An Integrated System for High Security Registration Plates using Morphological Operations, CCA and LVQ Neural Networks

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Abstract: Traffic management and security issues have been a growing concern over the past years. License plate recognition technology has been growing in use and has been implemented in various ways. Vehicle identification, automatic collection of toll, theft prevention are some of the applications of license plate recognition technology. With the introduction of high security license plates various new security features have been introduced. We present an integrated method for localization and detection of high security license plates using morphological operations, CCA, and LVQ Neural Networks.

Keywords: License Plate Recognition, License Plate Detection, High Security Registration Plate, Morphological Operations, CCA, LVQ Neural Networks.

I. INTRODUCTION

License Plate Recognition (LPR) technology has been used to uniquely identify vehicles. Vehicle License Plate registration plates are assigned by the regional transport office to uniquely identify a vehicle after the vehicle has been registered with the regional office[1]. This helps in identifying the owner of the vehicle, insurance information and other. The new high security registration plate (HSRP) offers security features like a hot stamped chromium based hologram, ingressed IND legend, laser etched 9-digit code, snap lock, security inscript, embossed borders and alpha-numerals, and superior grade reflective sheeting. It also has a height, thickness and separation of characters.

Fig 1. High Security Registration Plate.

II. LICENSE PLATE RECOGNITION SYSTEM

A License Plate Recognition System can be thought of as composed of three phases [2]

1. LP Detection : LP Detection is the detection of the license plate within the input imge. Various Methods have been identified for license plate detection Binary Image Processing, Gray Level Processing, Color Processing and Classifiers [2].
2. Character Segmentation: After license plate detection, individual characters are extracted. This phase extracts individual characters from the

3. license plates. Various techniques like binary image processing, gray level processing, histogram processing, local adapative thesholding and transformation [2] have been developed.
4. Character Recognition : After characters have been segmented individual characters can be recognized by various techniques like classifiers, template matching [2].

III. RELATED RESEARCH WORK

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

In [3] 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.

In [4] the authors have the authors have presented a system that uses frequency domain filter, the Mexican hat operator filter and the spatial filter for image enhancement to improve results of an LPR system for high security registration plates.

In [5] The authors have used the basic morphological operations of skeleton, end points and thinning of binary images along with a standard LPR system. For recognition of characters three features of characters - holes, junctions and end points are used. The proposed method claims to achieve a success rate of 100 %.

In [6] The authors have illustrated a comparsion between various techniques for license plate localization like block based techniques, Otsu, and state of the art. For character recognition the methodology is based on fuzzy clustering and neural networks.

In [7] 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.

In [8] the authors present 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.

In[9] 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 color 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 %.

In[10] the authors have 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.

In [11] the authors have 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
In [12] authors 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.

In [13] the authors have used Gaussian Hermite Moments and Wavelets for calculation of features of characters. These features are then used as input to neural networks for character recognition. The recognition rate of the system is 97.6%. The authors compare recognition rate between PCA (Principal Component Analysis), MI (Moment Invariants) and the proposed work to show that PCA achieves 95 %, MI achieves 96% while Gaussian Hermite moments with Wavelets achieves 97.6%.

In[14] the authors 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 %

In [15] an LPR system is developed which recognizes characters using OCR inside the framework of LABView 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%.

In [16] authors present a new methodology for image segmentation and character recognition from standard Indian number plates. (Choubey & Sinha, 2011). This method differentiates between the characters on the basis of the difference between the characters on the basis of the difference in pixel distribution density in different regions of the alphabets and numeric characters. It first recognize character is belong to which group using euler technique and which subgroup does the input belong to and then tries recognize the input by comparing the input with the critical regions that differentiate among the elements of the same subgroup.This method eliminates the problem of confusion between similar looking elements like C, G and T, I, J by exploiting the small but important differences between them.Initial experiments have shown success in differentiating between similar looking characters. It is not very successful on non standard characters and when skewness is present in license plates.

In [17] the author has 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 Learing 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.

In [18] the authors have proposed a novel method of License plate localization based on morphological operations on a preprocessed, edge image yielded by a PCNN. Then connected component analysis follows to get some candidate regions which probably contain the license plate. Finally horizontal and vertical projections are used to carry work on each candidate region for an accurate plate extraction. The PCNN has the property that neurons that are close to each other pulse at the same time. The algorithm has been tested on database of RGB natural scenes containing 100 natural samples in which 10 images with noise are contained. The algorithm is implemented in Matlab and an accuracy of 92% is obtained.

In [19] a system is described that can recognize vehicle license plate under poor environmental condition using neural network. The various phases are 1. Image acquisition : images of various vehicles have been acquired manually and then by cropping the license plate. 2. Segmentation : Segmentation of gray scale image generated by finding edges using the Sobel filter for smoothing images is used to reduce the number of connected components and then bwlabel is used to calculate the connected components, finally a single character is detected.3. Recognition : Recognition is done using an ANN. In general if the characters are large in size the system achieves 100 % accuracy, however with others the system might achieve sub-optimal accuracy.

In [20] 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 presense of noise with 50% density.

We would like to summarise the results of the survey in the form of a table showing various techniques used for detection, segmentation, and recognition

Ref	Technique Used			Results
	Plate Detection	Character Segmentation	Character Recognition	
[3]	Changes in contrast, width by height factor	Character characteristics similarities	ANN	93.7%
[6]	Block based, otsu, state of the art		Fuzzy and Neural Network	
[7]	Edge detection, morphological operations	Connected Component Analysis	Block based ANN	98.2%
[8]	Estimate of plate location or image	Component analysis	Optical Character Recognition	93%
	segmentation			
[9]	Multi-thresholding	Blob-extraction	ANN	98.4%
[10]	SURF	Morphological operations and Connected Component Analysis	Radial Basis Function ANN	95%
[11]	Edge Detection, Morphological operation, radon transform	Peak to valley method and statistical parameters of license plate	ANN	97.43%
[12]	Edge detection, Wavelets	Connected Component Analysis	Wavelets, ANN	91.5%
[13]	-	Connected Component Analysis	Gaussian Hermite Moments and Wavelets and ANNs	97.6%
[14]	Edge detection, Morphological operations, Connected Component Analysis & otsu	Connected Component Analysis	ANN with four angle Radon Transform	94.1%
[15]	Thresholding	ROI Based character segmentation	Optical Character Recognition	98%
[17]	Morphological operations	Lines and Clips functions	Learning Vector Quanitzation Neural Network	94.4%
[19]	Manual	Edge detection, histogram equalization, thresholding	ANN	
[20]	Thresholding	Cutting regions and thresholding	ANN	95%

IV. PROPOSED METHODOLOGY

We propose a method consisting of the following three phases

A. License Plate Detection

For this we propose a series of morphological operations. The following figures illustrate the operations
1. Original Image

2. Image is converted to greyscale and median filter is applied to remove noise.

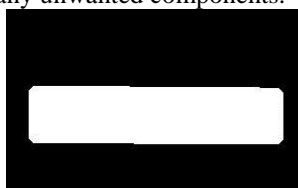3. Edge Detection is performed using the canny edge filter.

4. Morphological closing operation is performed to isolate the license plate area.

5. Morphological hole fill operation is performed to close out any holes in the plate area.

6. Morphological opening operation is performed to isolate any unwanted components.
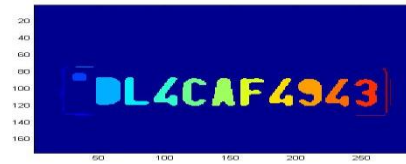

7. Finally the license plate is extracted.

B. Morphological Operations

Certain morphological operations are applied to the extracted number plate

C. Character Segmentation

1. Connected component analysis is used to label the individual components.

2. Individual characters are extracted by looking at the connected component at the center. Now all the connected components which have similar height as central character are extracted. Thus we get the characters as shown below.

D. Character Recognition

Character recognition is done with the help of neural networks. For this purpose an LVQ neural network is used. The LVQ Neural network is trained with the following reference image containing characters.

The LVQ neural network has 35 hidden neurons in the hidden layer and a learning rate of 0.003. the hidden layer has 35 neurons. The input layer is fed the $37 * 3 = 111$ characters from the image and outputs one of 37 alphabets – 0 – 9, 0 and A – Z.

V. RESULTS AND CONCLUSIONS

The methodology has been applied on a set of 23 images and we have tabulated the results.

License Plate Number	Results		
	Plate Detected	No. of characters segmented	No. of characters recognized
AB1CD2345	YES	9	6
DL4CAF4943	YES	10	10
DL8CN8726	YES	-	-
GA03MJ1011	YES	7	3
GJ05KP2603	YES	6	2
HR26BC8009	YES	10	7
IJ1KL2345	YES	1	1
KA19P8488	YES	8	7
KA01MC9499	YES	9	6
KA03MJ	YES	-	-
KA03MJ1011	YES	5	3
KA28A8858	YES	9	8
KA52A5255	YES	8	7
MH04EQ601	YES	-	-
MH12DE1433	YES	7	4

MZ01E7773	NO	-	-
PB65T7614	YES	8	7
SK01P5456	YES	3	2
TN0600000	YES	-	-
TN10S9790	YES	5	3
UK04M	YES	5	3
WB02W6886	YES	9	5
WB06F5977	YES	3	2

From the results we can conclude that when the license plate is clear and characters and distinct a results of 80-100% can be achieved. However, in case of license plates that are diffuse, or noise is present, or skewness is present, a recognition rate of 10-40 % is achieved.

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