License Plate Localization: A Review

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***Abstract*— Automated License Plate Recognition (ALPR) has turned out to be an important research issue in recent years, which is a famous Intelligent Transport System. License Plate Localization is the core module of License Plate Recognition System, which determines the overall performance of the whole License Plate Recognition System. The main contribution of this paper is to provide a brief source of reference study of various License Plate Localization methods depending on the techniques they have used and a comparison of each technique in terms of their merits, demerits, computational power, detection success rate and accuracy, the execution time and speed of the whole License Plate System, which will be helpful for the researchers.**

***Keywords*— Automated License Plate Recognition, Intelligent Transport System, and License Plate Localization.**

I. INTRODUCTION

INTELLIGENT Transportation Systems (ITSs) have a powerful impact on human beings' lives nowadays. The main aim of Intelligent Transportation System is to exploit the transportation mobility and safety to improve the productivity by the use of emerging technologies and is built up of sixteen various types of technology based systems which are categorized into intelligent vehicle systems and infrastructure systems. Among them, Automated License Plate Recognition (LPR) Systems play an important role in various real time applications including the following such as: electronic payment systems (toll payment and parking fee payment), traffic monitoring systems, border crossing control systems, identification of stolen vehicles, petrol station forecourt surveillance systems, red light violation systems, vehicle tracking systems, speed enforcement control systems, ticketing vehicles without the human control, policing, security and customer identification systems. License Plate numbers uniquely identifies a particular vehicle. Each country has their own license plate format which differs in their sizes and colors. So there is a necessity for them to develop the License Plate Recognition system suitable for the vehicle License Plate format. Hence the Intelligent Transport Systems heavily depend on the robust Automated License Plate Recognition Systems (ALPR). Cropping a License Plate manually with a mouse from the input image is a very simple method, but when it comes to do the same for any real time or automatic system, difficulty may arise and will not be suitable for such systems. Therefore, a License Plate Recognition (LPR) System consists of the following FOUR stages and the basic block diagram of the system is as shown in Fig. 1.

- Image Acquisition from digital camera.
- License Plate Localization (LPL: Detecting and verifying the location of the License Plates).
- Character Segmentation (Segmenting the characters from the License Plates).
- Character Recognition (Recognizing the segmented characters from the License Plates).

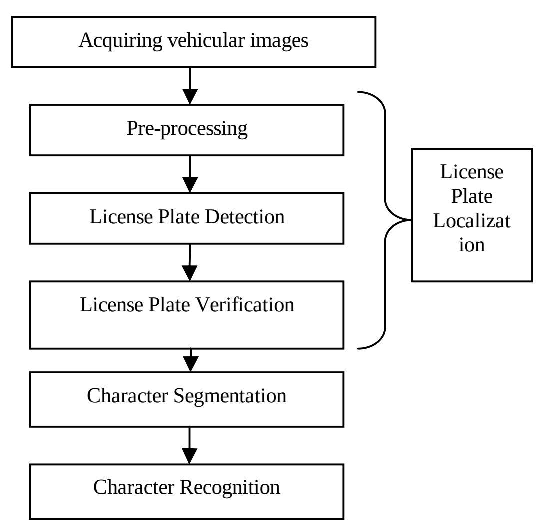

Fig. 1 The basic block diagram of the License Plate Recognition (LPR) System.

In image acquisition, the vehicle images are acquired from digital cameras; since digital technology has their advantages nowadays and it is a vital stage, since it relates to how to acquire high quality vehicle images. License Plate Localization (LPL), which comprises the 3 intermediate steps such as Pre-processing, License Plate Detection and License Plate Verification. This review paper deals with the above first two stages. License Plate Localization from the challenging situations is the heart stage of License Plate Recognition System, which determines the overall performance of the whole system.

An example of the License Plate Localization is shown in Fig. 2, Fig. 3 and Fig. 4.

Localization of accurate License Plate regions from vehicle images is one of the most important and difficult tasks because each vehicular image differs in large variations in quantity, color, size, texture, font, shape, occlusions, patches and spatial orientations or inclinations of the License Plate regions within them. The variations of the environmental conditions also cause difficulties in the License Plate Localization. The main challenges include non-uniform outdoor illumination conditions, speed and motion of vehicle, stationary backgrounds, presence of noise, blurring in the image, shadows, bad weather conditions (wind speed, pollution levels and foggy conditions) etc.

Fig. 2 The Vehicle Input Image

Fig. 3 The License Plate Localization

Fig. 4 The Extracted License Plates

The rest of this paper is organized as follows. The Section II constitutes a literature review of License Plate Localization. The comparison results of the review are given in Section III and finally, conclusions as well as future directions are summarized in Section IV.

II. LITERATURE REVIEW ON LICENSE PLATE LOCALIZATION

Several techniques have already been developed for the efficient License Plate Localization from the given input vehicle images in recent years. A brief description of some of previous works is demonstrated in this section. The traditional License Plate Localization algorithms are basically classified in to three approaches [29] such as colour-based (based on the colours of the characters in the License Plate and the background colour), edge-based (based on the edges of the characters and their boundaries) and texture-based (based on the pattern specification and textured present in the License Plates within the image). The traditional techniques for the basic steps for the License Plate Localization (LPL) are discussed below.

A. Pre-processing

Pre-processing techniques which improve the quality of the images, have to be processed, before the License Plate Localization algorithms are applied, which helps to increase the accuracy of the License Plate Recognition success rate. Numerous pre-processing algorithms have been exploited by the researchers of the License Plate Localization, are focused here in this section.

Firstly, the vehicle input images are converted into gray images through the gray-scale conversion [2] [3] [4] [5] [12] [13] [19] [21] [26] only if the algorithms for the License Plate Localization make use of the brightness information of the image. To remove the noises within the images a non-linear filter, Median Filtering [2] [3] [12] [16] is used which replaces the gray value of a pixel by the median of the gray values of its neighbors. Wiener2 filter [13] is also used to remove noise present in the images.

In [26], Histogram Equalization is used to enhance the contrast within the image is enhanced, which improves the quality of the images and the results of edge related operations. Image So many methods are there for binarization, which is another pre-processing technique, used to is used to convert a gray scale image to a binary image and is used to highlight the characters within the License Plates and to suppress the background details. In Otsu dynamic binarization method [9] [10] [15] [16] [19] [21], the image is segmented into sub-regions and the threshold value for each sub-region is calculated here, which we search for the threshold that minimizes the intra-class variance, defined as a weighted sum of variances of the two classes which gives two regions of the image. The main disadvantages while doing the binarization are, it cannot always produce useful results and some important information from the images will be lost. So a Local adaptive thresholding [11] is employed for binarization, which preserves the lost information. Since the threshold value depends on the local illumination statistics, under bad illuminating conditions, it will be low. A global threshold value can be used instead of an adaptive one to minimize the processing time.

Edge detection [10] [17] [26] [28] is the next pre-processing step, which detects sharp changes in image brightness and in properties of the object. The vertical edges created by the License Plate characters are extracted by Sobel edge detection operator [5] [12] [13] [15] [30]. Other edge detection operators are Roberts [6], Canny [6] and Prewitt [16] operators. The main disadvantage of using these operators is that while applying to complex images, it will be very sensitive to unwanted edges, which can be rectified by combining them with the morphological [3] [8] [11] [14] [19] [20] [22] steps (Dilation and Erosion [8]) that eliminate unwanted edges which will be fast and accurate. Mexican Top-hat [24] transform is another morphological operation, which is most commonly used and gives prominence to the License Plate region by suppressing background and weakening the other regions at the same time.

B. License Plate Localization (Detection and Verification)

Satadal Saha, Subhadip Basu, Mita Nasipuri and Dipak Kumar Basu [1] presented an Edge Based Multi-stage Approach to the License Plate Localization from the video snapshots of registered vehicles. After Gray scale conversion, the noises within the images are reduced by Median Filtering and the contrast of each image is enhanced by Histogram Equalization. The vertical edges created by the license plate characters are extracted by Sobel edge detection operator. The proposed algorithm is subdivided into the intermediate steps, namely identification of potential band of rows, primary localization of license plate regions based on statistical distribution of vertical edge pixels, refinement of license plate regions based on prominent vertical edges and localization of license plate bounding box by removing the noise segments. The success rate of this algorithm was found to be 89.2% and works well for the less noisy images since this approach is edge based and gives satisfactory performance.

Waing and Nyein Aye [2] developed an Efficient Geometric feature based License Plate Localization System. After projecting the enhanced binary image horizontally and vertically, the histograms are passed through a Low Pass Digital Filter to prevent the loss of important information and the Region of Interest (ROI) is extracted by filtering out the Unwanted Regions, based on geometric features within the License Plate image. This method is sensitive to the environmental conditions, angle of view and physical appearance.

In [3] Phalgun Pandya and Mandeep Singh presents an approach based morphological opening and closing operations for the Indian License plate localization by filtering the Candidate Regions and verifying the Localized Candidates. The License Plates, located at any corner of image and having variations in background, can be easily localized with this approach. The experimental results show that 98% of the License Plates were localized correctly and 2% images resulted in the localization of License Plates with the non candidate regions

Chu-Duc Nguyen, Mohsen Ardabilian and Liming Chen [4] proposed a Real-time License Plate Localization method which approximates the edge content of gray-scale image using line segments and a new scale and rotation invariant texture descriptor (LSTD) which describes the regularity, similarity, directionality and alignment of line segments into potential License Plates. After a line-based slope estimation and correction, false candidates are eliminated by using geometrical and statistical constraints. The success rate of this algorithm was 97.25%. This method is robust to illumination conditions and geometric changes induced by viewpoint changes such as scaling, orientation and deformation.

Muhammad H Dashtban, Zahra Dashtban and Hassan Bevrani [5] evaluated a Novel Approach for Vehicle License Plate Localization in real dynamic environment which nominally includes the following steps:

i) Noise alleviation using Gaussian low pass filter

ii) Changing color space using gray-scale conversion

iii) Intensity dynamic range modification using Histogram Equalization

iv) Vertical Edge detection using Sobel operator

v) Separating objects from background using Connected Component Analysis (CCA [26] [27], which scans the image and labels the pixels according to the pixel connectivity: 4-Connectivity or 8-Connectivity)

vi) Finding connected component (CCA)

vii) Candidate selection using geometric features (Area, Ratio of length to width, Range of length and width, Region intensity) extraction.

The method achieved accuracy over 91% for localizing plates.

In [6] Yuwang Yang, Jun Tao and Jingyu Yang proposed a Level set method for License Plate Localization Technology. This paper encompasses Mumford-Shah model with Level Set method, the finite difference and third order TVD (Total Variation Diminishing) Runge-Kutta schemes for space and time discretization. The edge detection results obtained from level set method are better than the other edge detection methods such as Roberts, Sobel and Canny and can also obtain accurate result compared to other general gradient algorithms when it is used in license plate localization.

In [7] ubhadip Basu, Satadal Saha, Mita Nasipuri and Dipak Kr. Basu presented A real-time Color Feature Based ANN Approach for the License Plate Localization. After designing the neural network and generating the training dataset, the colour information of the License Plate is used as the knowledge base for training an artificial neural network system using back propagation algorithm. The trained network is then used to find the potential license plate region within a new traffic image. This technique efficiently identifies potential License Plate regions from the surveillance-camera captured vehicle images. Experimental results shows that this method performs quite satisfactorily with rounded accuracy of 80% for localizing vehicle License Plates. It cannot perform well under certain conditions such as the very poor quality of the license plate characters, the reflection of sun light from the license plate etc.

In [8] Nelson Kennedy Babu and Krishnan Nallaperumal used another Morphological Plate Localization Algorithm (MPLA). This algorithm uses morphological operations (Dilation and Erosion) on the preprocessed, edge images of the vehicles. Characteristic features such as license plate width and height, character height and spacing are considered for defining structural elements for morphological operations. The robustness of the algorithm and false detection minimization can be enhanced to detect additional features present in the license plate region. The experimental results are reasonably very encouraging because the algorithms were developed based on Morphological operations combined with good thresholding and efficient structuring elements.

Baoming Shan proposed [9] a new License Plate Localization Method which made use of Otsu binarization (pre-processing step to get the License plate candidates), Character filtering and text-line construction (to verify the License Plate candidates) and locally optimal adaptive binarization (to make more accurate License Plate Localization).The experimental results show that this method can localize the License Plates effectively.

For localizing the License Plates from the vehicle images, Pawan Wawage and Shraddha Oza [10] utilized binarization, edge detection and Selection of probable Band as basic steps.This system works satisfactorily for wide variations in illumination conditions and different types of number plates commonly found in India and cannot works satisfactorily on parameters like speed of the vehicle, script on the number plate, cleanliness of number plate, quality of captured image and skew in the image.

Reference [11] presented a comparison study done by Kinjal A. Shah, Harsh K. Kapadia, Vipul A. Shah and Maurya N. Shah, in which they discussed about localization of License Plates from vehicle images using different methods such as Cropping of Object (unsuitable for automatic system), Morphological operations (difficult procedure to extract license plate as color information of the image gets lost), thresholding methods(if the vehicle is white then the result will contain some unwanted objects, So it fails to detect only license plate in such cases) and Mean-Shift algorithm(accurate enough and robust to be used in the same area). As the Morphological operations mainly operate on binary images, time parameter is not that important. The localization by thresholding contains more steps and filters to remove non-plate objects, so it takes a bit longer time than the Morphological operations. In mean shift algorithm, the mathematical computation is little complex and the implementation contains so many loops and takes longer time to get the result. This disadvantage is rectified by adding few critical conditions to break the loop.

An Automatic Localization and Recognition of License Plate Characters for Indian Vehicles had proposed by Satadal Saha, Subhadip Basu and Mita Nasipuri in [12]. Here after Image acquisition, Image pre-processing is done, which employs some of the quality improvement techniques such as rotation, Gray scale conversion, Median filtering and Edge Detection using Sobel Operator to facilitate the localization of the license plate. The algorithm is further subdivided into the following intermediate stages: identification of potential band of rows, primary localization of license plate regions based on statistical distribution of vertical edge pixels, refinement of license plate regions based on prominent vertical edges and localization of license plate bounding box by removing the noise segments. A quantitative measure of the performance of this method for the following categories is summarized in tabular form and is given in Table 1 below; where, Category A: False negative case if true license plate is not found and/ or false locations are detected as License Plate.

Category B: False positive case if the true license plate is found but along with that other false locations are also detected as license plate.

Category C: True positive case if only true license plate is detected as a license plate. By considering the simplicity of the system, the overall performance of the system is quite satisfactory.

TABLE I
PERFORMANCE SUMMARY [12]

Category	LPL detection rate
Category A	7.50%
Category B	2.50%
Category C	90.00%

Anish Lazrus, Siddhartha Choube and Sinha evaluated An Efficient Method of Vehicle Number Plate Detection and Recognition in [13]. After the conversion of manually acquired vehicle images in to gray-scale images, wiener2 filter is used to remove noise present in it. The smoothed edges are genrated by Sobel filter for the segmentation process of gray scale image and are used to reduce the number of connected component and finally, single character is detected. The experimental results show that the proposed method achieved accuracy of 98% and there is a need to be taken care of the issues like stains, smudges, blurred regions & different font styles and sizes. Therefore to achieve an accuracy of 100%, further optimization is required.

There is another License Plate Localisation Algorithm based on Morphological Operations, proposed by iaojun Zhai, Faycal Benssali and Soodamani Ramalingam in [14], which consists of the major steps: Morphological operations for extracting plate features, Selection of candidate regions and the Verification of License Plate region. The basic morphological operations such as open and close are used to extract the contrast features of the License Plates where the different Structuring Elements(SE) are used to eliminate non-plate region and to enhance the candidate plate region. This method had shown outstanding License Plate Localization rate (98%), which reduces the computational complexity.

Peter Tarabek proposed a fast real-time License Plate Localization method in [15]. The vertical edges are detected from the image using Sobel operator. After binarization, two-stage candidate detection (Coarse Detection and Fine detection) process is done for extracting the License Plates. Here a sliding-window technique is used to mark all windows which satisfied edge density conditions computed on integral edge image and finally the false candidates are filtered out based on the geometrical and textural properties of the License Plates. Then the candidate verification is done. The proposed method can detect multiple license plates with different sizes in a complex background. The experimental results show the robustness of this mehtod by localizing 97.4% of License Plates.

Reference [16] is a study on the license plate based strategy for checking the annual inspection status of motorcycles from images taken along the roadside and at designated inspection stations done by Yo-Ping Huanga, Chien-Hung Chenb, Yueh-Tsun Changand

Frode Eika Sandnes.The input image is first pre-processed by binarization (Otsu's method), noise reduction (median Filtering) and edge detection(Prewitt operator).Then, horizontal and vertical projections through a search window is performed to locate the License Plate. If the license plate is not found, the original image is inverted to assess whether it is a light motorcycle license plate. If the license plate still cannot be found, it is concluded that the image does not contain any license plates. Experiments yield a recognition rate of 95.7% and 93.9% based on roadside and inspection station test images, respectively.

An edge-based color-aided method for license plate detection [17] was implemented by Vahid Abolghasemi and Alireza Ahmadyfard. After pre-processing, the proposed method consists of two major steps. In the first step, for enhancing contrast in License Plate regions within the image, two main features are to be considered such as local intensity variance and local vertical edge density. The second step filter out the non-plate regions. It encompasses the designing of a matched filter (which is a mixture of Gaussian functions) to detect candidates for license plate region, Region extension procedure and the extraction of License Plate using morphological operations. After that, for increasing the accuracy of the detection of license plate, we use Color analysis of the candidate license plates. The experimental results show that this image enhanced License Plate detection method is robust against bad illumination conditions.

A Fuzzy-based algorithm for color recognition of license plates (FCRA) was introduced by Feng Wanga, Lichun Manb, Bangping Wanga, Yijun Xiaoa, Wei Pana and Xiaochun in [18]. In this algorithm, to perform color feature extraction, the HSV (hue, saturation and value) color space is employed, which are firstly mapped to fuzzy sets according to different membership functions. The fuzzy classification function for color recognition is, then, described by the fusion of three weighted membership degrees. The accuracy and adaptability of this algorithm is improved by integrating a learning algorithm to obtain the correlative parameters with it. Experimental results show that the proposed algorithm can accomplish the color recognition task for license plates effectively and efficiently. The accuracy and execution time of the algorithm can meet the requirements of the practical engineering applications. But most of the images that were not recognized correctly were caused by wrong localization, vehicle lights and some other image regions whose structure and texture were similar to License Plates and camera distortion. So there is a need of further optimization of the algorithm to improve its efficiency.

Abo Samra and Khalefah introduced a design of a new genetic algorithm (GA) to detect the locations of the License Plate (LP) symbols in [19].After the gray scale conversion, an adaptive threshold binarization method has been applied to overcome the dynamic changes of illumination conditions. Then the moprphological processing is done followed by Connected Component Analysis (CCA) which extracts the candidate objects within the image. A scale-invariant Geometric Relationship Matrix (GRM) has been introduced to model the symbols layout in any LP which simplifies system adaptability. Two new crossover operators, based on sorting, have been introduced which greatly improved the convergence speed of the system. Most of CCAT problems such as touching or broken bodies have been minimized by modifying the GA to perform partial match until reaching to an acceptable fitness value. Experimental results reported 98.4% overall system accuracy.

Nikul Ukani and Harsh Mehta implemented another method for License Plate Localization using Morphological Operations and Edge Processing in [20]. After color segmentation (in the YCbCr color space for special license plates) and contrast stretching morphological processing is done which makes use of the basic morphological operations such as reconstruction, dilation, erosion and then Edge processing is done to exploit the license plate edge characteristics. Finally, by using statistical properties of the edge image, candidate selection/rejection is happened and the Skew correction is obtained by applying Harris corner detection. This algorithm is robust, reliable and can adjust to different lighting conditions. The success rate of the algorithm was found to be 96.88%. The only limitation of the algorithm is the failure to reject certain types of vehicle grilles since they share all the characteristics of license plates.

In [21] Yuh-Rau Wang, Wei-Hung Lin and Shi-Jinn Horng proposed a DWT (Discrete Wavelet Transform) based method for the License Plate Localization (LPL) to find the horizontal and vertical gradients of the License Plates. After transforming the gray image into frequency domain by 1-level 5/3 DWT, the License Plates are extracted with the help of HL and LH frequency sub bands. The noises in both sub bands are reduced by thresholding. After the extraction of the features of the License Plates, the accurate verification of the location of the License Plate is done by the Sliding Window technique. It seems difficult for this algorithm to localize the License Plates, if the image background color is very close to the color of the License Plate. The experimental results show that the successful detection rate and the average run time of the proposed License Plate Localization method are 97.33% and 0.18 s respectively, which can localize both front and back LPs of different vehicles with high accuracy.

A new License plate Localization algorithm [22] is proposed by Mohamed Mansoor Roomi, M. Anitha, and R. Bhargavi, based on histogram analysis and Wavelet along with mathematical morphology. This method consists of two modules. In the first module, the plate regions are roughly located based on the gradient feature and are searched in whole image. In the second module, accurate localization of region of interest (ROI) is detected by using the vertical coefficients of wavelets. It applies vertical sub band feature of 2D discrete wavelet transform (DWT) to significantly highlight the vertical edges of license plates and suppress the surrounding background noise. Then, license plates can be extracted and located by the orthogonal projection histogram analysis with morphological operations. This method can extract license plate of various vehicles both front and back. The experimental results show that the proposed method can achieve good license plate localization results with short runtime and high accurate detection rate (horizontal detection: 98.46% and vertical detection; 96.15%) irrespective of the limitation arises from the distance, height and orientation.

In [23], the “character recognition” approach is done by Lama Hamandi, Khaled Almustafa, Rached Zantout and Hasan Obeid to recognize a vehicle license plate. Localization of the plate is done by first determining all objects in the image which can possibly be characters in the license plate. Then all large or small objects are discarded and this method concentrates on the objects that have appropriate size. The coordinates of the centre point of the bounding box for all remaining objects are found and then possible alignments between these objects are checked. This algorithm has shown good results in locating Saudi plates. The only limitation occurs when the license plate has large screws or when the license plate is rotated in the image.

In [24] Dhawal Wazalwar, Erdal Oruklu and Jafar Saniie, proposed a Design Flow for Robust License Plate Localization and Recognition in Complex Scenes, in which it made use of a Mexican hat operator combining both smoothing operation and the detection of edges, when there is only partial contrast between the license plate and its surrounding regions. In order to prevent the discontinuity within the edge image due to the blurriness, a dilation operation is done to make these edges continuous and thick. After that a region growing segmentation is performed, in which the pixels are grouped, based on some predefined pixel connectivity information to form smaller sub regions. Then a Euler number criterion is used for a binary image, which helps to reduce the sensitivity of algorithm to license plate dimensions. This algorithm is highly useful with real-time license plate recognition systems having high complexity. The results are encouraging with success rate of 98.10% for License Plate Localization and the performance of the algorithm can also improve if higher resolution input frames are used.

In the paper [25], Lihong Zheng, Xiangjian He, Bijan Samali and Laurence T.Yang, have constructed a cascaded classifier consisting of 6 layers for license plate detection using both global edge features and local Haar-like features. The classifiers on the first two layers are based on the two global edge features and the detection speed is greatly increased in the next four layers from further training or testing. The classifiers on these four layers are trained by AdaBoost learning procedure. This algorithm obtains a very high real time detection rate with very low false positive rate even under various controlled conditions or complex environments with more flexibility and can be applied to any areas where the cameras are mobile and the backgrounds are changeable. The successful plate detection rate is 96.4%.

In [26], Muhammad H Dashtban, Zahra Dashtban, Hassan Bevrani, proposed a general algorithmic model for the License Plate identification. The main steps for this method includes noise alleviation using Gaussian filter, changing color space using gray-scale conversion, intensity modification using Histogram Equalization, edge detection using Canny's method, separating objects from context using diagonal fill for eliminating 8-connectivity, finding connected component using 8 and 4-ary connectivity and finally, candidate selection using the geometrical features such as area, ratio of length to width, range of length and width, region intensity etc. Experimental results showed that the proposed method performs well with an accuracy of 91% for localizing vehicle license plate. But, this method is not a color based approach and due to the special processing, it can be used in car screening systems of several countries worldwide.

The Licence Plate detection algorithm used in [27] which was implemented by Zoe Jeffrey, Soodamani Ramalingam and Nico Bekooy is divided into four parts namely input image normalization, edges enhancement using filters, edges finding and linking to rectangles using connected component analysis (CCA) and plate candidate finding The edge finding method helps to verify the presence of an edge and works by scanning the image and a list of edges is found using contrast comparison between pixel intensities on the edges' boundaries using the original gray scale image. The experimental results show satisfactory localization result.

Rong Lia, Musa Yassin Fortb, and Georgios C. Anagnostopoulos proposed [28], a novel License Plate Recognition system where a new de-skewing stage, which can be significantly advantageous, is added between license plate localization steps and allows to remove input image distortion due to perspective projection. They also proposed a LP localization method based on vertical edge density that has improved performance on images with complicated edge background, which is a common problem for edge density approaches. This method minimizes the number of candidate regions and thus greatly improved the LP detection rates and has a success rate of 86.4%.

Reference [29] is a review of automatic License Plate Recognition done by Wenjing Jia, Xiangjian He and Massimo Piccardi. The main License Plate Localization techniques discussed in this paper are Texture-based License plate localization, Vertical lines-based License plate localization, Color-based License plate localization and Skew Detection of License plate. For evaluating the performance of the above methods, a test bed needs to be developed that could easily be adapted and allow different algorithms to be tested.

In [30] Ali Tahir, Hafiz Adnan Habib, M. Fahad Khan implemented a License Plate Extraction technique based on vertical edge matching, which locate the right regions of the license plates. Firstly, vertical Edge Detection is done by Sobel edge detector which can identify half of the vertical edges. Next, filtering is employed to wipe out the objects, which do not suit for some specific features and select the regions that can give out as possible license plate boundaries and eliminate the others by filling black colors in their place. Finally, Vertical Edge Matching of the width to height ratio of license plate is exploited to match the vertical edges for locating the region of where there is a possibility of license plate. This algorithm is effective in various illumination conditions.

III. COMPARISON RESULTS

The License Plate Localization accuracy of different researches is shown below. Depending on the different License Plate Localization techniques used, the accuracy of the success rate is varied.

TABLE II is a comparison of different License Plate Localization algorithms being reviewed, of different researches.

TABLE II
REVIEWED RESULTS

Reference Number	**License Plate Localization method**	**% Success Rate**
[1]	License Plate Localization from Vehicle Images: An Edge Based Multi-stage Approach	89.2%
[3]	Morphology Based Approach To Recognize Number Plates in India	98.0%
[4]	Real-time license plate localization based on a new scale and rotation invariant texture descriptor	97.3%
[5]	A Novel Approach for Vehicle License Plate Localization and Recognition	91.0%
[7]	Localization of License Plates from Surveillance Camera Images: A Colour Feature Based ANN Approach	80.0%
[12]	Automatic Localization and Recognition of License Plate Characters for Indian Vehicles	90.0%
[13]	An Efficient Method of Vehicle Number Plate Detection and Recognition	98.0%
[14]	License Plate Localization based on Morphological Operations	98.0%
[15]	A Real-Time License Plate Localization Method Based on Vertical Edge Analysis	97.4%
[16]	An intelligent strategy for checking the annual inspection status of motorcycles based on license plate recognition	95.7%
[20]	An Accurate Method for License Plate Localization using Morphological Operations and Edge Processing	96.9%
[21]	A sliding window technique for efficient license plate localization based on discrete wavelet transform	97.3%
[22]	Accurate License Plate Localization	98.5%
[24]	A Design Flow for Robust License Plate Localization and Recognition in Complex Scenes	98.1%
[25]	An algorithm for accuracy enhancement of license plate recognition	96.4%
[28]	Multi-stage Automatic License Plate Location & Recognition	86.4%

A graphical representation of the above reviewed results is also shown in fig.5. From this plot, we can observe percentage efficiency of system as per given data.

IV. CONCLUSION

Various researches have been developed using different methods to process License Plate Localization, which helps the researchers to efficiently localize the License Plates and thus lead them to the reduction of false localization rate. This comprehensive review work also provides a comparison study of each License Plate Localization method in terms of their merits, demerits, computational power, detection success rate and accuracy, the execution time and speed of the whole License Plate System. Also, we think that this review work will direct the future researchers to develop the better methods for the License Plate Localization.

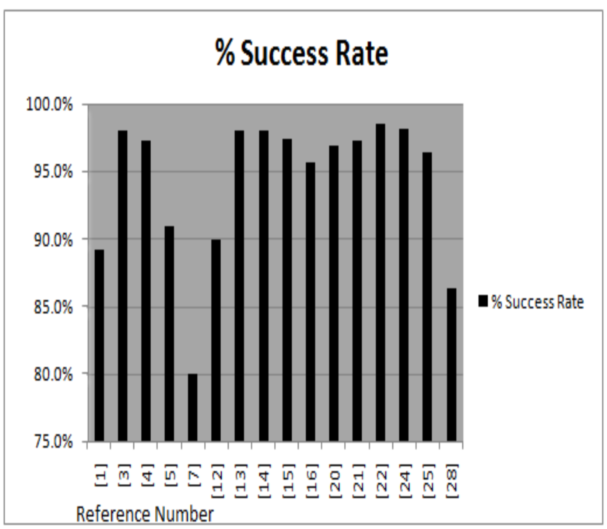

Fig. 5 The Reviewed Results

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