Design of Algorithm for Vehicle Identification by Number Plate Recognition

Vijayalakshmi. Palanisamy,
Department of IT,
Pandian Saraswathi Yadav Engineering College,
Arasanoor, Sivagangai.
Sumathi. Mahadevan,
Department of computer Science,
Sri Meenakshi Govt. women's College,
Madurai

Abstract—**Design of an algorithm for vehicle identification by recognizing the number plate is presented. Automatic number plate recognition plays an important role in numerous applications. However, most of them works under restricted conditions, such as fixed illumination, limited vehicle speed, designated routes, stationary backgrounds etc. This, new vehicle identification technique consists of vehicle detection, plate localization, character extraction and recognition. Here, Genetic algorithm (GA) is employed at two levels: for detecting the vehicle from traffic image and recognizing character from the number plate. Detection is based on contour and shape information. GA controls window size to capture each vehicle in a separate widow. Pixel connectivity and adjacency concepts are used to locate and extract the number plate. A digital board (DB) with window panes is introduced to recognize characters uniquely. GA is adopted at the second level to control and map character pixels into the window panes of the digital board. Distinct feature vector is derived from the DB for each character of the number plate. Finally, a feature based matching is adopted for recognition. Experiments have been conducted with images taken from various scenes and conditions and the detection rate is found to be 92.5 %. Experiments have conducted for recognition with LPR images taken at different conditions and the recognition rate is found to be 91 %. Potential applications include provisioning of vehicle parking facilities and campus security system for permitting authorized vehicles into the premises.**

Index terms- Genetic algorithm, road traffic images, feature extraction, detection and character recognition

1. INTRODUCTION

Object detection is still a challenging task. It is a critical part in many applications like image search, image understanding and scene analysis. However, still it is an open problem due to complexity of object classes and images. Current approaches for object detection are categorized as top down approaches and bottom up approaches. Top down approaches include training stage or to define object configurations. The later approach includes low level image features to high level image features. Here, we include both the approaches for vehicle detection and character recognition [1],[2],[3],[4]. An automatic numberplate recognition (LPR) technique was proposed. It consisted of two modules: a number plate locating module and a number identification module. The former was characterized by fuzzy disciplines attempted to extract number plates from an input image, while the latter used conceptualized in terms of neural subjects to identify the number present in a license plate[5]. An algorithm using adaptive segmentation technique and connected component analysis in conjunction with a character recognition neural network was proposed. The character recognition system was a two-layer probabilistic neural network (PNN), trained to identify alphanumeric characters from car number plates based on data obtained from algorithmic image processing [6]. Numbers in vehicle plates of the input image was detected that used color conversion, edge detection and connector measurement techniques. Edge detection techniques using sobel operator was employed to extract numbers in a vehicle plate [7]. Another automatic detection and recognition of vehicle number plates using template matching employing GAs and neural networks were presented. Neural networks were trained to recognize characters. To control size of the neural network inputs and template, a GA search was applied. The drawback was that a huge color database was to be created manually extracting colors from number plates [8]. In another paper, detection was performed in two steps: incoming vehicle detection and vehicle motion analysis. A 3-D Pulse-Coupled Neural Network (PCNN) model using optical flow calculation was presented. Vehicle which entered the observation field was identified by inspecting its vehicle-related features. The training of neural network was performed in an off-line mode and it took longer training time [9]. A tree based Genetic Programming (GP) for classification methods were reviewed and analysed. Strengths and weaknesses of various techniques were studied and a framework to optimize the task of GP based classification was provided. The major drawback was a conflict between more than one classifier [10].

A framework using active learning to train a robust monocular on-road vehicle detector based on Adaboost classification and Haar-like features was presented. Ada boost training took 14 days to train a cascade of 20 stages on a 2.9GHz Pentium desktop computer. Detection posed difficulty with images captured in poor illumination and background conditions [11]. An algorithm was presented for vehicle's number plate recognition system, consisted three major parts: extraction of plate region, segmentation of characters and recognition of plate characters. For extracting the plate region, edge detection algorithms and smearing algorithms were used. In segmentation part, smearing algorithms, filtering and some morphological algorithms were used. And finally statistical based template matching was used for recognition of plate characters [13]. Another paper had aimed at automatic detection of car number plate using gentle Ada Boost algorithm which combined with a cascade structure. The gentle Ada Boost (GAB) algorithm had a higher detection rate and a lower false positive rate than the basic discrete. The use of a cascade structure in the gentle Ada Boost algorithm was efficient [14].An approach for vehicle detection employing sensor fusion of a laser scanner and a video sensor was proposed. A pattern recognition algorithm using neural networks based on contour and shape information was employed. More data were required for system evaluation and ground truth data was labelled by hand. The preparation of labelled data was time consuming and costly [16]. A framework to measure the influence of image resolution on appearance-based object classification was presented. It was based on measuring the signal energy that was preserved in a low resolution image with respect to a high resolution image. The approach employed an ADA Boost algorithm with Haar-like features for vehicle detection. The detection results were based on a trade-off between classification performance and computational load [17]. An automatic system to detect preceding vehicles on highway under various lighting and weather conditions was proposed. A particle filter was used and that included processes like initial sampling, propagation, observation, cue fusion and evaluation. Since sensors interpret colors differently, color filter's parameters needed to be adjusted for optimal detection operation [18]. A modification of GA for shape detection using edge detection algorithm was presented. The time and storage complexity of the method were more and it was a function of number of detected features [19]. An approach using GP based object detection to locate small objects of multiple classes in large pictures was described. It used a feature set computed from a square input field that contained objects of interest. There were errors in detection in complex images [20]. An approach for effective objective function for stochastic search algorithm was presented. N-Queen problem was solved employing genetic algorithm. A weight is computed to each bit (gene) position to compute over all fitness of the string [21]. Here, an algorithm for vehicle identification by number plate recognition and its application to vehicle screening at parking places is presented. It consists of vehicle detection, plate and character extraction and character recognition. GA is employed for detecting the vehicle and recognition of plate characters. Features based matching is also adopted for recognition. The experimental results show that the new algorithm produce good results in terms of detection accuracy and time. The new method is linear to the number of objects present. The remaining paper is organized as follows: In chapter 2, proposed method for vehicle identification is presented. In chapter 3, performance of various phases and analysis of experimental results are provided. In chapter 4, conclusion and future work are presented.

II. PROPOSED METHOD

Traffic images are captured and it is compensated for noise and illumination variations. Edge and gradient techniques are employed to extract fore ground details. Number of regions in the image is computed by counting the gray levels transitions. Windows equal to number of regions with left, right, top and bottom lines are defined. GA is employed to control the window size to detect and capture each object region in a separate window. Based on the geometrical features of the detected window such as height, width and aspect ratio, objects regions are categorized as small, medium and heavy vehicles. Then, number plate is localized and extracted by pixel processing techniques. A digital board (DB) is introduced to align the character pixels into unique line features. GA is employed at the second level to control and map the character pixels into the window panes of DB. Finally, a features based matching is adopted for character recognition.

A.GA based detection

Parameters that decide the solution for the detection of vehicle are collected and a seven bit string is coded as shown in Fig 2.1. The first bit is to decide if the detected window encloses a vehicle or non vehicle. Next three bits define left, right and top lines of the capturing window. Fifth bit is to find if more than one vehicle is overlapped. Sixth and seventh bits are used to define the vehicle category. Traffic reference line may forms a the bottom line for all the windows. Windows equal to number of object regions in the image are defined. Initially, window lines are misaligned and hence fitness value of string is less than expected. Iterations are performed till all window lines are aligned. At that point, each window detects and captures a separate vehicle region disjointly. Based on the geometric features of detected window, vehicles are classified. Table 2.1 lists object categories considered here.

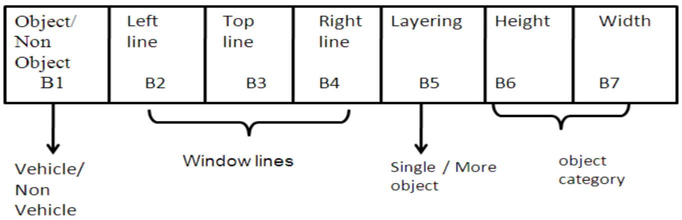

Fig 2.1 String for vehicle detection

TABLE 2.1 LIST OF OBJECT CATEGERY

B6 B7 in String	**Object Categories**	**Examples**
0 0	Small Vehicle	Scooter, motor cycle
0 1	Medium vehicle	Van, Car, Jeep
1 1	Heavy Vehicle	Bus, Lorry, Truck and Container

B. Localization and extraction of Number plate

Usually, number plate in the vehicles is fixed nearly at the bottom both in the front and back. Also, characters are printed either in a single row or in two rows. Original image of captured window serves as input image for plate localization. Using connected component analysis and density of line and edge features, number plate is localized and extracted [1], [2], [3], [4].

C. Digital Board Format and Character Recognition

Here, a digital board (DB) format that is similar to a LED display is introduced. It is used to extract pixels of the character uniquely for recognition. It is a two dimensional 36x36 pixel array of four window panes of each 3x3 pixels shown in Fig 2.2. Rules are framed how to map character pixels into the DB window panes. Four lines line1, line2, line3 and line4 are defined to map pixels into DB window panes. For example, two pixels fall in the same line as defined in Fig 2.3 are to be mapped as in Fig 2.4 into a full column or row. If two pixels fall in different lines, then they are mapped into both column and row, shown in the figure 2.4. Here, two pixels are present in “Line1”in the first example; in the second example one pixel present in “Line1” and another in “line4”. Each character in the number plate is mapped on to a Digital board (DB) one by one. A unique feature vector is computed for each character.

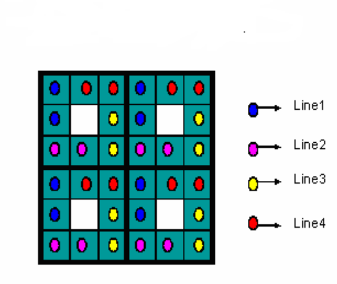

Fig 2.2 Digital Board Format

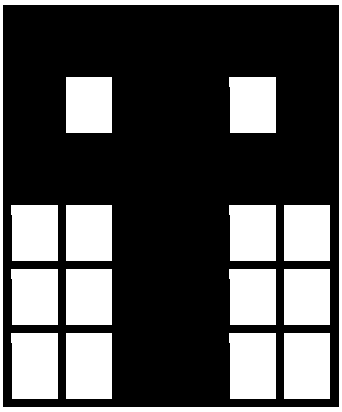

Fig 2.3 Digital Board Format Letter “T”

Four window pane’s values represent a feature vector of that character. A white pixel represents 255 and black pixel represents by a ‘0’ value. A DB consists of four window panes. Each window pane consists of 9 pixels. Sum of white pixels in each window forms a feature and four window panes together forms a feature vector of that character, shown in the following equation 2.1. The feature vector for character ’T’ is shown in Fig 2.3. DBF (letter ‘T’) = [255,255, 1530, 1530].

$$DB = \begin{bmatrix} \sum white\ pixel\ in W1, \sum white\ pixel\ in W2, \\ \sum white\ pixel\ in W3, \sum white\ pixel\ in W4 \end{bmatrix} \quad 2.1$$

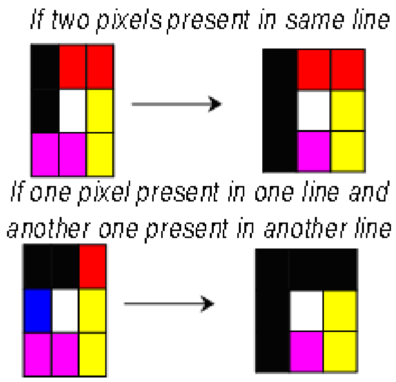

Fig 2. 4. Rule for mapping character pixel into DB

GA is employed for character recognition at the second level. String for character recognition consists of six bits shown in Figure 3. The first bit is to decide if the captured character is an alphabet or a number. The second bit is to decide if the captured character matches more than one. The remaining four bits represent mapping of four window panes of digital board.

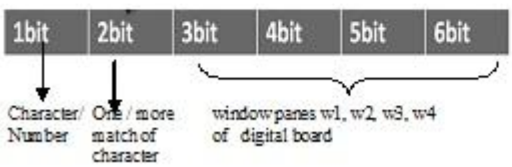

Fig 2. 5 String for Character Recognition

D.Algorithm

Read_jpeg,file
Extract fore ground object details
Decode a string for detection
{ struct of GA for detect
generate initial population;
fitness evolution;
reproduction;
cross over;
mutation};
Train for more traffic images
Localize and extract Number plate
cx=dim[0]/2;
cy=dim[1]/2;
Decode a string for character recognition
{ struct of GA for character recognize
bit=intarr(7,2,windows+1);
Design a DBF to recognize character
character[1,i]=total(w1);
character[2,i]=total(w2;
character[3,i]=total(w3);
Character [4,i]=total(w4);
{generate initial population;
fitness evolution;
reproduction;
cross over;
mutation ;}
Do iterations till algorithm converges
Train for more character images

III. EXPERIMENTAL RESULTS

TABLE 3.1 SAMPLE FEATURE VECTORS

Character	Feature vector
T	[255,255, 530,1530]
D	[1020,255,255,255]
N	[0,1530,1530,0]
F	[0,2295,1530,2295]
0	[510,510,510,510]
5	[255,1530,1530,0]
4	[255,1530,1530,255]
6	[255,765,255,255]
7	[1530,255,255,1530]

This algorithm for vehicle identification by plate recognition employs GA. The new algorithm is tested on road traffic images captured in national highways in India also. Traffic images may consist of a truck, bus, scooter, bike, car, motor cycle etc. This algorithm is implemented on Intel Core to Duo Processor in Windows XP using RSI's IDL platform. Experiments are carried out with images from LPR images. Edge based segmentation and is adopted to detect object regions and they are captured in separate windows using GA. If more than one object present in a single window, overlapping region is detected and removed. Experiments are repeated for detection with eight bit string using a separate bottom line for each window. Experimental results are better for edge images obtained by gradient methods than threshold methods. Shape information is employed to detect vehicle categories. Shape features like height, width, aspect ratio of all road vehicles are computed and maintained in a separate data base. Experiments have conducted with more than 100 images taken from various conditions. For 8 images, detection was poor and wrongly detected the vehicle regions; vehicle detection rate is 92.5 %. Detection experiment outputs are shown in Fig 3.2. From, Fig 3.2 d to f, detected window size of a scooter, car and bus and they are obviously different. Detection accuracy and detection time are two performance indicators of any recognition algorithm. Execution time of new detection algorithm is compared with state of art algorithm and is shown in Table 3.2. It is observed that IDL tool is an array processor and supports images and hence, more efficient for detection. Pixel connectivity and line features are used to localize and extract number plate and output results of extraction.

To recognize character uniquely, a digital board is introduced. It is employed to capture each character into four window panes (3x3 pixel arrays). GA is adopted to align and map character pixels into the DB window. A six bit string is decoded character recognition. Using the DBF Standard feature vector for all characters (letters and numerals) are computed and maintained in a data base. Sample feature vectors of characters are tabulated in Table 3.1. Feature vector for a test character is computed and matched with standard vector to recognize individual character. For experiments, images from LPR data bases shown in Fig 3.1 are employed. Experiments are conducted on test images that were taken under fixed illumination, with static backgrounds. For few characters recognition results are very poor and they are not good for dirt and shadow images. Experimental outputs of character recognition are shown in Fig 3.3 b - j. The resultant extracted number plate is shown in Fig 3.3 k and compared with original plate Fig 3.3 l. We faced difficulties to map cursive style characters into DB, otherwise recognition results are good. Detection accuracy is computed as the ratio of number of successful instances to the total instances of classification. Detection and character recognition rate are tabulated in Table 3.3. Also it is found time is linear to number of objects present in the image.

TABLE 3.3 EXPERIMENTAL RESULTS OF NEW ALGORITHM

Stages	Test images	Success instances	failure instances	Detection/ recognition rate in %
Detection	108	100	8	92.5
Character Recognition	310	283	27	91

Fig 3.1 LPR database

TABLE 3.2 COMPUTATIONAL EFFICIENCY OF DETECTION

Research	Feature Extraction	Learning, Classification	Image Size	Detection Time (ms)
Ref [18]	Vertical, horizontal edges, Motion	Particle filter	320×240	47
Ref [20]	MLP Hidden space	Multi layer Neural Networks	32×32	0.328
Ref [9]	Haar like features	Adaboost	Not specified	80
Ref[11]	Haar like features	Adaboost	704×200	57
Proposed Algorthm	Edges, Digital Board features	GA	767×403	30

Fig. 3.2 a) Input Traffic image b) captured vehicle window by GA

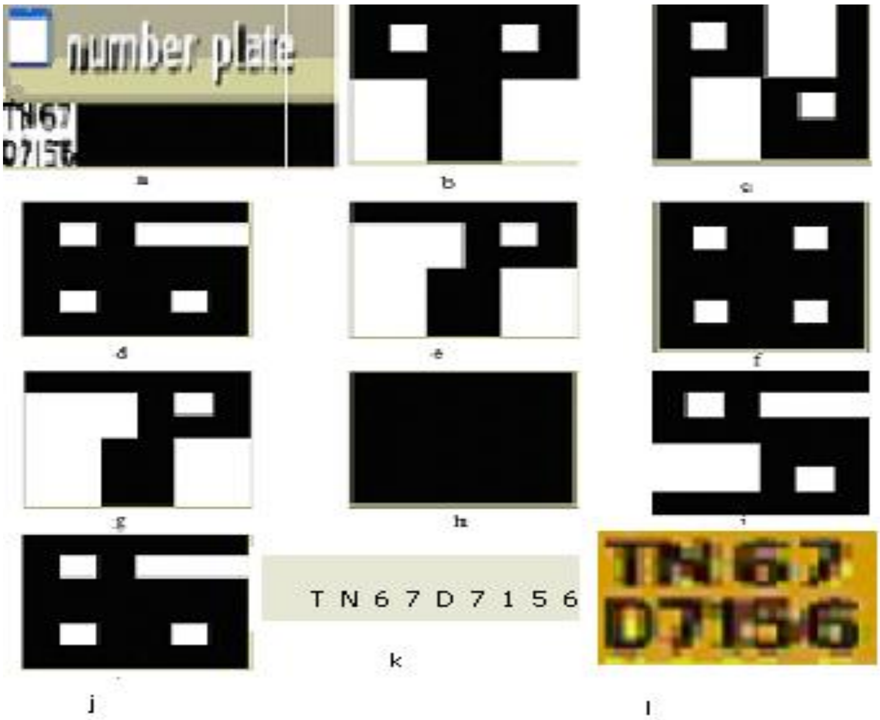

Fig. 3.3 a)Extracted Number Plate; b - j) Recognized number plate characters ;
k) Recognized number plate l) original number plate

IV. CONCLUSION

An algorithm for vehicle identification by plate recognition is designed and tested for vehicles and number plate images. For a large set of images including diverse angles and different lighting conditions, the system is tested. Experiments have been conducted for more images for detection, and character recognition taken from various scenes. The algorithm can quickly and correctly detect the vehicles and recognize the characters in the number plate. The proposed algorithm can be applied for any system with required modifications.

REFERENCE

[1]. David E Goldberg," Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley Professional; 1 edition, ISBN-10: 0201157675, 1989,

[2] Mengjie Zhang, Victor Ciesielski, "Genetic Programming for Multiple Class Object Detection", Springer Berlin / Heidelberg, ISBN No. 978-3-540-66822-0, 2007, pp

[3]. Milan Sonaka, Vaclav Hlavac, Roger Boyle, "Image processing, Analysis, and Machine Vision", Thomson learning Inc. ISBN : 981-240-061-3, 1998, pp.822-827.

[4] Rafael C.Gonzalez, Richard E.Woods, "Digital Image processing," PHI Learning Private Ltd. New Delhi, ISBN: 978-81-203-3640-7. 2008,138 pp125-

[5]. Shyang-Lih Chang; Li-Shien Chen; Yun-Chung Chung; Sei-Wan Chen, "Automatic Numberplate Recognition", ; IEEE Transactions on Intelligent Transportation Systems, Volume: 5 Issue:1, pp. 42-53, 2004.

[6]. Anagnostopoulos, C.N.E.; Anagnostopoulos, I.E.; Loumos, V.; Kayafas, E.; "A NumberPlate-Recognition Algorithm for Intelligent Transportation System Applications", IEEE Transactions on Intelligent Transportation Systems. pp 377-392, 2006.

[7]. P.K.Suri, Ekta Walia, . Amit Verma, "Vehicle Number Plate Detection using Sobel Edge Detection Technique", IJCST, Vol. 1, pp:179-182, 2010

[8] Stephen Karungaru, Minoru Fukumi, Norio Akamatsu, "Detection and Recognition of Vehicle NumberPlates Using Template Matching, Genetic Algorithms And Neural Networks", International Journal of Innovative Computing, Information and control, ISSN 1349-4198 Volume 5, Number 7, pp. 1975—1985, July 2009.

[9] S. Wender, K. Dietmayer, "3D vehicle Detection Using a Laser Scanner and a Video Camera", Intelligent Transport Systems, IET, , vol.2, no.2, , pp.105-112, June 2008.

[10] Hajir Jabeen, Abdul Rauf Baig , "Review of Classification Using Genetic Programming", international Journal of Engineering Science and Technology, Vol.2 (2), 94-103Issue 2, 2010.

[11] Sayanan Sivaraman and Mohan Manubhai Trivedi, "Active Learning Based Robust Monocular Vehicle Detection For On-Road Safety Systems", IEEE , 978-1-4244-3504-3/09, 2009.

[12] G. Saravana Kumar and S. Ravi, " Eye Detection and Tracking Using Genetic Algorithm", MASAUM Journal of Computing, Vol.1, No.1, pp: 32-36, 2009.

[13] ozbay, and Ergun Ercelebi, Serkan, "Automatic Vehicle Identification by Plate Recognition", A World Academy of Science, Engineering and Technology, pp:222-225, 2005.

[14] Dong Cui; Dongbing Gu; Hua Cai; Junxi Sun; "Numberplate detection algorithm based on gentle AdaBoost algorithm with a cascade structure ," IEEE International Conference "Robotics and Biomimetics (ROBIO), 2009 Issue Date: 19-23 Dec. 2009 ,On page(s): 1962 - 1966

[15] Faradji, F.; Rezaie, A.H.; Ziaratban, M," A Morphological-Based NumberPlate Location" IEEE International Conference on Image Processing, on Issue Date: 2007 pp: I - 57 - I – 60.

[16] Y. Cao, A. Renfrew, P. Cook, "Vehicle Motion Analysis Based on a Monocular Vision System", Road Transport Information and Control- RTIC 2008 and ITS United kingdom Members' conference, pp.1-6, 20- 22.

[17] A. Haselhoff, S. Schauland, A. Kummert , "A Signal Theoretic Approach to Measure the Influence of Image Resolution for Appearance- based Vehicle Detection", Intelligent Vehicles Symposium, IEEE, June 2008. pp: 822 - 827

[18] Y. Chan, S. Huang, L. Fu, P. Hsiao, "Vehicle Detection under Various Lighting Conditions by Incorporating Particle Filter", Intelligent Transportation Systems Conference, 2007, pp.534-539.

[19] S. M. Abdel- gaied, "Employing Genetic Algorithms for qualitative Shapes Detection", ICGST-GVIP, December 2008, ISSN 1687-398X, Volume (8), Issue (IV).pp:18-25

[20] O.L. Junior, U. Nunes, "Improving the Generalization Properties of Neural Networks: an Application to Vehicle Detection", Intelligent Transportation Systems, , 11th International IEEE Conference on, 2008, pp.310-315, 12 -15.

[21]. P.Vijayalakshmi, M.Sumathi, "Design of efficient objective function for stochastic search algorithm", ICMMSC 2012, CCIS 283, 2012.© Springer-Verlag Berlin/ Heidelberg ,2012, pp. 480–487,