Mobile Phone Based Vehicle License Plate Recognition for Road Policing

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Abstract

Identity of a vehicle is done through the vehicle license plate by traffic police in general. Automatic vehicle license plate recognition has several applications in intelligent traffic management systems. The security situation across the globe and particularly in India demands a need to equip the traffic police with a system that enables them to get instant details of a vehicle. The system should be easy to use, should be mobile, and work 24×7. In this paper, we describe a mobile phone based, client-server architected, license plate recognition system. While we use the state of the art image processing and pattern recognition algorithms to automatically recognize non-uniform license plates, the main contribution is in creating an end to end usable solution. The client application runs on a mobile device and a server application, with access to vehicle information database, is hosted centrally. The solution enables capture of license plate image captured by the phone camera and passes to the server; on the server the license plate number is recognized; the data associated with the number plate is then sent back to the mobile device, instantaneously. We describe the end to end system architecture in detail. A working prototype of the proposed system has been implemented in the lab environment.

1 Introduction

License Plate Recognition (LPR) systems are usually designed to read vehicles license plate and automatically recognize license plate number in ASCII. of vehicles passing through a certain point. Systems are readily available for mass surveillance that utilizes optical character recognition (OCR) and hardware capable of reading license plates of moving vehicles[1, 2, 3] but still continue to hold the interest of researchers [4, 5, 6, 7, 8, 9, 10, 11, 12] mainly because of several challenges that exist. Low quality images due to severe illumination conditions, vehicle motion, viewpoint and distance changes, complex background are some of challenges. LPR is preceded by localization of license plate. [11] use a feature-based license plate localization algorithm that copes with multi-object problem in different image capturing conditions which they claim is robust against illumination, shadow, scale, rotation, and weather condition. Vahid et. al. [5] address some of these problems by using intensity variance and edge density image enhancement methods. More recently Luis et al [4] have suggested the use of artificial neural networks for license plate detection and Cristian et al [6] suggest a mechanism to fuse decisions for improving the license plate recognition. Some systems make use of infrared cameras to increase the efficiency of the system. LPR systems can be used for vehicle identification [13], enforcement, collect electronic tolls[14], traffic monitoring and travel management [15]. In all these systems the camera is fixed and is therefore only able to scan the vehicle passing through a particular point. On the other hand, mobile LPR system has become a necessity for law enforcement especially with increasing volumes of vehicles being added to Indian roads every year.

Traffic police not only make sure that the vehicles on the road follow traffic rules but also make sure that the vehicles have necessary authorizations to be on the road. In any large city the traffic police inspectors can police a fraction of the city and when ascertaining details of the vehicle have to rely solely on the details provided by the vehicle driver. In this paper we address the problem of equipping the traffic
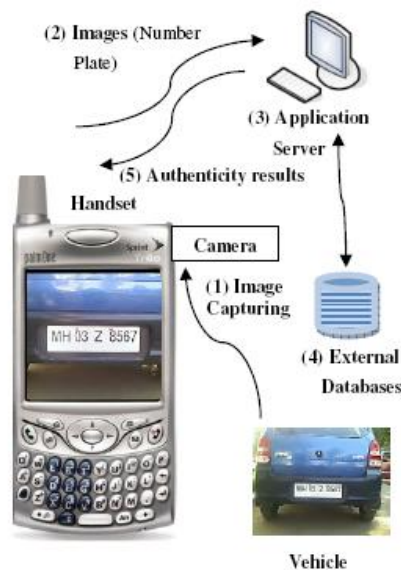
Figure 1: The high-level client-server architecture of the solution.

police with a mobile tool that can be used to get on the spot exact details of a vehicle on the road 24×7. We propose a mobile phone based vehicle license plate recognition system to assist the traffic police.

The mobile phone based LPR has several applications. They could be used to identify (a) vehicles involved in road accidents, (b) trace stolen vehicles, (c) trace VIP escorting vehicles, (d) monitor and issue memo for violation of traffic rules. The paper is organized as follows: in Section 2 we describe the overall system architecture of the solution. Experimental setup and results are discussion of Section 4 and conclude in Section 5.

2   The Solution Architecture

The proposed solution has two parts (a) mobile client which enables capture of the license plate of a vehicle and send the image to a remote server and (b) a remote server which has a LPR software and access to an external database which has vehicle number and vehicle information association details. Figure 1 shows the high-level client-server solution architecture.

The major client side components (Figure 2(a)) are (a) a server interface module and (b) a media interface (capture image) module. The client module communicates with the server using the HTTP. In a typical working scenario, the client application requests the user to capture the image of the vehicle license plate and enables the camera capture mode on the mobile phone. Once the image is captured, the image is pushed to the server for recognition. On receiving information from the server, the client software displays the obtained information about the vehicle as a text message to the user. Figure 2(a) shows the client side solution architectures in detail.

Note that the client application can be downloaded over the air (current implementation is on BREW but can be enabled for multiple mobile devices and multiple OS).

The major components on the server (Figure 2(b)) include (a) image processing and pattern recognition modules for recognizing license plate and (b) a database interface. The server can interact with external databases (for example, in case of stolen vehicles [16]) and find the association between vehicle number and its status against a stolen vehicle. The ownership details (name, contact address, number),

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(a) Client Side   (b) Server Side
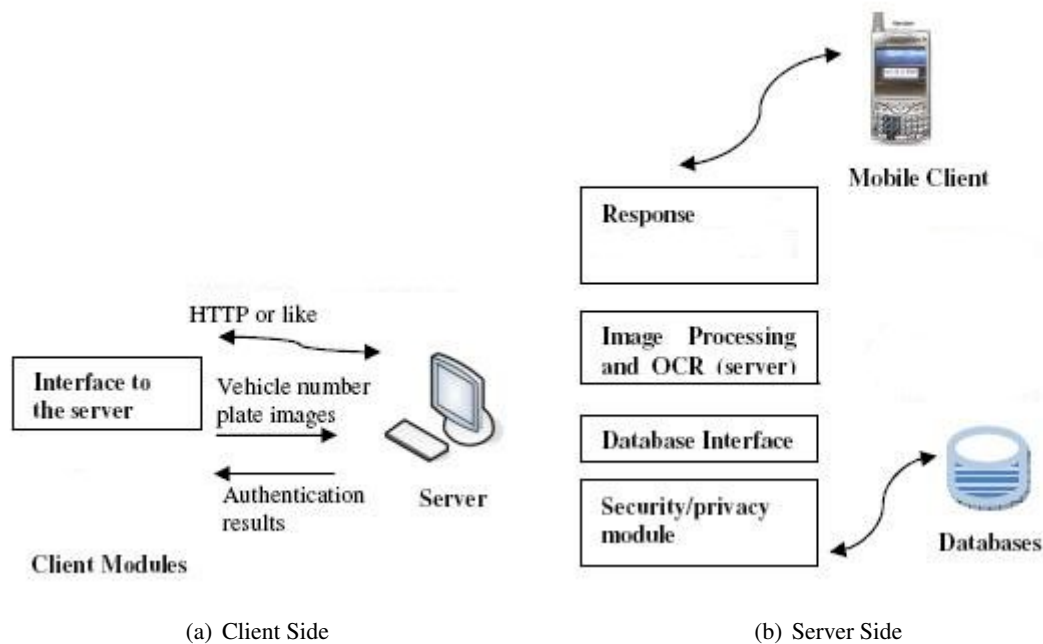
Figure 2: Solution Architecture Details

vehicle details (make, model, engine number etc.), tax details and previous complaints registered against the vehicle can also be obtained if a database is available. The server works on the image sent by the client while maintaining a link between the image uploaded and the mobile device from which the image was uploaded through a unique session number. A module to recognize vehicle registration number from the image forms the heart of this solution and is described in greater detail in Section 3.

3   License Plate Recognition

The LPR engine resides on the server and is a hub of several image processing and pattern recognition modules. The important functional units include image pre-processing, license plate localization, character segmentation and character recognition [17, 18]. Figure 3 shows the block diagram of the LPR engine. After initial pre-processing of the LP image, the next task is that of locating the exact position of the LP in the image (LP localization). Once the LP is located the actual LPR happens.
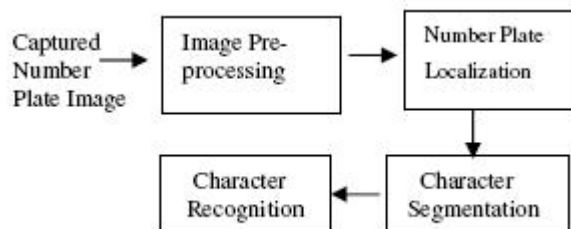

Figure 3: Block diagram of LPR engine

Actual sample images of vehicle license plates captured by mobile phone cameras are shown in

Figure 4: Images of the license plates taken using mobile phone cameras

(a) Input   (b) Output

Figure 5: Sample vertical edge output

Figure 4. It can be observed that the input images have a great deal of variability in terms of variability in lighting conditions, shadows on the plate region, plates from front or rear part of the vehicle with messages or icons, skewed images, background and foreground of the number plate and one line and two line writing, the recognition system needs to work under all these conditions.

License Plate Pre-processing: The color image captured from the camera is first converted into a gray scale image and is then binarized using Otsus global thresholding technique [19]. Note that we could use an adaptive threshold technique to get a binary image but our analysis with a range of LP images showed that Otsus thresholding technique works well. We also use, skew correction up to about ± 5 degrees and slant normalization before license plate localization is carried out.

License Plate Localization: Determining the location of the LP within the captured image automatically is a critical task for successful recognition. The aim is to obtain a region of interest (usually a rectangular window) in the image (say $I(x,y)$ of size $M \times N$) that includes the license plate of the vehicle. For this purpose, the edge map $E(x,y)$ of $I(x,y)$ is initially computed by applying the Sobel edge operator in the vertical direction since presence of characters contribute more edges in vertical direction (see Figure 5). Note that the edge values are real numbers. We eliminate all but the top 3% of the edge intensity pixels and obtain a reduced binary edge map $E(x,y)$. We compute variance ($\sigma_E^2(x)$) of the each row of the edge image ($E(x,y)$) and calculate the maximum variance (σ_{max}^2). We select all the rows (x)

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with $\sigma_E^2(x) \geq 0.5 \times \sigma_{max}^2$. We mark and collect contiguous rows as regions (say $\xi_1, \xi_2 \ldots$); this isolates the license plate in the horizontal direction. To perform vertical cropping of the selected regions, we examine the edge strength (by observing the vertical profile of the horizontally segmented region) in vertical direction ($E(x, y)$ in the y direction). The columns with 50% of the maximum edge strength are retained and the co-ordinates of the license plate region are identified. We end up with one or more candidate license plate regions.

Character Segmentation: After identifying the regions of interest the next step is to segment the characters from the LP as a spatial sequence of alpha-numeric number (which gives the exact number of the vehicle). Segmentation of the characters written in different formats (single line, double line, or in different orientation) is a challenge. The character segmentation (isolation) process involves use of connected component analysis to segment the characters [20]. Post processing on the identified connected components is performed to eliminate non-character like logos. Post processing involves use of spatial position of the connected components (all the characters are more or less aligned in horizontal direction along the plate region and have different vertical special positioning depending upon the character width), the aspect ratio of the bound box on the connected component (all the characters are more or less of the same size) and also use of high level information like the maximum number of characters expected in the license plate and its format, possible combinations of characters used to represent Indian states etc. The isolated characters are then size normalized using affine transformation and bilinear interpolation techniques [21].

Character Recognition: The segmented characters are recognized using template matching technique. Here the segmented character is compared with all the reference character set and the similarity is computed (correlation coefficient). The reference character with the highest correlation is chosen as the identified character. Note that the template database consists of all English capital letters and Arabic numerals. Algorithm 1 describes the proposed solution.

Algorithm 1 Steps in LPR

 1: Convert Colour ($I_c(x, y)$) image to Grayscale ($I(x, y)$)
 2: Extract vertical edge map using Sobel edge detection algorithm ($E_v(x, y)$)
 3: Compute variance ($\sigma_E^2(x)$) of the each row of the edge image and compute the maximum variance (σ_{max}^2)
 4: Select all the rows (x) with $\sigma_E^2(x) \geq 0.5 \times \sigma_{max}^2$
 5: Mark and collect contiguous rows as regions from the original Grayscale image (say $\xi_1, \xi_2 \ldots$)
 6: Binarise all the selected region ($I_{\xi_1}, I_{\xi_2}, \cdots$) using Otsu's algorithm
 7: Perform vertical cropping of the identified region based on vertical profile
 8: Apply morphological dilation for bridging the discontinuities within the character segments in the plate region.
 9: Perform character segmentation based on connected components
10: Perform rule (area /aspect ratio / existence ratio) based elimination of the non character components.

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4   Experimental Results

There is no standard test bed, to the best of our knowledge, to test the performance of a LPR system; hence we collected our own data. Additionally, we needed to work on mobile camera resolution images. We collected images as follows: (a) the images are colour images of actual Indian license plates taken under various conditions, (b) all images are taken in 640×480 resolution or lower with different mobile phones at our disposal. The database contained a total of 871 images of 230 different vehicles. The

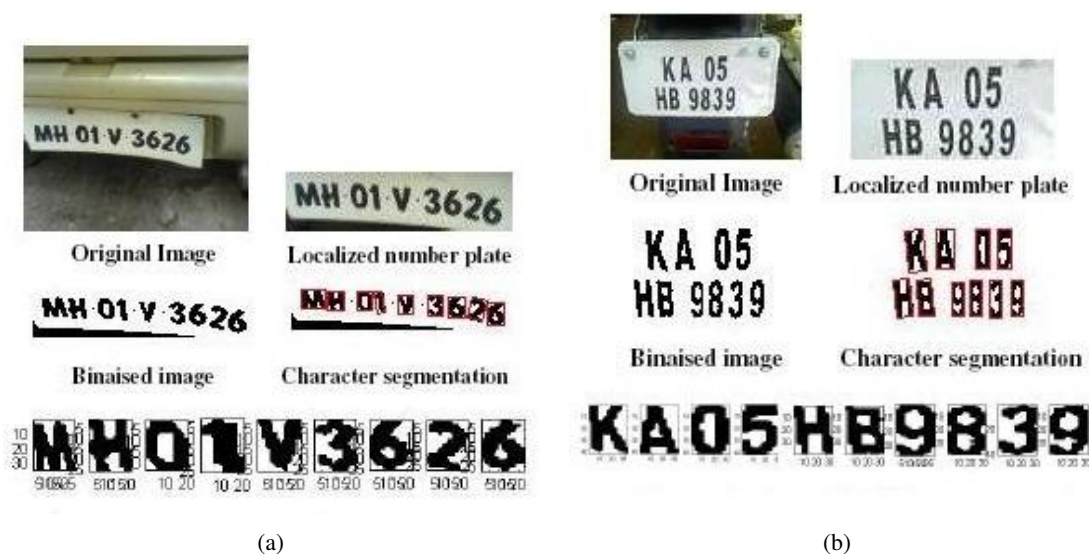(a)   (b)

Figure 6: Some Experimental Results

results of image processing algorithms used in the recognition including plate localization, binarization, character segmentation and size normalization are given below.

Sample experimental outputs shown in Figure 6. Results show that the license plate recognition engine is capable of handling images which are skewed and also able to handle when license plate characters come in more than one row. The performance of the proposed system is not affected by the motion of the vehicle. Is should be notted that the moving vehicle images are not "blurred" in the traditional sence in image processing; it is more of a "size blur".The system has shown successful LP localization and character segmentation about 98% and character recognition about 93% with an overall LP recognition of about 90+%.

5   Conclusions

In this paper, we presented the solution architecture and a sequel of algorithms for the recognition of LP of a vehicle in Indian context using mobile phone camera images. This system has been tested over a large number of real images with very encouraging results. The proposed system is fast and yields robust recognition results Almost all existing vehicle license plate recognition systems use one or more fixed cameras which put a restriction on mobility. In contrast, the system proposed uses mobile phone camera to capture license plate images, meaning we have a vehicle plate recognition system which is mobile (we can take it to any location). Mobility facilitates handling vehicles parked anywhere or when vehicles are stopped for inspection by the traffic police. We believe, mobile phone based systems are currently not available anywhere in the world and especially for Indian license plates. Comparison with any existing LPR system is difficult because of differences in the working environment of the proposed system with a existing LPR system. As a future enhancement, location information can be captured along with the LP images and can be used in vehicle tracking application. The average speed and travel time between two points can be calculated and presented in order to monitor traffic flow and load in a specific area of a city.

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