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A Review on Automatic Vehicle License Plate Recognition System

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***Abstract*: Automatic License Plate Recognition (ALPR) system is a kind of an intelligent transport system which is of considerable interest because of its potential applications in highway electronic toll collection and traffic monitoring systems. It allows traffic penalties to be automatically generated and sent to the appropriate violator without the need of human intervention. This type of applications puts high demands on the reliability of an LPR System. A lot of work has been done regarding LPR systems for Korean, Chinese, European and US license plates that generated many commercial products. However, little work has been done for Indian license plate recognition systems. The purpose of this paper is to study a real time application which recognizes license plates from cars at a gate, which have some missing values for example at the entrance of a parking area or a border crossing. An ALPR system can be located either on the side of or above a roadway, at a toll booth, or at another type of entrance way. All ALPR systems follow a basic high level process. In this Paper, the current status of ALPR Systems and directions for future research are suggested.**

***Keywords*: Image Acquisition; License Plate Extraction; Digitization; Preprocessing; Segmentation; optical character recognition (OCR) or neural networks and LabVIEW.**

1. Introduction

Missing character License plate recognition (MCLPR) is an image-processing technology used to identify vehicles by their license plates for missing value. 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. This thesis presents a license plate recognition system as an application of computer vision. Computer vision is a process of using a computer to extract high level information from a digital image. License plate recognition systems have received a lot of attention from the research community. Much research has been done on Korean; Chinese, Dutch and English license plates. A different point of research work in this area is being limited to a special field, range, great town, or country. This is due to the lack of standardization among different license plates (i.e., the dimension and the layout of the license plates). Despite the time nearly three decades from ANPR's emerging has long been passed it still is an active area of research. From a social point of view the need for the intelligent transportation management without human being intervention in different countries throughout the world automatically influenced this field for being long active in literature. Large magnitude of papers within three last decades for ANPR have been demonstrated which shows the importance and the worth of this subject in literature [1]. These researches and corresponding implementations mainly fall into two categories, the vehicle plate localization and the plate character recognition which some literatures are particularly devoted to one of them and some considers both parts. Taking a look beyond the published papers and completed works in license plate identification over the years shows a particular motivation and enthusiastic from researchers. These motivations might address the essence of the subject and corresponding algorithms. In regard to the essence of problem one can classify three factors as main reasons and goals of researches. First is the accuracy which itself is divided into two subclass including accuracy on localization of vehicle license plate and accuracy on recognizing the license plate characters [2]. In this field, especially more complex and robust works have been done in recent years and this is the attribute of advances in technologies which are proportional with increasing accuracy for intelligent agents. The second factor is algorithm time complexity which is significant when the science purpose is implementation. For the APNR, some authors present such robust algorithm but due to the high time complexity they are not applicable in real time systems. However, the authors believe that those approaches could provide a proper pattern for novel hybrid or more simple algorithms. Third factor is adaptability as we expect the intelligent agent, the algorithm or the model has the ability to adapt itself with environment to cope with dynamic outdoor conditions therefore without human being intervention the expected tasks has been done. In the case of license plate identification such conditions address the various lighting, weather, crashed etc. To achieve adaptively more efforts must be performed. Algorithms with enough generality and high accuracy can perform such tasks that need high adaptive capabilities. Such algorithms by supporting simple and complex conditions in their structural model bring confidence out for human beings [3, 4]. Increasing of confidence to machines is a direct relation with reliability of intelligent agents.

This paper gives an overview of the research carried out so far in this area and the techniques employed in developing an LPR system in lieu of the following four stages: image acquisition, license plate extraction, and license plate segmentation and license plate recognition phases.

Image Acquisition: This phase deals with acquiring an image by an acquisition method. In our proposed system, we used a high resolution digital camera and adequate light source to acquire the input image.

License Plate Extraction: This phase extracts the region of interest, i.e., the license plate, from the acquired image. The proposed approach involves "Masking of a region with high probability of license plate and then scanning the whole masked region for license plate".

License Plate Character Segmentation: License Plate Segmentation, which is sometimes referred to as Character Isolation takes the region of interest and attempts to divide it into individual characters. In the proposed system segmentation is done in the OCR section.

Optical Character Reorganization: There are many methods used to recognize isolated characters. In the proposed system we are using Optical Character Recognition which is an inbuilt feature in Vision Assistant.

2. Related work

A variety of research work has been done on license plate recognition system. Most can be classified as differing on the plate detection methods, extraction methods, character segmentation methods and the character recognition methods.

A. Image Acquisition

This phase deals with acquiring an image by an acquisition method. Image Acquisition is the first step in an LPR system and there are a number of ways to acquire images, the current literature discusses different image acquisition methods used by various authors. *Yan, Dai., Hongqing, Ma., Jilin, Liu., and Langang, Li,* [5] used an image acquisition card that converts video signals to digital images based on some hardware-based image pre-processing. *Naito, T., Tsukada, T., Yamada, K.s Kozuka, K., and Yamamoto, S.,* [3,6,7] developed a sensing system, which uses two CCDs (Charge Coupled Devices) and a prism to split an incident ray into two lights with different intensities. The main feature of this sensing system is that it covers wide illumination conditions from twilight to noon under sunshine, and this system is capable of capturing images of fast moving vehicles without blurring. *Salagado, L., Menendez, J. M., Rendon, E., and Garcia, N.,* [4] used a Sensor subsystem having a high resolution CCD camera supplemented with a number of new digital operation capabilities. *Kim, K. K., Kim, K. I., Kim, J.B., and Kim, H. J.,* [8] uses a video camera to acquire the image *Comelli, P., Ferragina, P., Granieri. M. N., and Stabile, F.,* [9] used a TV camera and a frame grabber card to acquire the image for the developed vehicle LPR system.

B. License Plate Extraction

License plate extraction is the most important phase in an LPR system. This phase extracts the region of interest, i.e., the license plate, from the acquired image. *Hontani, H., and Koga, T.,* [10] proposed a method for extracting characters without prior knowledge of their position and size in the image. The technique is based on scale shape analysis, which in turn is based on the assumption that, characters have line-type shapes locally and blob-type shapes globally. In the scale shape analysis, Gaussian filters at various scales blur the given image and larger size shapes appear at larger scales. To detect these scales the idea of principal curvature plane is introduced. By means of normalized principal curvatures, characteristic points are extracted from the scale space x-y-t. The position (x, y) indicates the position of the figure and the scale t indicates the inherent characteristic size of corresponding figures. All these characteristic points enable the extraction of the figure from the given image that has line-type shapes locally and blob-type shapes globally. *Kim, K. K., Kim, K. I., Kim, J.B., and Kim, H. J.,* [8] used two Neural Network-based filters and a post processor to combine two filtered images in order to locate the license plates. The two Neural Networks used are vertical and horizontal filters, which examine small windows of vertical and horizontal cross sections of an image and decide whether each window contains a license plate. Cross-sections have sufficient information for distinguishing a plate from the background. *Lee, E. R., Earn, P. K., and Kim, H. J.,* [11] and *Park, S. FL, Kim, K. I., Jung, K., and Kim, H. J.,* [12] devised a method to extract Korean license plate depending on the color of the plate. A Korean license plate is composed of two different colors, one for characters and other for background and depending on this they are divided into three categories. In this method a neural network is used for extracting color of a pixel by HLS (Hue, Lightness and Saturation) values of eight neighboring pixels and a node of maximum value is chosen as a representative color. After every pixel of input image is converted into one of the four groups, horizontal and vertical histogram of white, red and green (i.e. Korean plates contains white, red and green colors) are calculated to extract a plate region. To select a probable plate region horizontal to vertical ratio of plate is used. *Cho, D. U., and Cho, Y. Ft.,* [13] presented histogram based approach for the extraction phase. *Kim G. M* [14] used Hough transform for the extraction of the license plate. The algorithm behind the method consists of five steps. The first step is to threshold the gray scale source image, which leads to a binary image. Then in the second stage the resulting image is passed through two parallel sequences, in order to extract horizontal and vertical line segments respectively. The result is an image with edges highlighted. In the third step the resultant image is then used as input to the Hough transform, this produces a list of lines in the form of accumulator cells. In fourth step, the above cells are then analyzed and line segments are computed. Finally, the list of horizontal and vertical line segments is combined and any rectangular regions matching the dimensions

of a license plate are kept as candidate regions. The disadvantage is that, this method requires huge memory and is computationally expensive.

C. Segmentation

License Plate Segmentation, which is sometimes referred to as Character Isolation takes the region of interest and attempts to divide it into individual characters. Many different approaches have been proposed in the literature and some of them are as follows, *Nieuwoudt, C, and van Heerden, R.,* [15] used region growing for segmentation of characters. The basic idea behind region growing is to identify one or more criteria that are characteristic for the desired region. After establishing the criteria, the image is searched for any pixels that fulfill the requirements. Whenever such a pixel is encountered, its neighbors are checked, and if any of the neighbors also match the criteria, both the pixels are considered as belonging to the same region. *Morel, J., and Solemini, S.,* [16] used partial differential equations (PDE) based technique, Neural network and fuzzy logic were adopted in for segmentation into individual characters. *M.K. Sharma and V.S. Dhaka* [26] have proposed a segmentation technique for words and characters. The proposed Pixel Plot and Trace and Re-plot and Retrace (PPTRPRT) technique extracts text region from text scripts and lead iterative processes for segmentation of text lines along with skew and de-skew operations. The outcomes of iterations are used in pixel-space-based word segmentation, and the segmented words are used in segmentation of characters. Investigational outcome shows that the proposed technique is competent to segment characters from text scripts, and accuracy of outcomes is up to 99.578 %. *M.K. Sharma and V.S. Dhaka* [28] have proposed a segmentation technique for words and characters. The PPTRPRT is a new technique for reconstructing the bilingual offline handwritten cursive scripts and will give a concrete base to design an OCR with optimum correctness and bottommost cost. The proposed PPTRPRT framework gives best segmentation outcomes up to 99.78 % using FFNN as a classifier, and the size of dataset was 68,000. *M.K. Sharma and V.S. Dhaka* [29] have proposed a segmentation technique for cursive script. That research work presents a realistic technique for character segmentation of English offline handwritten cursive scripts using a FFNN. The PPTRPRT technique is a new technique for reconstructing English offline handwritten cursive and is driving the results by keeping an approach between under-segmentation and over-segmentation. The technique will provide a concrete basis by which design of an optical character reader with fine accuracy and low cost will be achieved.

D. Recognition

This section presents the methods that were used to classify and then recognize the individual characters. The classification is based on the extracted features. These features are then classified using either the statistical, syntactic or neural approaches. Some of the previous work in the classification and recognition of characters is as follows, *Hansen, H., Kristensen, A. W., Kohler, M. P., Mikkelsen, A. W., Pedersen J. M., and Trangeled, M.,* [17] discusses a statistical pattern recognition approach for recognition but their technique found to be inefficient. This approach is based on the probabilistic model and uses statistical pattern recognition approach. *Cowell, J., and Hussain, F.,* [18] discussed the recognition of individual Arabic and Latin characters. Their approach identifies the characters based on the number of black pixel rows and columns of the character and comparison of those values to a set of templates or signatures in the database. *Cowell, J., and Hussain, F.,* [19] discusses the thinning of Arabic characters to extract essential structural information of each character which may be later used for the classification stage. *Yu, M., and Kim, Y. D.,* [20] and *Naito, T. Tsukada, T. Yamada, K. Kozuka, K. and Yamamoto, S.,* [6] used template matching. Template matching involves the use of a database of characters or templates. There is a separate template for each possible input character. Recognition is achieved by comparing the current input character to each of template in order to find the one which matches the best. If I(x,y) is the input character, T„(x,y) is template n, then the matching function s(l,Tn) will return a value indicating how well template n matches the input. *Hamami, L., and, Berkani, D.,* [21] adopted a structural or syntactic approach to recognize characters in a text document, this technique can yield a better result when applied on the recognition of individual characters. This approach is based on the detection of holes and concavities in the four directions (up, down, left and right), which permits the classification of characters into different classes. In addition, secondary characteristics are used in order to differentiate between the characters of each class. The approaches discussed in this paragraph are based on the structural information of the characters and uses syntactic pattern recognition approach. Hu, M. K., [22] proposed seven moment that can be used as features to classify the characters. These moments are invariant to scaling, rotation and translation. The obtained moments acts as the features, which are passed to the neural network for the classification or recognition of characters. Zemike moments have also been used by several authors [25, 23, 24] for recognition of characters. Using zernike moments both the rotation variant and rotation invariant features can be extracted. These features then uses neural network for the recognition phase. Neural network accepts any set of distinguishable features of a pattern as input. It then trains the network using the input data and the training algorithms to recognize the input pattern. *M.K. Sharma and V.S. Dhaka* [27] have proposed a recognition technique for words and characters. In these three classifiers namely GADNT, GANNT and GNDT, with the storage constraints are proposed for image classification. The proposed GADNT is able to design the proper number of child nodes of each decision node in the GDT according to the classification error rate and computing complexity of GDT. In GNT, the GANNT is proposed to search for the proper number

of hidden and output nodes in the neural network according to the classification error rate and computing complexity of GNT.

E. Some ALPR Techniques

Fajas, F. Yousuf, P. R. Remya, S. Ambadiyil, & S. A. Varsha [30] In this License Plates are localized by firstly pre-processing which includes rgb to gray, edge detection and noise reduction following which possibly license plates are identified by changes in contrast, width by height factor. Character segmentation is done by looking for similarities in characteristics of characters. Character recognition is done with the help of ANNs.

M.H. Dashtban, Z. Dashtban and H. Bevrani [31] which gave a general algorithmic model proposed for vehicle plate identification. The proposed algorithm generally consists of three main parts, first the license plate detection model which has several steps. For enhancing overall results it converts 8-connectivity of background and finds desired connected components of input image with 8- connectivity. In the first step they had some special preprocessing which decay such issues as shadow or shadiness which are the result of various illumination conditions. That issue is done by using Gaussian low pass filter and histogram equalization for sharpening and increasing image intensity dynamic range. After extracting the appropriate object among the four biggest 8- connected objects, the character segmentation system utilized the Hough transform to find the longest line within the extracted boundary. This line was then used for its angle as the angle of the plate and rotation problem in skewed car plates using the obtained angle would be solved. Local binarization is used and then some basic morphological operations for enhancing the extracted plate are utilized. Then, a vertical projected histogram based technique in regard with the valleys is used to find space between characters.

D. Sagar, & M. Dutta [32] give a new method of block based ANPR system is presented for recognition of Indian License plates. The methodology consists of image pre-processing which consists of gray processing, image enhancement, filterization, binerization, thresholding and morphological operations – image erosion, removing small objects, image filling. Further character segmentation is performed which consists of Connected Component Analysis, Center Line Rule and Blob Extraction. Finally block based character recognition is performed using subphases of block based feature extraction and recognition. The authors claim to achieve a very high recognition rate of 98.2 % and a speedup of processing time to 3.3 ms. The system is also very robust.

G. T Sutar, A.V Shah [33] presents a method which uses improved segmentation along with OCR to recognize vehicle license plates. In this work LP extraction is done using either an estimate of plate location or image segmentation methods like image binarization, otsu's method or color segmentation. Improvement of segmentation of characters is done by calculating components, extracting each character and cropping individual characters. Finally, OCR is used to recognize characters.

B. Bhushan, S. Singh, & R. Singla [34] give a novel technique of multi-thresholding combined with neural networks has been adopted for LPR which helps in achieving a higher recognition rate. Multi thresholding is a powerful technique for image segmentation. This is based on the assumption that an object and background pixels in an image can be distinguished by their gray-levels or colour values. According to the authors previous techniques using otsu method achieved 96.64 % recognition rate while multi thresholding technique has achieved a much improved recognition rate of 98.4 %.

A. Chaturvedi [35] proposed a method for implementing ALPR using Speed up Robust Feature matching (SURF) technique for plate detection and Advanced Radial Basis Function (RBF) for matching characters.

V. Mai, D. Miao, & R. Wang [36] implemented ALPR for all types of Vietnam license plates using edge detection and neural networks. The proposed methodology consists of 1. License Plate location (LPL) – combination of edge detection, image subtraction, mathematical morphology, radon transform, interpolation and specific characteristics of Vietnam license plate. 2. Character Segmentation – Peak to valley method and statistical parameters of Vietnam LP to segment characters & numbers in one-row and two-row types of Vietnam LP. 3. Character Recognition – Multilayer perceptron and back propogation algorithm. Overall the algorithm seems to outperform previous work in terms of recognition rate and computation time. It achieves the following rates

1. LP Location 97.13 %
2. LP Segmentation 98.21 %
3. LP Recognition 97.25 %
4. Overall ALPR System 97.43 %

The computation time is 0.25 s for a total of 700 Images

D. Ahuja, Kuldeepak [37] use different wavelets for license plate detection and feature extraction of license plate characters. Using different wavelets shape features of license plate characters are extracted and analysis of wavelets is done on the basis of recognition rate and time. It is found out that bior 3.9 has the highest recognition rate of 91.5 %. Haar wavelet requires the least time.

Mr. G. T. Sutar and Prof. Mr. A.V. Shah [38] that give a system which first captures the vehicle image then vehicle number plate region is extracted using the image segmentation in an image. Optical character recognition technique is used for the character recognition. The resulting data is then used to compare with the records on a database. The system is implemented and simulated in Matlab, and it performance is tested on real image.

D. Ventzas [39] present an approach distinguished by digit recognition performed by feed forward back propogation neural network, trained with four angle Radon transform of sample letters and numbers. The proposed algorithm is able to recognize correctly characters on license plate with probability of 94.1 %. The system was tested on 51 plate images including

old type license plates; the recognition rate of 357 character strings was 99.15%. For the 51 images the outcomes were as follows

1. License plate isolation 51/51: 100 %
2. License plate recognition 48/51: 94.1 %
3. Character recognition 354/357: 99.1 %

M. Vashishath [40] an LPR system is developed which recognizes characters using OCR inside the framework of LAB View software. The system has been tested for vehicles containing different number plates for different states. In the process of final evaluation after optimizing the final parameters like brightness, contrast, and gamma, adjustments, optimum values for light and angle from which the image is taken, the system achieves an overall efficiency of 98%.

A. P. Nagare [41] presented character recognition using two neural networks, one is Back Propogation Neural Network and the other one is Learning Vector Quantization Neural Network (LVQNN). It is observed that character recognition results obtained using Learning Vector Quantization Neural Network is better than those obtained by using Back Propogation Neural Network. The efficiency of the system can be further improved by increasing the number of fonts for training the neural network.

M.A. Saeed, M. Waqas, Z. Akbar, N. Ali [42] give a recognition scheme which is independent of the Language Alphabets written on number plate, extraction is done with the help of edge detection and connected components labeling. That show the number plates are detected and extracted precisely based on connected components and sobel edge detection algorithm with a success rate of 81%.

V. Koval, V. Turchenko, V. Kochan, A. Sachenko, G. Markowsky, & P. Square [43] the authors discuss a method to recognize license plates through image fusion, neural networks, and threshold techniques. In the proposed methodology license plate extraction is done using thresholding technique while recognition is done using neural networks. The LPR system was designed using MATLAB 6.5. The structure of neural networks includes input layers with 366 inputs, one hidden layer with 50 neurons and output layer with 46 neurons. Some noise is added to the input images. A recognition rate of 95 % is achieved in the presence of noise with 50% density.

3. Conclusion

The process of vehicle number plate recognition requires a very high degree of accuracy when we are working on a very busy road or parking which may not be possible manually as a human being tends to get fatigued due to monotonous nature of the job and they cannot keep track of the vehicles when there are multiple vehicles are passing in a very short time. To overcome this problem, many efforts have been made by the researchers across the globe for last many years. A similar effort has been made in this work to develop an accurate and automatic number plate recognition system.

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