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Wavelet Transform and Morphological Processing Based License Plate Localization

Pankaj Mukhija, Priyanka

Department of Electronics and Communication Engineering, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana, India.

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Abstract:

Automatic License Plate Recognition (ALPR) system has a significant role in safety, security and other services of transportation. ALPR is becoming a crucial part of an intelligent transportation system. Any ALPR system includes plate localization as an important step. In this paper, a simple technique to localize the license plate area has been proposed using wavelet transform and morphological operations. Most of the previous works are limited to particular environment and physical conditions, however, the proposed method of license plate localization (LPL) can be used in different environmental conditions and it is also robust to the size and color of the license plate. This method provides good accuracy (96.33%) with less processing time.

Index Terms—License Plate Localization (LPL), Automatic License Plate Recognition (ALPR), Wavelet Transform (WT), Morphological operations.

I. INTRODUCTION

ALPR includes optical character recognition-based technology that is used to read vehicle License Plates (LP) character. ALPR is used in various applications such as parking, traffic law enforcement, motorway road tolling, access control, border control, journey time measurement, and many more [1]. In 1976 ALPR was invented at Police Scientific Development Branchin Britain, it was initially developed for identification of the stolen car in the UK [2]. ALPR system contains four main stages: "Image Acquisition, License Plate localization (LPL) or License Plate Detection (LPD), Character Segmentation (CS) and Character Recognition (CR)" [3]. All four stages of ALPR are important. The accuracy of one stage affects the accuracy of the overall system. LPL is an important and challenging task due to various factors like poor lightning conditions, complex background, the view angle of the vehicle, dust on the plate, etc. [4]. The gross accuracy of the ALPR process depends upon the accuracy of the LPL[5].There are various features of the image like boundary, texture, global, color, character aspect ratio, rotation angle, etc.[6][7] that can be processed to localize the LP area from an input image (captured at the first stage ALPR system).

II. LITRARTURE REVIEW

Different researchers have proposed different techniques for license plate localization depending upon the different features used. Rasheed et al. [8] proposed LPL technique using Hough Transform and Canny edge detection module. The Euclidean distance was used to group strong vertical edges and check the similarity of strong edges in x-y coordinates. Massoud et al. [9] used Morphological Operation and Sobel edge detection to find out the candidate regions, further geometric property and aspect ratio were used for verification. Najeem et al. [10] proposed an LPL for Nigerian vehicles. LPL was done by utilizing a Sobel edge detection channel, morphological operations, and analysis of bounding boxes. Verification of candidate regions was made by aspect ratio. John et al. [11] proposed a technique based on dynamic threshold and morphological operations for plate detection in varying light conditions. Dynamic thresholding was able to detect the rectangular shape of the LP region. Connected component labeling was also used to distinguish LP. Chen et al. [12] used sturdy algorithm to localize LP using Adaptive thresholding and searching. This method could work on complex and poor illumination images. The verification of candidate regions was made by the color feature of the license plate. Mahini et al. [13] used a database of 269 pictures with different conditions to propose a technique that can extract candidate regions using the edge statistics method and the incorrect regions were being removed from morphological operations. Saini et al. [14] proposed the technique of Empirical Modes Decomposition (EMD) and Multi wavelets Transformation (MWT) analysis to extract the number plate from the vehicles of various countries under various conditions like shadow, blur, dirt, etc. with good accuracy. Chen et al. [15] used a moving object detector to detect the vehicle image only to reduce pixel count further vertical edge histogram was used to find the candidate LP lines, thereafter, these lines were merged depending upon the height of characters. Wang et al. [16] used a technique for LPL using the magnitude of the gradient in a vertical direction. Further, verification was made with geometric features like width, size, and orientation. Kamatet al. [17]used modified Sobel edge detection to detect edges and to detect lines Hough Transform (HT) were used. The license plate area was established by a set of lines that meets a criterion. A window of interest was used to find peaks curbed Hough space. Faradji et al. [18] used a Sobel filter to take out vertical edges from an input image. The analysis of histogram was used to find candidate regions of the LP. These candidate regions were further confirmed by using compact factor. Lastly, morphological operations were used. Duan et al. [19] used "boundary line-based HT and Contour algorithm" for LPL. By applying Hough transform to the contour of the LP region the speed and accuracy were optimized. Table 1 summarizes the work done by the above-said authors in terms of techniques used and their limitations.

Table 1: Summary of Literature Review

Author and Reference	**Technique used**	**Limitation**
Rasheed et al. [8]	Canny edge detection and Hough Transform.	Cannot detect LP in the shadow image as strong edges are only grouped.
Massoud et al. [9]	Sobel Filter and Morphological Operation.	Not robust to the size of LP as fix criterion is used for verification.
Najeem et al. [10]	Sobel Edge detection and Morphological operations	Sobel edge detection is sensitive to noise and threshold.
John et al. [11]	Dynamic Thresholding& Morphological Operations	Dynamic Thresholding require more computational Time.
Chen et al. [12]	Adaptive Thresholding and searching.	Verification of LP is based on fixed color analysis. Not robust to color of LP.
Mahini et al. [13]	Edge statistics method and Morphological Operations	Sensitive to noise, Algorithm require large Computation time.
Saini et al. [14]	Multiwavelet transforms and EMD analysis	Not robust to position, In case of skew perfect minima to identify wave crest is difficult.
Chen et al. [15]	Vertical Edge Histogram	Sensitive to noise.
Wang et al. [16]	Magnitude of gradient in vertical direction.	Sensitive to LP like structures due to merging of broken regions.

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Kamat et al. [17]	Modified Sobel filter & Hough Transform (HT)	Environmental conditions affect accuracy
Faradji et al. [18]	Edge Detection and morphological Processing.	Less accuracy due to noise and other reason.
Duan et al. [19]	Contour algorithm and Hough transform	The algorithm requires large Processing Time.

III. PROPOSED METHODOLOGY

Practically most of the work proposed by different researchers have their limitations as shown in table 1, i.e., illumination/light condition, the plate size, quality of image and type of LP, etc., none of the technique proposed by researchers was robust to almost all environmental and physical conditions. One of the reasons behind these limitations can be due to the application of classical edge detection techniques in LPL. The classical edge detection techniques have inherent pros and cons [20][21] as given in table 2. This inherent limitation reduces the overall accuracy of the LPL system.

Table 2: Pros & Cons of Different Edge Detection Techniques

Technique	Pros.	Cons.
Sobel	Simple in implementation	Less efficient to texture based image
Canny	Good signal to noise ratio (SNR)	Complexity in computation, false zero crossing and time consuming.
Prewitt	Simple in implementation	Sensitive to noise.

In this paper, a technique has been proposed which can localize the license plate in challenging environmental and physical conditions. In the proposed method, “wavelet transform” is applied to detect the features, as the WT is better to detect the edges even in conditions when the images are dull. In comparison to other classical edge detection techniques [22], wavelet transform gives more structural or textural information. The next stage of the proposed method is morphological operations (dilation and erosion) to detect the exact LP from the boundaries provided. The proposed method comprises of the following steps as described in the flow chart:

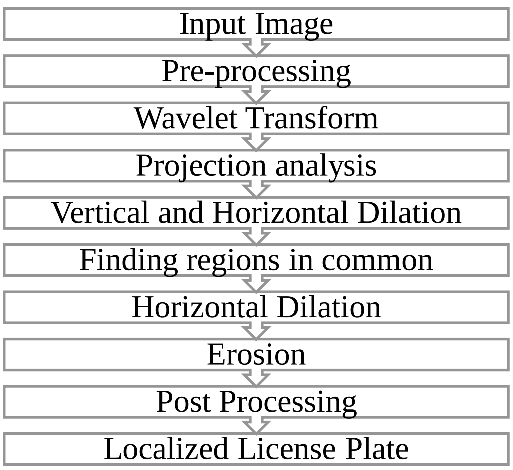

Fig. 1 Flow Chart of proposed method

The steps involved in the proposed method can be summarized as follows:

a. Input Image and pre-processing: The color or grey image of any size is first converted to a standard 256*256 image after that color image is converted into a **greyscale** image using standard RGB weights. (**Grey**=0.299R+ 0.587G + 0.114B) as the requirement is only to detect intensity changes (edges). Gaussian filtering and histogram equalization[23][24] are also applied to enhance the features of the License Plate image. Fig. 2 shows input and corresponding grey images.

b. Wavelet Transform: WT decomposes the image into various sub bands as shown in Fig 3. The name of these sub-bands are "Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH)" [25][26]. The LL sub-band shows the low pass filtered output of Input image or approximation sub-image, LH sub-band may extract horizontal feature of the input image, HL sub-band may extract the vertical features of the input image and HH sub-band extracts a diagonal feature of the input image. Most of the edges in the LP are in a vertical direction, therefore it is preferable to process the HL sub-band further. In this paper, a Haar wavelet is applied to decompose the image into four sub-bands.

c. Projection Analysis: HL sub-band (vertical details) is projected to find the approximate vertical regions [27](vertical sharp edges) shown in Fig. 4. Vertical projection is a 2D graph; the Y-axis of this graph is rows of HL band, and the X-axis is the sum of pixel intensity value in each row. The rows corresponding to the peak values in the vertical projection are considered as the candidate rows for the license plate region.

d. Vertical and horizontal dilation: Vertical and horizontal dilation of the image is performed to grow the region of interest as shown in Fig. 5. In the process of dilation, "the pixels are added to the boundaries of objects in an image". The structural element of dilation is considered according to the geometry of the license plate.

f. Finding Region in Common: Vertical dilation and horizontal dilation have produced out two images with different areas. These two images are anded to find a common area as shown in Fig. 6a.

g. Horizontal Dilation and Erosion: The grown-up Candidate regions are further dilated horizontally so that further improved areas may be grown up. The image is eroded to reject the unwanted regions. By applying the erosion operation, the extra regions which did not belong to the plate were excluded[28].

h. Post Processing and localizing LP: The biggest rectangle is considered as LP (as shown in Fig. 7) and other rectangles are rejected.

IV. EXPERIMENTAL ANALYSIS

The technique proposed in this paper was implemented on a personal computer with an Intel I3 processor, 64 bit, 4GB RAM using MATLAB. The data set used in the experiment is of images available open-source database and images captured using an Android device. Most of the images tested are license plates as a frontal view. Most of the images used are JPEG color images. A total of 300 images of different sizes are used for testing. These images belong to different environmental conditions. Out of these 300 images, 289 images of different conditions show the accurate license plate region, an approximate rate of success is 96.33%. Most of the images failed were due to the background texture of the vehicle. The processing time of the proposed algorithm is less which makes it realizable in real-time. The criterion used in the verification of candidate regions makes it robust to the size of the LP.

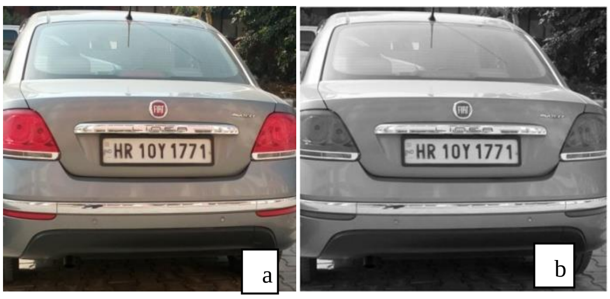

Fig 2. a) Input color image captured by camera. b) RGB to Grey conversion of Input Image.

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Fig.3Wavelet transforms performed on the greyscale image, representing LL, LH, HL, and HH sub-bands.

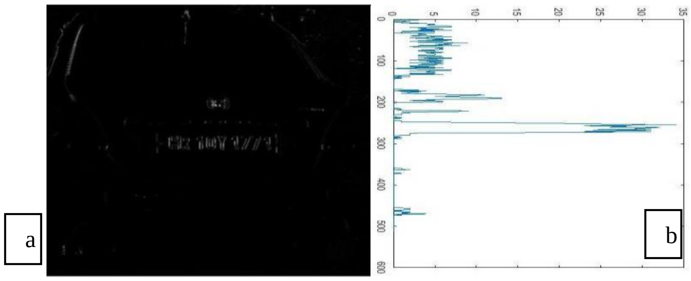

Fig.4 a) The HL sub-band, i.e. the vertical details of the Grey image. b) The vertical projection of the HL Sub-band, vertical pixel details are represented on Y-axis, the sum of pixel intensity on X-axis.

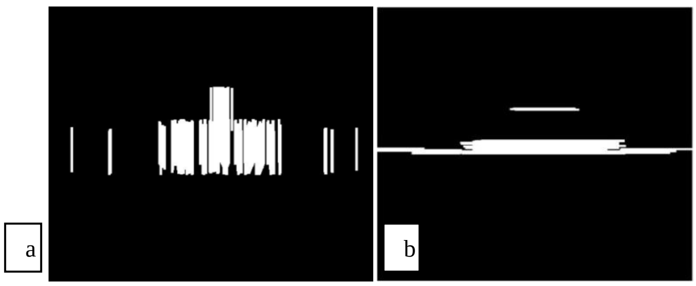

Fig.5 a) The vertical dilation, b) The horizontal dilation

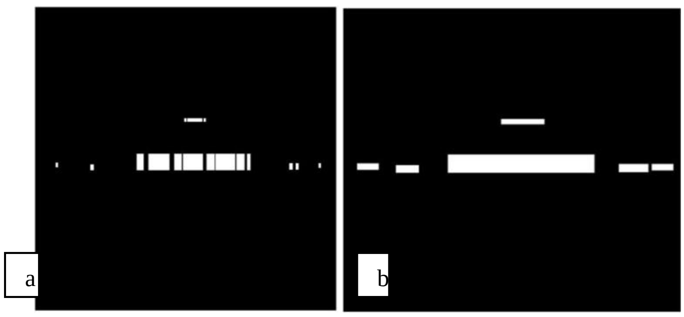

Fig. 6 a) The AND operation on Horizontal and Vertical Dilated images. b) Filled region in image.

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Fig 7 a) Unwanted regions are eroded by Morphological operation, final LP region is retained. b) Final Plate region

V. RESULT COMPARISION

Proposed Algorithm was tested on 300 images of different conditions. Out of which 289 images show an accurate License plate. Most of the techniques available in Literature have their limitations as shown in Table 1. The proposed technique is robust to environmental conditions, robust in size and color of LP and provides good results in dull images also. Comparison of results with existing techniques is given in table 3.

Table 3 Comparison of Results

Author and Ref. No.	**Accuracy in Percent**
Rasheed et al. [8]	94.11
Massoud et al. [9]	91
Najeem et al. [10]	85
Saini et al. [14]	94.4
Kamat et al. [17]	83.50
Proposed Method	96.33

VI. CONCLUSION AND FUTURE SCOPE

In this paper, an effective and simple method for license plate localization based on wavelet transform and Morphological operations are proposed. The wavelet transform can be used more efficiently for edge detection in challenging environment images, rather than classical edge detection methods, which make the proposed technique robust to different environmental conditions. The morphological operation grows the region of interest and rejects other portions which make the technique robust to the size and color of the LP. The proposed algorithm gives good accuracy in less time. The most of the images used in the experiment are of frontal view (horizontal and vertical angle less than 10 degrees). In future work, the same technique may be applied with some modification on to the vehicle images with a high degree of horizontal and vertical angle. The other kind of wavelet like Daubechies wavelet may also be tried.

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