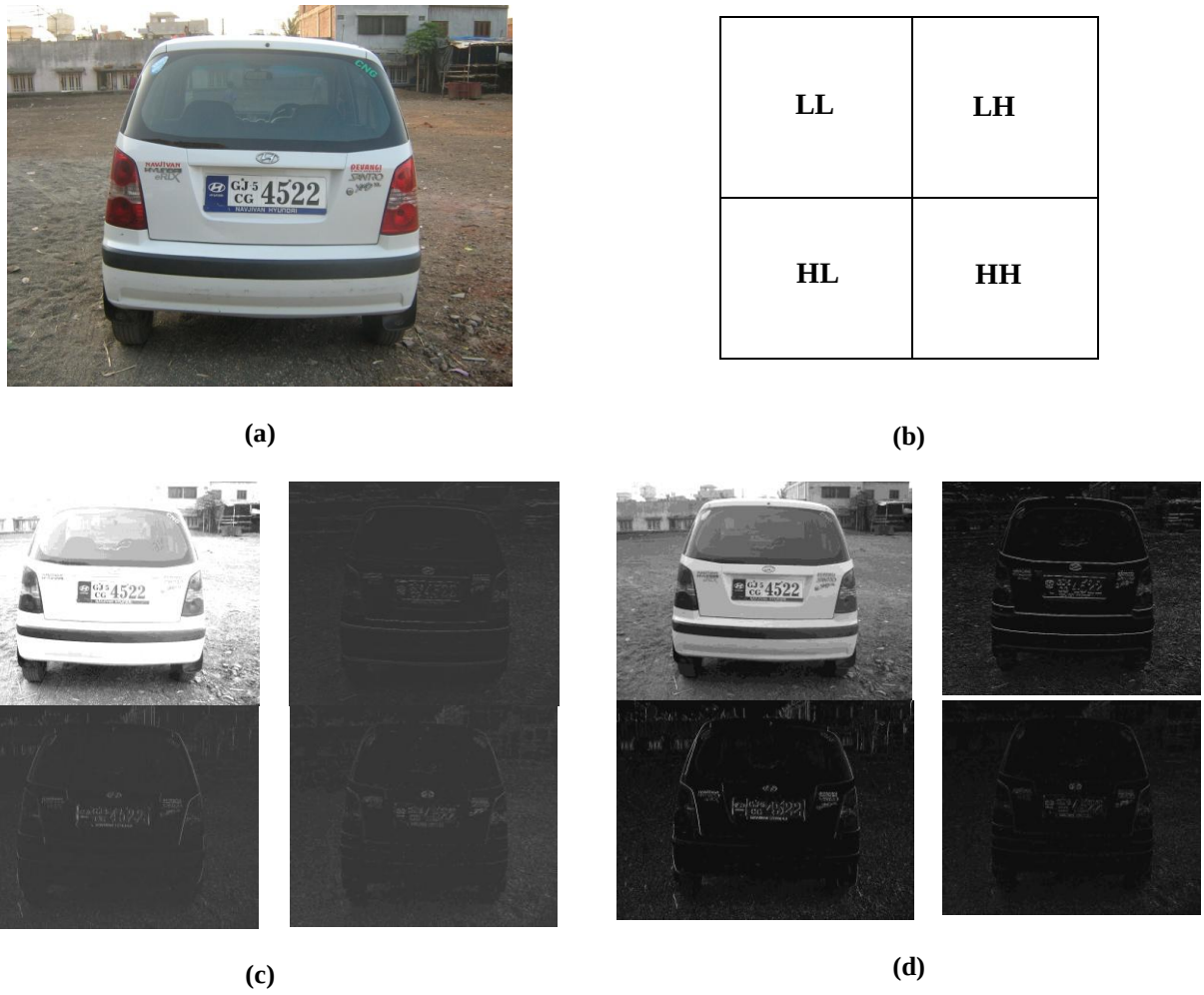


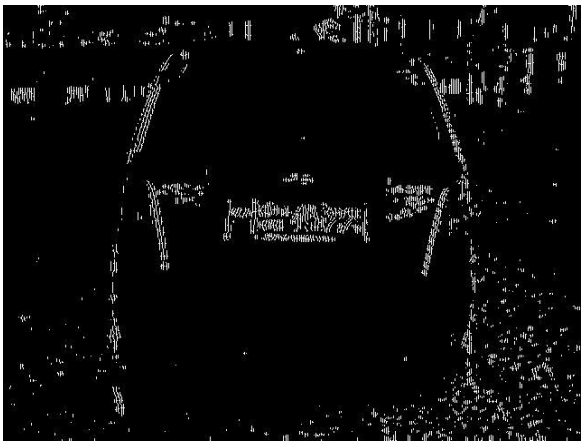
Fig-3: (a) Input Image (b) Sub-band Configuration in 2-Dimensional Wavelet Decomposition (c) Sub-bands after applying original Haar Wavelet Transform (d) Sub-bands after applying Expanded-Haar Wavelet Transform.

3.2 Rough Detection of License Plate

3.2.1 Mathematical Morphology

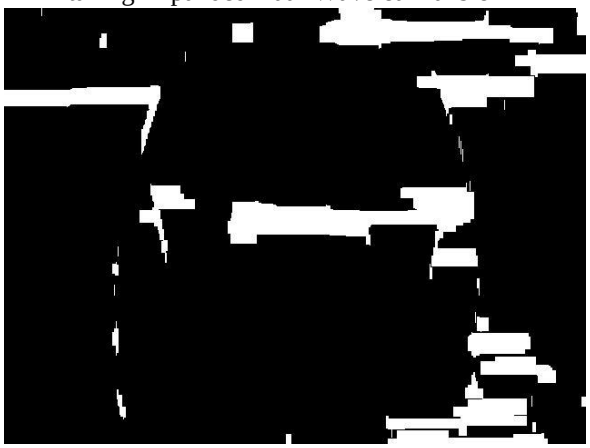
Mathematical morphology [9] is a non-linear filter, with the function of restraining noises, to extract features and segment images. Mathematical morphology's basic arithmetic's are erosion and dilation. The mask used for neighbourhood operation is called structuring element (SE). Some of basic morphological operations are erosion and dilation. These operations are performed by convolving the SE with binary image. Erosion is used to remove irrelevant details from binary image and dilation is used to fill gaps or holes. Erosion and Dilation operations are usually combined to get two important operations viz. (a) Opening and (b) Closing.

Opening is combination of erosion followed by dilation using same SE and is used eliminate objects of size less than the size and shape of specified structuring element. Similarly Closing combine's dilation followed by erosion with same structuring element and is used to fill gaps or holes. We use a series of morphological operations in order to highlight the regions that may contain the license plate. While doing so we take into account the following factors about license plates: 1) Maximum Width 2) Minimum Width 3) Maximum Height 4) Minimum. As a structuring element we have used vertical and horizontal lines oriented at 90^0 and 0^0 respectively. The length of SE was governed by the four above mentioned parameters. These are illustrated in Fig-4(a)-4(d).

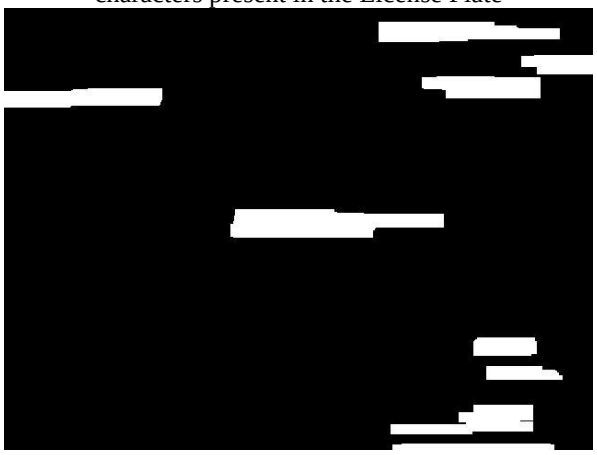


(a) Edges present in the HL Sub-band Obtained after taking Expanded Haar Wavelet Transform

(b) Closing Operation with Horizontal SE to connect the characters present in the License Plate



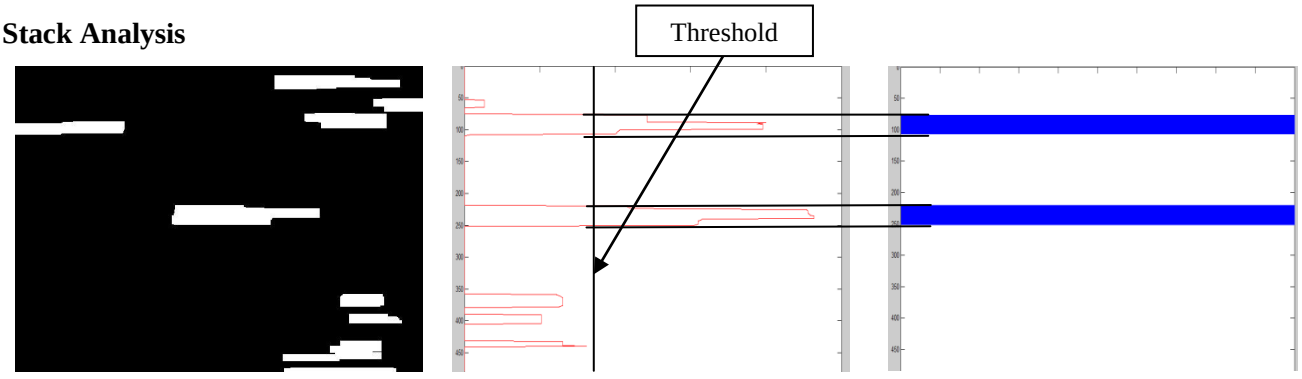
(c) Opening operation with vertical structuring element to eliminate the regions having height less than the expected height of license plate



(d) Remaining regions after removing the regions with height and length greater than the expected height and length of the license plate region.

Fig-4: Series of Morphological Operations to highlight the candidate regions

3.2.2 Stack Analysis



Processed Image

Horizontal Projection

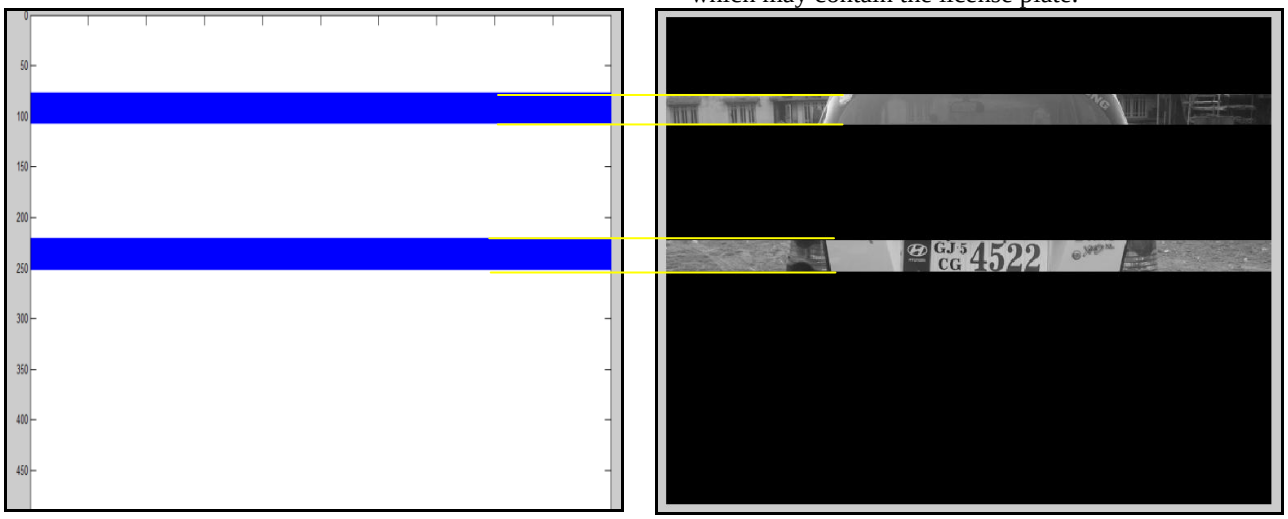
Rows with Projection value greater than Specified Threshold

Fig-5: Stack Analysis

To obtain the probable rows which can contain the license plate we project the details present in the processed image horizontally. This is done because the license plate is assumed to be located horizontally and after Morphological deal the remaining regions present in the processed image are the ones which contain edge information similar to that of a license plate. To eliminate rows with less edge information the corresponding rows with horizontal projection value less than the specified threshold are assigned a stack mark of 0. This is depicted in Fig-5.

3.2.3 Probable Candidate Regions

Once we obtain the stack mark, the next step is to retrieve the corresponding rows from the original image as shown in Fig-6. These regions from the main image will serve as candidates which may contain the license plate.



Probable Rows from Stack Mark

Probable Rows from Main Image

Candidate Region no. 1

Candidate Region no. 2

Fig-6: Probable Candidate Regions

3.3 Exact Detection of License Plate

3.3.1 Edge Detection

Once the probable candidate region is selected the next step is to locate the left and right boundaries of the exact license plate. To obtain this we once again explore the edge information contained in the LP candidate. Sobel's operator [9] is considered for detecting the vertical edges present in the candidate region as shown in Fig-7. After this we compute vertical projection profile based on the edge information.

3.3.2 Vertical Projection and Stack Analysis

Vertical projection simply shows the edge pixels column wise for every row as shown in Fig. 8 below. Once again we compute a stack mark column wise based on a prescribed threshold. Using stack mark we determine the left and right boundaries of exact license plate region. To do this we consider the region having longest continuous value of stack equal to 1.

4 EXPERIMENTAL RESULTS

The proposed system has been implemented on Matlab 7.8.0 (R2009a) on a PC with Intel Dual-Core 3rd Generation Processor having 4 GB of RAM capacity. The Database used for evaluating the performance of our algorithm consists of 580 images taken in different illumination conditions. This database contains Vehicle images from India and Foreign Countries. Fig-9 shows some of the images from our database and the extracted license plates.

Fig-7: Vertical Edges in the LP-Candidate

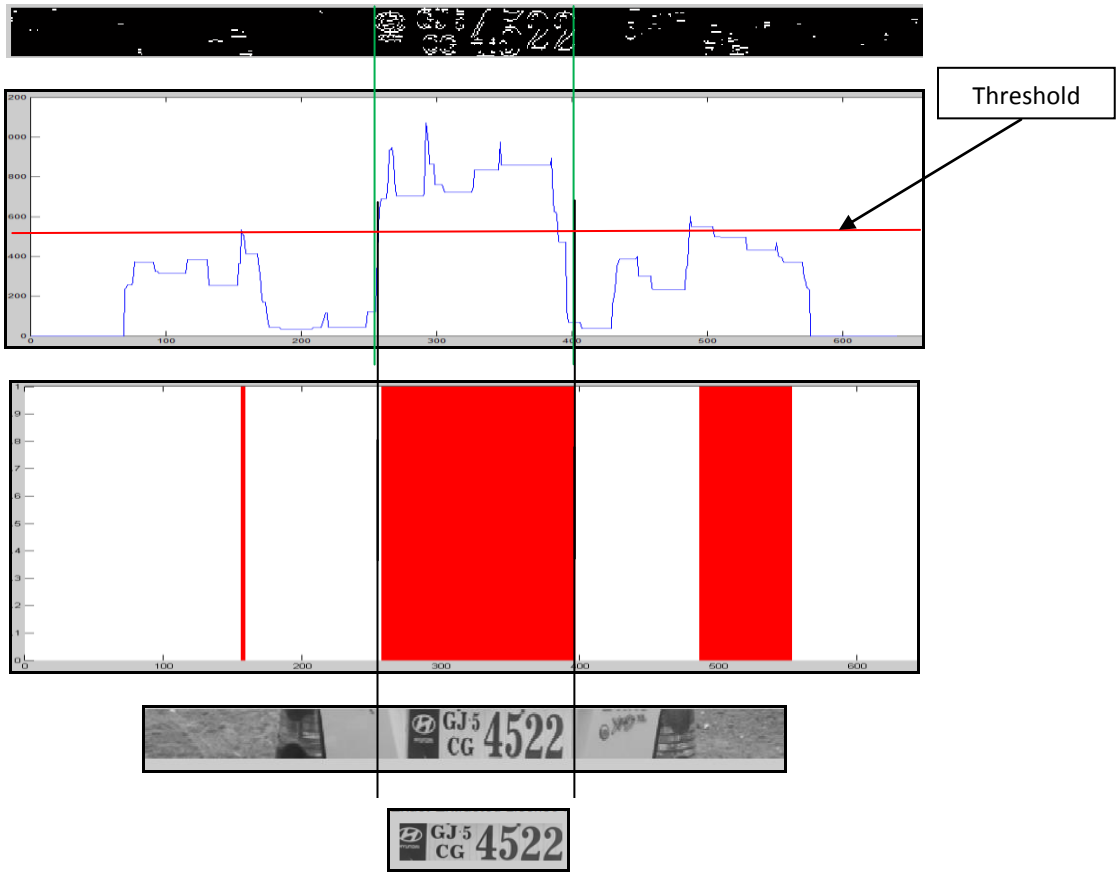


Fig-8: Steps used in detecting the left and right boundaries of the exact license plate

4.1 Simulation Results

Fig-9: Few Images from our Database and Extracted License Plates

5. CONCLUSIONS

In this work we have developed an effective method for vehicle license plate localization in Indian conditions. The use of Expanded Haar Wavelet Transform helps to detect the minor edges in the license plate region and in turn effective localization of the License Plate. The proposed technique is extensively tested on a database comprising of 580 vehicle images from India and abroad. The method gives promising results irrespective of the type of license plate. To show the effectiveness of the method we have considered different types of vehicles carrying license plates of variable dimensions, shape and characters. Also since simple morphological operations have been employed the execution time in detecting the exact license plate is much lesser as compared to other techniques employing complex transforms. This is because morphological operations are applied on a binary image where only two working levels are considered. As a part of future work we look forward to integrate character recognition with proposed approach.

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