License Plate Detection Using Hybrid Morphological Technique and Recognition Using Neural Network

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Abstract : In this paper we discuss an efficient approach to detect license plate and recognize them. Our approach automatically detects and track license plate using Kanade Lucas Tomasi (KLT) algorithm. In this algorithm, we used two modes. First is detection and second is tracking mode. In detection mode, we used two-stage approach to detect license plate (LP) to improve accuracy. In first stage, a set of candidate plate regions were detected using Viola-Jones algorithm. In second stage, AlexNet as a feature extractor and SVM as a classifier are used. If image passes the test then using various morphological operations, exact plate region extracted. After successful detection of LP, alphanumeric areas were extracted. To recognize alphanumeric images backpropogational neural network is used. In second mode licence plate tracked. Counter applied to refresh target after every 50 intervals. Experimental results show that this method provides improved LP detection as compared to the existing baseline methods.

***IndexTerms* - Kanade Lucas Tomasi (KLT) algorithm, Viola-Jones algorithm, AlexNet, SVM Classifier, Morphological operations, Alphanumeric, Backpropogational Neural Network.**

I. INTRODUCTION

License plate processing (LPP) systems are gaining popularity in security and traffic installations. The complexity of algorithms for automatic number plate recognition varies throughout the world. The toughest part in developing typical LPP system is the detection and segmentation of the plate. It affects the performance of the LPP systems.

Proposed system consists of an algorithm for detection of license plate, based on two-stage approach. The two-stage approach is effective in plate detection. Viola-Jones algorithm provides faster and effective results as compared to existing techniques.

A strong convolutional neural network filters candidate plate region [1]. This approach showed significant improvement in performance. After this stage, alphanumeric area detected using various morphological operations. The main advantage of using morphological technique is that it does not require training dataset. Feature extraction algorithm speeds up the computation of neural network.

The organization of this paper is as following. In Section 2, we mentioned modifications to method constructed and provided illustrations of the modifications. In Section 3, we present research findings and analysis of those findings. Finally, Section 4 concludes the paper.

II. METHODS AND MATERIAL

This section explains the present approaches for plate detection and recognition.

In paper [1], author has localized plate, using knowledge based approach. Sparse Network of Winnows (SNoW) classifier identifies candidate plate regions. A recent knowledge based approach found is Viola Jonas approach which showed slightly improved performance. AlexNet classifier filtered the candidate license plate. Instead of processing the plate if image is too bright or dark, it classified them into different categories for human review purpose. HOG features with SVM classifier has been used for OCR.

Appearance based approaches were found in [3], [4] and [5] used for detection of license plates.

In paper [3] author proposed convolution operation of Riesz fractional derivative (mathematical model) to enhance minutes of edge information in plate to get accuracy in text detection and recognition.

In paper [4] author has used novel Line Density Filter method. It enabled to connect regions with high edge density and removes sparse regions in each row and column from a binary edge image.

In paper [5] author has done pre-processing, morphological operations and bounding box method for segmentation. License plate recognized using Template matching.

Following is the implemented method and refinement in it. This approach showed improved performance in terms of both accuracy and efficiency.

A. Input video

Camera captured video is taken as input. Video converted to sequence of frames.

B. Viola Jones Algorithm

In this approach candidate, plate regions are detected using following key concepts:

Algorithm has following four stages:

1. Haar-features
2. Creating Integral Image
3. Ada-Boost Training and
4. Cascading Classifiers

1. Haar-features: Haar-features also called as Haar wavelet. It is a sequence of rescaled square-shaped function. They are like convolutional kernels. Features are calculated using sum of pixels within rectangular area. Haar-features are calculated using addition of white shaded pixel intensities subtracted from the addition of black shaded pixel intensities. Following are the examples of line and edge based feature.

(a) (b) (c) (d)

Fig.1(a) Horizontal line feature, (b) Vertical line features, (c) Horizontal edge feature and (d) Vertical edge based features.

Δ = dark - white = $\frac{1}{n}\sum_{dark}^{n} I(x) - \frac{1}{n}\sum_{white}^{n} I(x)$

Where, n is the number of pixels in given region.

Viola-Jones algorithm compares how close the real scenario is to the ideal case. Ideal value of haar feature is one. Closer the value to 1, the more likely it is to be a haar-feature. Edge features can detect edges effectively and line features can detect lines effectively.

2. Integral image: It is summed area table. Integral image used to detect features quickly. In a constant time, rectangular features evaluated. Hence, it results in increased speed for detection of features. Increase in speed occurs because each feature's rectangular area is adjacent to at least one other rectangle. The two-rectangle feature computed using six array references. The three-rectangle feature computed using eight array references and the four-rectangle feature were computed using nine array references.

3. Ada-Boost: It is learning algorithm. It combines different classifiers using same dataset. When testing an image evaluating all the features would be computationally expensive. Hence, AdaBoost learning algorithm implemented to select the best features for plate detection. It constructs a “strong” classifier as a linear combination of weighted simple “weak” classifiers.

$$h(x) = \text{sgn}\left(\sum_{j-1}^{M} \alpha_j h_j(\text{x})\right)$$

Each weak classifier is a threshold function based on the feature f_j.

$$h_j(x) = \begin{cases} -s_j \ if \ f_j < \theta_j \\ s_j \ \ otherwise \end{cases}$$

The threshold value θ_j and the polarity $s_j \in \pm 1$ are determined in the training, as well as the co-efficient α_j.

4. Cascade Classifier: It consists of binary classifiers.

In a cascade, the strong classifiers arranged.

After passing through the preceding classifier, only on the selected samples each successive classifier trained.

No further processing performed if at any stage cascade classifier rejects the sub-window under operation and next sub-window proceeds further.

Cascade of classifiers appear like a degenerative tree.

At each stage in cascading has strong classifier.

Each stage has specific number of features. All the features were grouped into several number of stages.

The duty of every stage is to find whether current window is candidate plate region or not. The current window will get rejected if it fails in at any stage.

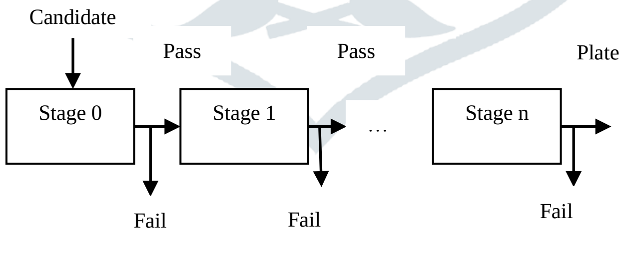

Fig.2 Cascade of Classifiers

C. *Kanade-Lucas-Tomasi (KLT) Algorithm*

Candidate plate regions were detected using Viola Jones algorithm. Corner points were searched using the eigen value algorithm inside the detected region to find feature points. The minimum eigen value algorithm [8] is used to find feature points. KLT algorithm works well when motion is small. It computes displacement of features or interest point in consecutive video frames.

Assuming a local translational model between subsequent video frames, the displacement of a feature computed using Newton’s method to minimize the sum of squared distances within a tracking window around the feature position in the two images [9].

The KLT works in following manner:

1. Detect candidate plate
2. Identify plate features
3. Track the plate

KLT is an easy tracking algorithm. In its basic form, it tries to find the shift an interest point might have taken.

The framework based on local optimization: usually a squared distance criterion over a local region that we optimize wrt. the transformation parameters, e.g. displacement in x and y.

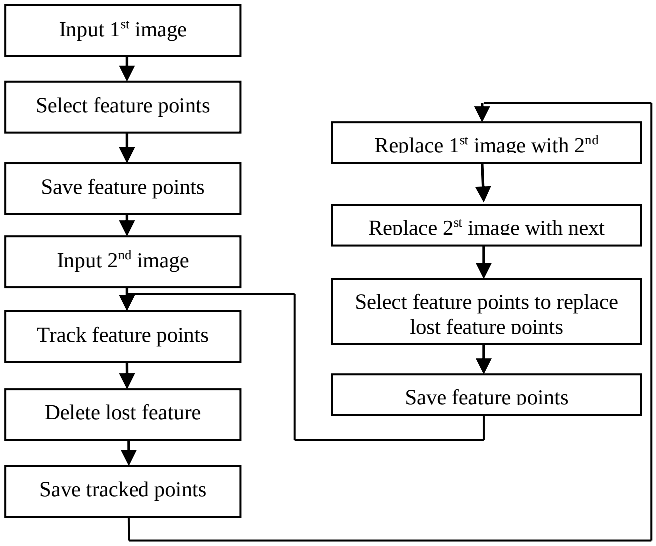

Fig. 3 Flowchart KLT

In order to solve this problem, we approximate the feature displacement with a linear term using taylor series. This framework can be also used to solve for more realistic transformations (considering rotation or general affine transformations etc). This algorithm usually works well for corner-like features that do not suffer from any aperture problem.

D. Plate region confirmation using CNN

Candidate plate regions provided as input to AlexNet. Features of candidate plates extracted using AlexNet [1].

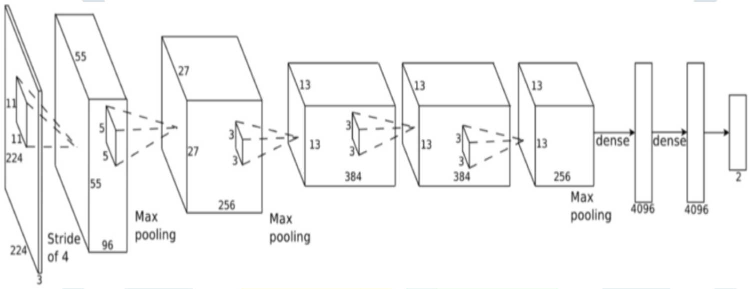

Fig. 4 AlexNet

The AlexNet consist of five Convolutional layers and three fully connected layers. The first layer is the image input layer. It explicitly requires input images of size 227-by-227-by-3. Where, 3 is the number of colour channels. Features extracted from AlexNet at fc7 layer.

SVM classifier gets features extracted from AlexNet. It classifies the input into two classes such as plate or no plate. It also calculates confidence score for candidate plate regions.

E. Hybrid Morphological Processing

This method includes conversion of color image into indexed image. A quantized color is set at five. Regions sorted based on color. This gives a binary image having zeros outside the region of interest and ones inside. Background opening operation used to adjust the background illumination. In this project, original image opened with rectangle shaped structuring element having dimension 3x30. To obtain consistent background, the original image is subtracted by background image. Contrast is first increased using saturating 1 percent of the input at low and high image intensities. Then intensity values increased to fill the uint8 dynamic range. This results in adjusted intensity of image. Then erosion, adaptive histogram equalization, morphological reconstruction operations performed. For morphological reconstruction, the fast, hybrid, greyscale reconstruction algorithm is used. For Border clearing, morphological reconstruction is used. For this input is the mask image and marker image consist of zeros excluding the border.

Intensity is adjusted in the image by maximizing histogram H-maxima transform is set at 6 and connectivity is set at 26.

Binarization followed by filling holes, logically AND operation and morphological clean operation results in pre-processed image.

For extracting the candidate plate, horizontal histogram using threshold, detects the regions, which will satisfy the dimensions of license plate. Figure 1 shows horizontal histogram.

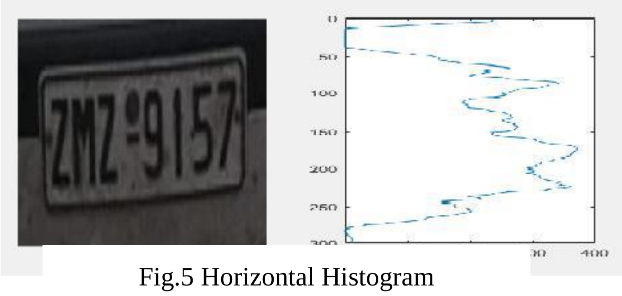

Fig.5 Horizontal Histogram

Image dilated using vertical and horizontal structuring elements followed by filling holes operation. Then combine the results. Remove the extra objects intersected in combined image. Performing element wise multiplication removes unwanted regions and keeps only those, which are present in both of them. Every region present in image labelled. Then region extracted with biggest area. This considerably removed some false designate areas. After that candidate, plate regions smoothed and enlarged. Bounding boxes calculated around remaining places and the coordinates of those bounding boxes noted.

F. Character Extraction and Recognition

Thinning operation shrinks an object without holes to smallest connected stroke. It shrinks an object with holes to a connected ring in middle between hole and its outer edge. For example, thinning of a set A by a structuring element *S* is done by removing a part of A from set A specified by the hit-or-miss transform $A \circledast S$. The thinning is denoted by $A \circ S$ and written in set notation as $A \circ S = A \setminus (A \circledast S)$ where, the set operation $X \setminus Y$ is a subtraction, which results in the elements, which are in *X* but not in *Y*, i.e. $X \cap Y^c$. To use the hit-or-miss transform, $A \circledast S$, the two components of *S* must be chosen so that connectivity is unaffected. Thinning reduces thickness of object to single pixel.

Break operation changes the edge-connected pixels to zero.
For example,

1	1	1		1	1	1
0	1	0	Transforms	0	0	0
1	1	1	into	1	1	1

Majority operation changes the value of central pixel to one if its 3-by-3 neighbors have five or more than five pixels as one. Otherwise, it changes the value of central pixel to zero.

Image region properties are measured. Each 8-connected object in the binary image measured. Regions labeled with double precision helps to detect areas in binary image.

Bounding boxes are plotted, which are specified as a 4-element vector. Strongest bounding boxes from overlapping clusters were selected using aspect ratio. Height and width of every bounding box and size of detected plate is used to decide which bounding having highest possibility for presence character image**.**
Each cropped region resized into 70 x 50 pixels. To extract features, the cropped binary image has taken and changed it to 5x7-character representation in single vector. Then chunks of image vectors (10x10) has taken and converted that to a single number by summing the whole area. The summation is then stored in (1) to (35) locations. The numbers stored converted to a number within a value between ranges 0 to 1. The whole row vector converted into a column vector. Then this column vector presented to the backpropagational network neural for recognition purpose. Artificial neural network trained by using extracted feature vector. Scaled Conjugate Gradient Backpropagation architecture used for training purpose.

III. RESULTS AND DISCUSSION

A. Methodology

Our proposed approach implemented in MatlabR2017a. This approach evaluated on the widely used Medialab vehicle dataset. It includes more than hundred vehicle images.

The NPR algorithm designed has six parts:

1. Input video
2. Viola Jones Plate Detector
3. KLT Detector and Tracker
4. Plate region confirmation using CNN
5. Plate Extraction
6. Character Extraction and recognition

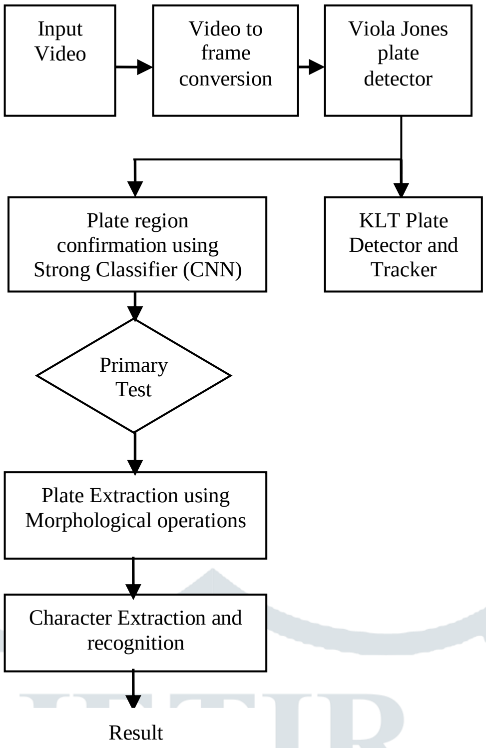

Figure 6 Methodology of Proposed work

TABLEI
PERFORMANCE ANALYSIS ON VIDEO DATASET

Sr. No.	Accuracy		
	Test	**Detection**	**Recognition**
1	Proposed Approach	98	87
2	Existing Approach	88	85

B. Output

Outputs obtained are as following:

1. Processing at single frame are as following:

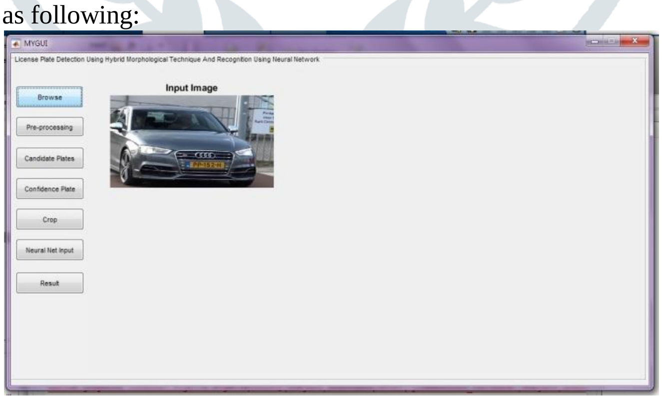

Figure 7 Input Image

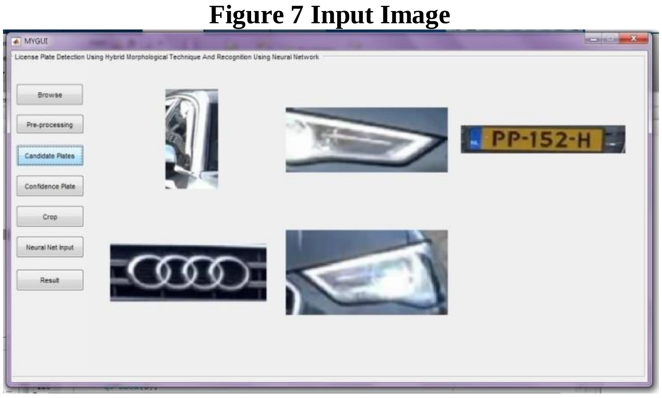

Figure 8 Candidate Plate Region

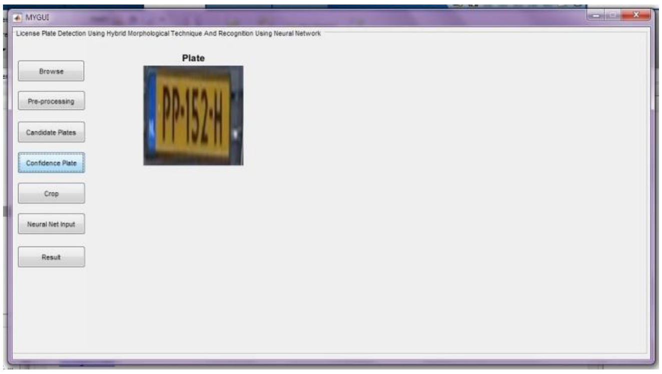

Figure 9 Plate or No plate Detector

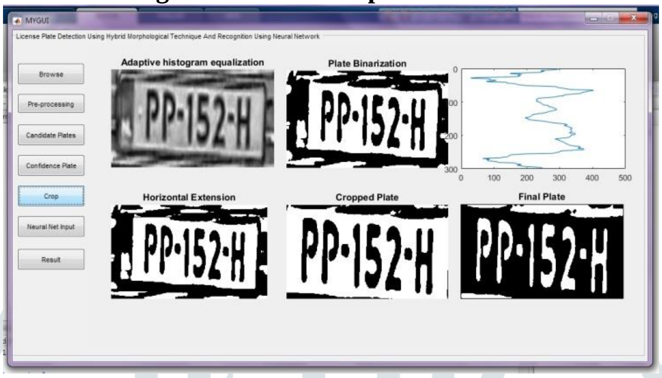

Figure 10 Morphological Processing

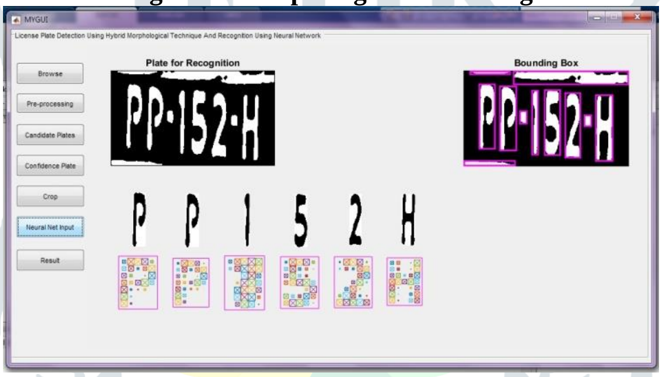

Figure 11 Neural Network Input

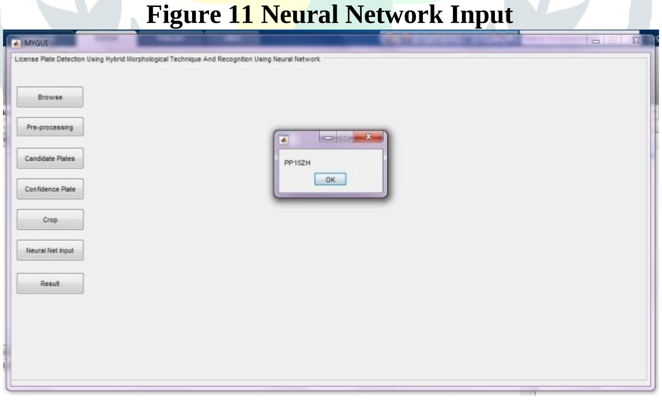

Figure 12 Neural Network Result

2. Processing at video is as following:

Figure 13 LPP system

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IV. CONCLUSION

The proposed system consists of six components: Input video, Viola Jones algorithm, KLT Detector and tracker, Morphological operations, candidate plate extraction, character extraction and recognition. A simple yet effective hybrid morphological technique substantially decreases the run-time complexity of license plate localization without affecting detection rate as compared to the knowledge-based approach. It extracts candidate plate regions from the image, AlexNet as a feature extractor and SVM classifier detects plate. Neural network recognizes license plate characters.

The system can further extended to recognize number of plates simultaneously.

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