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License Plate Recognition (LPR) system for Indian Vehicle License Plate Extraction and Character Segmentation

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Abstract

License Plate Recognition (LPR) is a challenging area of research due to its importance to variety of commercial applications. LPR systems are widely implemented for automatic ticketing of vehicles at car parking area, tracking vehicles during traffic signal violations and related applications with huge saving of human energy and cost. The overall problem may be subdivided into three distinct key modules: (a) localization of license plate from vehicle image, (b) segmentation of the characters within the license plate and (c) recognition of segmented characters within the license plate. In this paper, we proposed a method of feature extraction[12] for an offline License Plate Recognition System based on global features to identify the license plates. Before extracting the features, preprocessing[11] of the captured image is necessary in order to isolate the license plate region from the car backround and to remove the noise present, using filter[2]. Sobel edge detection e technique [1][7] is used to determine the edges of the license plate whereas the features are extracted using Radon transform[10]. Features are saved and tested against already saved database and the availability of the vehicle is displayed as an output .In this work, 100 real time vehicle images are captured from a high resolution camera during different contrast of day. The images are stored in a centralized data server.A sample of 20 images are tested against the already saved database in order to check the authenticity of each vehicle. The performance of the system is measured at the time of recognition which is 95 % and at the time of matching i.e checking the existence of a particular vehicle is 90% in a time duration of 15 sec.

Keywords: LPR (license plate recognition system), Sobel edge detection, Radon transform, Connected Component analysis.

Introduction

One type of intelligent transportation system ,technology is the License plate recognition (LPR) which can distinguish each car as unique by recognizing the characters of the license plates. In LPR, a camera captures the vehicle images and a computer processes them and recognizes the information on the license plate by applying various image processing and optical pattern[11] recognition techniques. Prior to the character recognition, the license plates must be separated from the background vehicle images. This task is considered asthe most crucial step in the LPR system, which influences the overall accuracy and processing speed of the whole system significantly. Since there are problems such as poor image quality, image perspective distortion, other disturbance characters or reflection on vehicle surface, and the color similarity between the license plate and the background vehicle body, the license plate is often difficult to be located accurately and efficiently. Researchers have found many diverse methods of license plate localization. The stepwise process is the following section.

Materials and Methods

1. Database Collection

The collection of data is first and most important part of the License Plate Recognition. Collection of about 100 license plate images are done .The images are collected at different contrast viz. day, afternoon, evening. The database is collected using a cyber shot 16.1 mega pixel digital camera. The images so collected are resized into 640 x 480 pixels and are further used in the process. The different steps which are followed in this system are shown in the flow chart given below as Fig 1 and the next step preprocessing is described below.

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2. Pre-processing

Grayscale conversion and Noise Reduction: In first step of pre-processing, we converts RGB values to grayscale values [2][8] by forming a weighted sum of the R, G, and B components, with 8 bits per pixel, which allows 256 different intensities. Thresholding in image processing is used to convert a gray scale image to binary format, where only two values are possible for the pixel, zero or one. The effective luminance is calculated by following equation:-

$$y = 0.2989 * R + 0.5870 * G + 0.1140 * B$$

.... (1)

where y is the value of the effective luminance and R,G,B are the weighted sum of components[2].Further we follow a morphological process in order to get the contrast of the image. The principal application of morphology is extracting image components that are useful in the representation and description of shape. In particular we consider morphological algorithms for extracting boundaries, connected components, convex hull, and skeleton of a region. The license plate image before thresholding is shown in figure 1.2(a) and gray scale image[8] of license plate along with morphologically[8] cleared image is also shown in Fig- 2 (b) and (c) respectively are shown followed by the next step filtering.

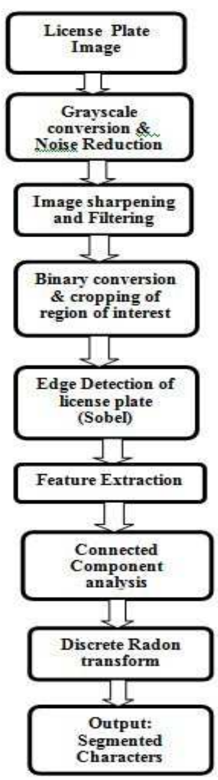
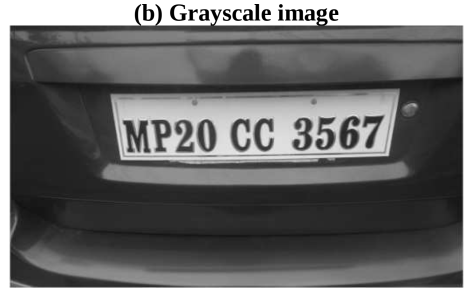


Fig 1 Different steps of LPR System

(a) original license plate

(b) Grayscale image



(c) Contrast image

Fig 2

Filtering and sharpening: The principal objective of sharpening[2] spatial filter is to highlight fine details in an image or to enhance detail that has been blurred either in error or as a natural effect of a particular method of image acquisition. The distortion which includes local variations, rounding of corners, dilation and erosion[3][8] is also a problem. Prior to the license plate recognition, it is necessary to eliminate these imperfections. The isotropic filters[2] response is independent of the direction of the discontinuities in the image to which filter is applied . The simplest isotropic derivative operator is the laplacian[7] ,which for a function image f (x,y) of two variables is defined as-

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (2)$$

$g(x,y)$ is the noisy image formed by the addition of noise to an original image .Thus the basic way in which we use the laplacian [7] for image enhancement is as follows:

$$g(x,y) = \begin{cases} f(x,y) - \nabla^2 f(x,y) & \textit{if the center coefficient of the laplacian mask is negative} \\ f(x,y) + \nabla^2 f(x,y) & \textit{if the center coefficient of the laplacian mask is positive} \end{cases}$$

(3)

Where $g(x,y)$ is the image formed after laplacian. The sharpened image is shown below in Fig 3 followed by the binary conversion.

Fig 3 Sharpened license plate image

Binary conversion and cropping region of interest

Binary images are also called bi-level or two-level. This means that each pixel is stored as a single bit (0 or 1).In this step we get binary license plate image after thresholding by Otsu's method[1] where license plate is in white on black background. In order to get the exact location[3] of license plate we select the license plate area in order to get the coordinate values of license plate. According to the dimensions, for instance, only the objects within the selected range are retained, and eliminate the other objects. After that,as otherwise, the objects are removed, and so on.

Afterwards, the result of this step is an image containing only the plate characters. The aim of this stage is to obtain the accurate location of the license plate region[2]. It is proceeds as follow:

a) Find out starting and ending position of the plate region by means of counting no. of ones in each row.

b) Extract that region only from the image.

The cropped image is shown in Fig 4. Further the edge is detected as discussed below.

Fig 4 Cropped binary image

License Plate Edge Detection

The edge-based methods make use of various edge operators to produce an "edginess" value at each pixel. The Sobel operator[1][7] was studied and implemented to find edges in images. The edges thus found could also be used as aids by other image segmentation algorithms for refinement of segmentation results. In simple terms, the operator calculates the gradient of the image intensity at each point, giving the direction of the largest possible increase from light to dark and the rate of change in that direction. Say the masks can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G_x and G_y)[1]. These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2} \qquad (4)$$

The result therefore shows how "abruptly" or "smoothly" the image changes at that point and therefore how likely it is that part of the image represents an edge The edge detected image is shown below in fig 5.followed by feature extraction and recognition.

Fig 5 License plate with sobel edge detection

Feature Extraction and Recognition

Feature Extraction[11] takes in a pattern and produces feature values. The license plate image after the pre-processing is in two dimensional binary license plate image, but we convert it into one dimensional feature vector by feature extraction[12] technique because they are easy to process and requires less space to store in memory. Feature vectors or sets play one of the most important roles in a recognition system. Most object recognition systems tend to use either global image features, which describe an image as a whole, or local features, which represent image patches. The global features are defined as that in which each image is represented by a single feature vector. The Advantages of Global features are compact representation of an image. Global features are extracted from the templates[9] images of 26 alphabets and 10 numerals such as the Hough transform[4] , Discrete Cosine transform, Discrete Radon transform[10], Fourier transforms, Walsh-Hadamard transform[11], Gabor transform[6] etc. In this paper we present Discrete Radon Transform (DRT) as a method for feature extraction. The concatenation process starts as below followed by feature extraction.

Connected Component Analysis

Connectivity[1][5] between pixels is a fundamental concept that simplifies definition of numerous digital image concepts ,such as regions and boundaries to establish if two pixels are connected[1][5] ,it must be determined if they are neighbours and if their gray levels satisfy a specified criterion of similarity. Let Y represent a connected component contained in a set A and assume that a point p of Y is known. Then the following iterative expression yield all the element of Y:

$$X_k = (X_{k-1} \oplus B) \cap A \qquad (5)$$

Where $k = 1,2,3, \ldots$

Where $X_0 = p$, and B is suitable structuring element.

Discrete Radon Transform Method

In mathematics, the Radon transform[10] is in two dimensions, it is the integral transform consisting of the integral of a function over straight lines. The radon function computes projections of an image matrix along specified directions. A projection of a two-dimensional function $f(x,y)$ is a set of line integrals.

Applying the Radon transform[10] on an image f(x,y) for a given set of angles can be thought of as computing the projection of the image along the given angles.

$$\rho = x * \cos(\theta) + y * \sin(\theta) \qquad (6)$$

Where ρ is the angle of orientation.

After that radon transform can be written as

$$R(\rho,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta\, dx\, dy) \qquad \ldots (7)$$

Where

$\delta(.)$ is the dirac delta function.Features are stored and each template[9] is compared with the already saved database. Each of the characters is recognised as shown in Fig 6 and the authencity of the vehicle is revealed by displaying whether the entry of the vehicle is allowed or not.

(a) Recognised characters of license plates

(b)Recognised characters of license plates
Fig 6

Results and Conclusion

The license plate characters are checked against the saved templates and are recognised. The efficiency in recognising each character is 95 %. These recognised values of the features are saved and now the present data is checked against the saved database. The efficiency in matching the values is 90% . Total time taken in a single process is about 15 seconds. The inefficiency is because of the extra characters that are present in the license plate which occupies a value other than the character thus creating a void which causes the mismatch and reduces the efficiency .The proposed method is mainly designed for real-time Indian license plates, and can be readily extended to cope with

license plates of other countries. The efficiency of the system can be increased if the features used in the templates involves special characters and we use techniques like unwanted lines elimination algorithm or the vertical edge detection algorithm for multi style license plates.

Table 5.1 Output values

No. of images	Proposed method recognition (in %)	Correct decision output(in %)	Time for process(seconds)
100	95	90	15

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