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An overview of Various Techniques for Automatic License Plate Localization

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Abstract: Automatic License Plate Recognition (ALPR) is a system that helps in extracting the information of the vehicle's license plate. It plays an important role in real life applications like traffic monitoring, toll payment, recovery of stolen cars, law enforcement etc. ALPR comprises of four stages- Image Acquisition, License Plate Localization (LPL), License Plate Segmentation, and Character Recognition. For a proper recognition, localization must be accurately processed. So, LPL is the main stage in ALPR system as the overall performance of ALPR system is largely dependent on the localization of license plate. The license plates can be hampered by lighting, dirt and scratches which are to be overcome for an accurate localization of the license plate. Several LPL techniques have been developed in the past decades. This paper presents an overview of various LPL techniques used in ALPR system based on different features and methods with their comparison result.
Keywords: Digital Image Processing, Automatic license plate recognition system, license plate localization, localization techniques, vehicle identification.

I. INTRODUCTION

Today, the world is attaining rapid growth in various fields of technology. One of the fields is image processing that helps in recognizing or identifying the image in a better view by enhancing the image features. Automatic License Plate Recognition (ALPR) is one of the applications of image processing that is helpful in reading license plate number from a vehicular image. As it is not feasible to inspect daily a large number of vehicles manually, so an ALPR system is a way to detect the vehicles automatically and in a very less time. All the license plates have their unique numbers that are also called as registration number which are helpful in identifying any vehicle. So, an ALPR system can be used for the identification of vehicles in various applications like security, traffic law enforcement, toll collection, road traffic monitoring, keeping time record in entry or exit of vehicles, fight crime and fraudulence and many more. ALPR system includes four stages [1] that are shown in fig 1.

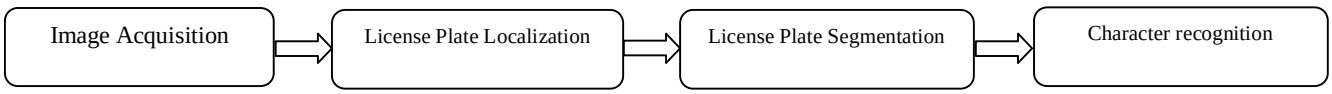

Fig 1: Stages of ALPR system

In the first stage, the vehicular image is acquired from any digital camera and that image is further processed for recognition. This stage is named as Image acquisition stage. In the second stage, the vehicle's license plate is localized or extracted from the image which is the main and difficult stage in ALPR system. This stage is named as license plate localization (LPL). In the third stage, the localized plate image is segmented by which only useful information is retained. This is processed to analyze the image easily from the objects and boundaries of an image. This stage is called license plate segmentation. In the forth and the last stage, the characters or registration number written on the license plate are identified. This stage is called as Character recognition. Among all these stages, LPL is the main stage that can give an accurate and desirable output in ALPR system if it is processed using efficient technique.

A. License Plate Localization

License plate localization (LPL) is the first processing stage after image acquisition and also the basis of last stage that is character recognition. LPL is the core stage in ALPR system as the performance of the whole system largely depends on the localization of the license plate. As the license plates of different vehicles are having different colors, sizes etc. so LPL is a challenging part in ALPR system. This is not challenging only due to different types of plate but also due to different environment conditions[1] like illumination, complex background etc. LPL has three basic steps as shown in fig 2.

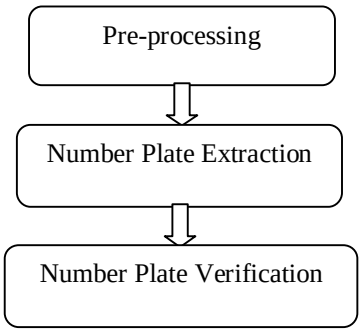

Fig 2: Steps involved in LPL

The first step in LPL is pre-processing which is done to improve the quality of the image by suppressing noise and enhancing some features that are required in further processing. The image may be pre-processed by converting colored image to grey scale image[2]-[19][22][26][28][32] noise reduction by using median filter [7][10][11][13][19][22], Gaussian filter [2][9][10][12][18][20], Laplacian sharping filter[9] and fuzzified Gabor filter [21], Contrast enhancement [10][11][13] to improve the image for better processing, Otsu's thresholding [3][11][28] is used for the binarization of image, Dynamic thresholding [12] to identify the regions where intensity is changing.

The second step in LPL is to extract the number plate. After pre-processing the acquired image, the extraction of number plates can be done by edge detection using Sobel operator [2][5][22][26], canny operator [28], connected component analysis [4][12][28], Cascade AdaBoost classifier [7][15][30], Mathematical Morphological operations [12][28][29], Wavelet transform [18][20][22], template matching [27], Discrete Fourier Transform [28], etc.

The third and the last step in LPL is number plate verification in which a true candidate region is detected from all the extracted candidate regions. HOG classifier has been used in [6], Heuristic judgment and voting-based methods [7] are used for the verification of candidate plates.

B. Various Features and Methods Used for LPL

There are different varieties of license plates all over the world such as rectangular shaped plates with different sizes (aspect ratio), colored plates, white background with black text, yellow background with black text etc. There are some features of license plates like aspect ratio, rotation angle, distance, colors etc. that can be helpful in extracting different types of license plates efficiently. So, taking these features into consideration while processing, license plates can be localized easily and accurately. Some features and methods for localizing the license plates are described in Table 1 and Table 2 respectively.

Features	Description/Rationale
Color	Specific color on number plate.
Texture	Change in intensity of license plate.
Edge / Boundary	Rectangular shape of license plate.
Stroke size	Character size on number plate.
Aspect ratio	Width to height ratio of the number plate.
Rotation angle	Angle between the camera and the license plate.
More than one feature	Combining more than one feature is influential.

Table 1: Various Features used for LPL

Methods	Description
Edge Detection	Identifies the sharp transition points.
Using filters	Removes the unwanted regions.
Wavelet Transform	Decomposes an image into basic functions called Intrinsic Mode Functions (IMF) called wavelets.
Neural Network	Used as non-parametric operators, non-linear operators & supervised feature extractors.
Hough Transform	Isolate features of a particular shape within an image.
Adaptive Boosting	Chooses the weak classifiers and combine them to form a strong and accurate classifier.
Morphological Operations	Rejects the regions other than candidate region.
Support Vector Machine (SVM)	Analyze data used for classification of images.

Table 2: Various methods used for LPL

The rest of this paper is presented as follows: The Section 2 and 3 represents a literature survey and its comparison results respectively. In the section 4, conclusion is summarized.

II. LITERATURE SURVEY

Various techniques have been developed for LPL in past years. In this section, a summary of previous proposed works on the basis of different features is demonstrated. There are many challenging problems occur due to plate variations and environmental variations in processing LPL. Methods for plate extraction using various features like boundary, color, texture, character, global image information and combining two or more features have been discussed with their pros. and cons. in [1].

In [23] and [34], Canny edge detection is recommended as better detection method that provide minimum processing time, fixed amount of time and recursion for desired edge detection.

In [24], Reji P.I and Dr. Dharun V.S provided a comparison study of LPL methods in terms of various parameters like computational power, detection rate, accuracy, execution time, speed of the whole system with their merits & demerits.

Vidhya. N and S. Guna Sundari [25], studied on different types of approaches and challenges that have to be improvised and discussed edge detection & sliding concentric window, morphology & template matching, connected component analysis, and Hough transform contour detection techniques with their accuracy as 98.4%, 92%, 93.7% and 93.1% respectively.

Further, an overview of LPL based on different features is discussed with their accuracy rate is discussed and tried to find the best method that would give better accuracy for real-time applications.

R. Azad et al. [2], proposed a detection method with different background, distance, view point, different lightning, atmospheric conditions and with low image quality. In this proposed method, edge detection and morphology operations are applied to enhance the edge features. Then, according to the geometrical range of the license plate, the non-plate areas are eliminated. Approximately 98% of the correct plate extraction has reached.

In [3], Pritesh Kanani proposed an Indian LPL using wavelet decomposition with a prior knowledge of vehicle's distance. By calculating the density of vertical pixels, probable characters are detected and confirmation is done using wavelet decomposition with an effective accuracy.

J. Chong, J. Tianhua and C. Linhao [5], proposed a median filtering with double edge based detection method. In this, Sobel operator and erosion operator has been used for edge extraction and to calculate the connected domain for plate area respectively. Finally the alternate license area has been rejected with some prior knowledge of length and width ratio.

Jingyu Dun and Sanyuan Zhang et al. [8], proposed an LPL method that is based on yellow and blue regions of the image. This method used two threshold methods that are global threshold and adaptive block threshold, applied on 2207 images in which 1314 are of daytime and left are of night time and achieved 95.01% location rate with large bounding box and fake plates.

Dingyi Li and Zengfu Wang [9] proposed a modified Maximally Stable Extremal Region (MSER-+) for the detection of multiple license plates in complex regions. MSER-+ can find both separated characters as well as separated backgrounds. Using width, height and angle as parameters, disturbances are eliminated. A hierarchical closed operation has been used to connect separated units. For coarse verification, geometrical limits are used and thresholds are selected. For fine verification, CNN is used with detection rate of more than 98.5%.

Pooya Sagharichi Ha, Mojtaba Shakeri [10], proposed an algorithm having strong robustness against noise which can deal the license plate of different colors with 16% missing rate over 70 vehicle images.

Ascar Davix X et al. [11], presented an efficient approach for LPL in which the image is pre-processed using median filter and histogram equalization then morphological operations and Sobel operator are used to detect the license plate by which a success rate of 97.14% is achieved.

Amit Kukreja et al. [13], has proposed an efficient vehicle number plate detection method on multifaceted image of Indian automobile number plate using Sobel edge detection.

Y. Yuan et al. [14], has proposed a novel method to extract the candidate regions with less area to be computed by using line density filter and the true candidate region is identified using Cascade License Plate Classifier (CLPC) based on SVM with 96.62% detection rate on 3828 images.

Abdulla et al. [15], proposed a robust method using a large number of AdaBoost cascades with three levels pre-processing local binary patterns classifiers (3L-LBPs) under low quality image. This method achieves a very high accuracy for detecting LP from one vehicle image with detection, precision and F-measure rates are 98.56%, 95.9%, and 97.19%, respectively.

Ali Al-Zawqari et al. [16], proposed an HD localization method for number plates. Firstly, the HD image resizes to SD image and then the features are extracted using morphological operations which then passed to CCA algorithm that identified white components using 4-connectivity. Through these components, aspect ratio and number of white pixels are calculated which are then compared with pre-specified aspect ratio. This image then tested in MATLAB and achieved 98% success rate with 32.48ms processing time.

Shouyuan Yu, et al. [20], proposed a less restrictive and robust method using Wavelet Transform and EMD analysis. This method can be applied on various features like colors, illumination conditions, blur images and even on the plates of different countries with an accuracy of 97.91% less running time.

Amir Hossein Ashtari, Md. Jan Nordin, and Mahmood Fathy [27], proposed a modified template matching method which searches the location of license plates of Iranian and Europian countries by using periodic strip that finds the hue of every pixel. This method is rotation and scale invariant that saves computational time as it does not require any transformations like resizing, Fourier, Wavelet and Hough transform and achieved a detection rate of 96%.

Yong Tang et al. [30], presented a method in which the vehicle detection is done by using cascade classifier that are constructed by AdaBoost algorithms and Haar-like features. Multi-oriented vehicle features are extracted by using LBP operator and Gabor wavelet transform.

Qiang Fu et al. [31], proposed a method in which candidate vehicles proposals are generated using convolutional features, then RPN (Region Proposal Network) is used to detect license by correlating vehicles and licenses. Finally, detection performance has enhanced by processing license boundary using canny operator and achieved accuracy of 98.42%.

Narasimha Reddy Soora and Parag S. Deshpande [32], proposesd an LPL method using CCA for the calculation of geometrical properties. Then three techniques that are distance, line and height based clustering are used to extract the probable LPs. Using beta (border percentage) as 70%, noisy and rotated plate characters are extracted by which overall accuracy of system is achieved as 94.66%.

P. Tarabek [33], proposed a method that detects multiple license plates in a complex background using vertical edge detection. A sliding window technique has been used for marking windows that satisfied edge density condition. Edge analysis has been performed to isolate complex background from license plate. Finally, true candidate is extracted using textual and geometrical properties and localized 97.4% on the dataset of 501 images.

S. Azam and M. Islam [35], proposed a new LPL technique that used mask in frequency domain to filter out the rain streaks from rainy image and Radon transform for the tilt correction. This method can handle low contrast, blurry, rainy, night, and foggy images with 94% detection rate.

G Hsu et al. [36], has discussed LPD in challenging conditions like extreme weather conditions, complex scenes and lightning effects using the deep learning based detector i.e. YOLO (You-Only-Look-Once) and its variant YOLO-2. In [37] YOLO-2 is considered the best and fast approach as it can detect around 9000 objects with a higher mean average precision and higher frame rate than YOLO.

Z. Yao and W. Yi [38], proposed an enhanced adaboost detector by using a multistage information fusion based LPL technique. In this paper, HAAR like features extraction is modified and then multistage fusion has adopted for the reduction of false rate of adaboost LP detector.

J. Wang et al. [39], proposed a novel LPL algorithm called Secondary positioning in which the plate's rough position is identified first by searching the red color regions and the accurate plate position is localized by finding vertical edge of the plate. Approximately 75% of precision is obtained from plate localization.

L. Chandrasekar and G. Durga [40], proposed a generalized Hough Transform method that uses parameter and image space. This method helps in eliminating the random noise and is mainly used to detect the feature points that are aligned.

In [41], a research is being carried out by C. S. Davix, X. Ascar and Christopher on an Edge based Marker Controlled Watershed Algorithm (MCWA). Two parameters are used- Shape factor and aspect ratio to identify the LP area. 96.04% of accuracy has been achieved.

Hitesh Rajput, Tanmoy Som & Soumitra Kar [45], presented an effective LPL method based on three steps that are filtering, thresholding and motion analyzing which can handle vehicular images under various weather and lightning conditions.

Esmat Rashedi and Hossein Nezamabadi-pour [46], employed four methods that include local binary pattern features and cascade classifiers, color, edge and contrast based methods. This method tested on 4000 vehicular images with an extraction rate of 98.45%.

III. COMPARISON RESULT

This section provides the comparison among the previous works on LPL by showing accuracy rates with their execution time and the number of images tested. Accuracy rate differs according to different LPL technique. Table 3 shows a comparison of this review.

Author(s)	Techniques and features Used	Tested images	Detection rate with execution time
X. Yang, et al. [42], 2012	Edge detection	600 images (600 × 330)from 104 countries and 784 images (768 × 576) from China	94.7%, 57ms
Peter Tarabek [33], 2012	Edge detection and sliding window technique	501	97.4%
Reza Azadet al.[2], 2013	Edge detection, Adaptive threshold, morphology operation , KNN classifier	-	98%
Amir Hossein Ashtari et al.[27], 2014	Color based feature, Modified template matching,	-	96%
J.Dun and S. Zhang et al. [8], 2015	Color based feature, Global and adaptive block thresholding, bounding box,	2207 images- 1314 daytime and 893 night time images.	95.01%
Chao Gou et al. [29], 2015	Edge detector, top-hat transformation and morphological operations	-	95.9%
Yong Tang et al. [30], 2015	LBP operator and Gabor wavelet transform.	800	97.3%
Shouyuan Yu et al. [20], 2015	Wavelet Transform and EMD analysis	765	97.91%
Pooya Sagharichi Ha and Mojtaba Shakeri[10], 2016	Edge detection, template matching	70	84.28%
S. Azam and M. Islam [35], 2016	Frequency domain mask, contrast enhancement, binarization and Radon transform	850	94%
Narasimha Reddy Soora and Parag S.	Connected Component Analysis (CCA)	-	94.66%

Deshpande [32], 2016			
Ascar Davix X et al.[11], 2016	Edge detection, Median filter and adaptive histogram equalization	-	97.14%
Dingyi Li and Zengfu Wang [9], 2016	Character feature extraction, Modified Maximally Stable Extremal Region(MSER-+)	-	98.5%
J. Wang et al. [39], 2017	Edge detection , Secondary Positioning	-	Approx. 75%
C. S. Davix, X. Ascar and Christopher [41], 2017	Edge based Marker Controlled Watershed Algorithm (MCWA)	-	96.04%
Y,Yuan et al.[14], 2017	Line density filter, CLPC based on SVM	-	96.62%, 42ms
Qiang Fu et al. [31], 2017	RPN (Region Proposal Network)	-	98.42%
Esmat Rashedi and Hossein Nezamabadi-pour [46], 2017	Cascade classifiers	4000	98.45%
M.S Al-Shemarry [15], 2017	AdaBoost Cascades with 3L-LBPs	630	98.56%
Ali Al-Zawqari et al. [16], 2018	CCA algorithm	-	98%, 32.48ms

Table 3: Shows Comparison of various techniques

IV. CONCLUSION

LPL is the core stage of ALPR System as the whole performance is dependent on LPL. This paper presents various techniques on license plate localization along with the number of images tested, their accuracy rates & execution time.

Various researches have been developed on LPL using different methods, which helps the researchers to localize the license plate efficiently and accurately and thus help them in reducing the false localization rate. Edge, color, character and combining features have been used for the plate detection. Edge based detection method is mostly used method for the plate localization because it gives efficient accuracy. In future, these methods can be modified to extract license plate more accurately, so that a better recognition can be made for real-time applications.

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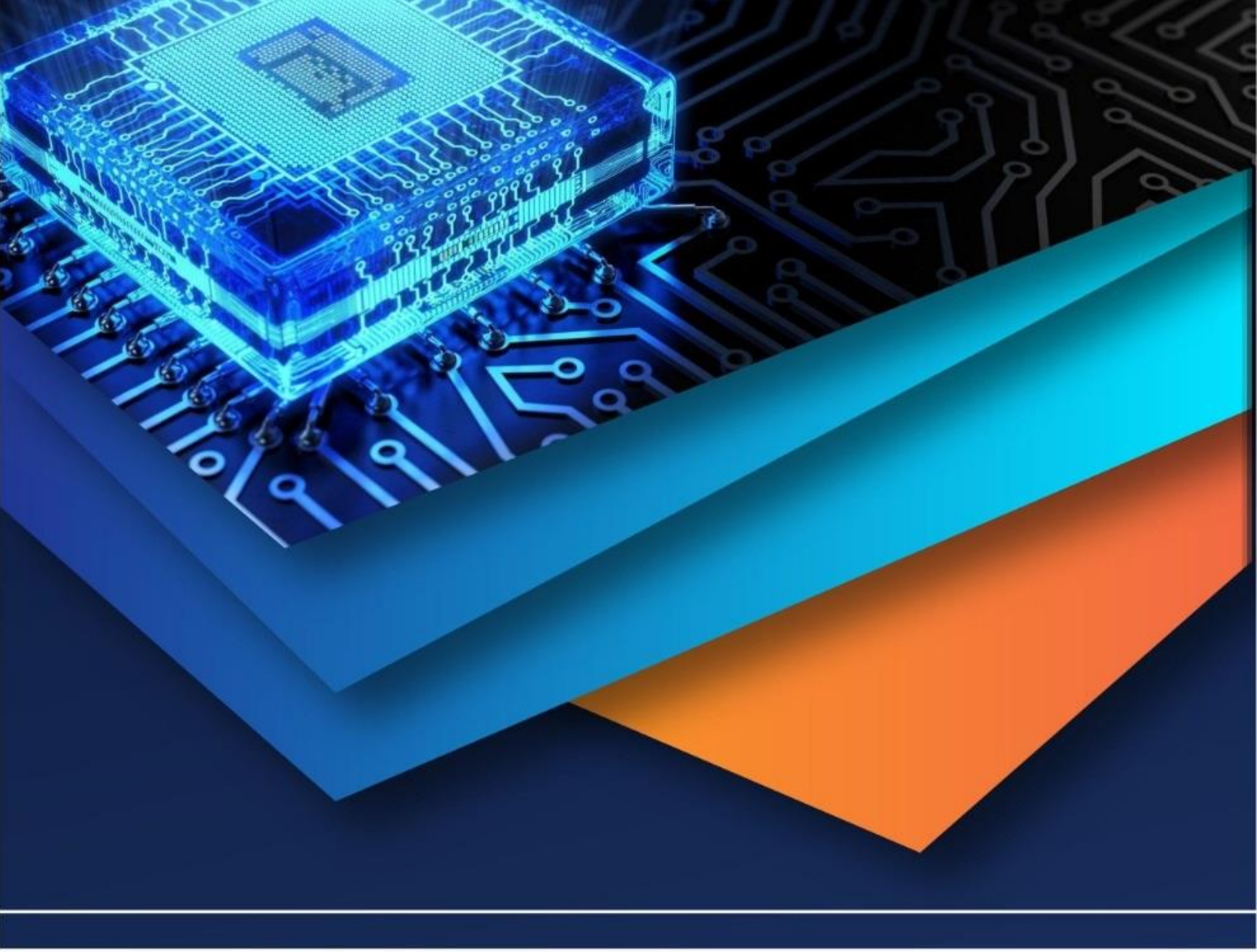

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