Automated Parking Management System Using License Plate Recognition

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Abstract— Automated Parking Management System (APMS) uses image processing for recognizing license plates for efficient management of parking and billing. APMS is an independent stand-alone system which reduces human involvement in parking management. In this paper we propose a system which consists of a digital camera interfaced with the software module. The software module extracts the license plate, segments the characters on it and recognizes the characters. This module is interfaced with the database which is thereby used to manage the parking system. The concept of connected components is used for extraction. The characters are segmented using projection and connected components and recognized using neural networks. The algorithms are implemented using MATLAB. In this paper we have illustrated experimental results from the proposed model.

Keywords— Automated Parking System, License Plate Recognition, LPR, Character Segmentation.

I. INTRODUCTION

License plate number is a numeric or alphanumeric code which is used to uniquely identify vehicles. License plate recognition applies image processing and character recognition technology to identify vehicles by automatically reading the license plates. The LPR process can have numerous applications. It can be used in parking lots, toll booths, highway surveillance etc. The objective of the LPR model here is automated toll collection. The vehicle license plate number is extracted and recognized from car images, the obtained image is processed and finally the data is used is prepare an electronic bill. Parking lots depend heavily on manual labour. APMS helps reduce staffing cost and improves overall performance of the parking management system. This system consists of vehicle number plate extraction, characters segmentation, and character recognition. Appropriate pre-processing is done before licence plate extraction. A database is maintained with the in-time and out-time of the vehicle. With the help of the database the electronic bill is generated.

II. PROBLEM STATEMENT

The APMS can be used for various applications like maintaining records of parked vehicles, authorization of vehicles in an area, billing systems etc. The size of parking lots has increased greatly due to the increasing number of vehicles. It becomes necessary to have an automated system that maintains information about the vehicles, like their license plate numbers, that are authorized to park. The billing information is also maintained. Thus the APMS system is proposed for simple revenue collection and parked vehicle management.

III. THE PROPOSED APMS SYSTEM

The Automated Parking Management System consists of two stations, one at the entry and the other at the exit of the parking lot. These two stations are linked to the main processing unit for bill generation and keeping the vehicle count. Both the barrier points are equipped with proximity sensors which are programmed to sense the presence of a vehicle. The flowcharts of the proposed APMS model at entry and exit points are shown below in fig.1 and fig.2.
IV. IMAGE EXTRACTION

The first process in the LPR system is the license plate extraction. The concept of connected components is used here. The software module is interfaced with a digital camera. The following steps are involved in the process:[1]

A. Capturing image

The digital camera captures the image and passes it to the software module. Vehicle images can have distortions due to multiple factors. Hence to obtain better recognition results, the image has to be pre-processed.

B. Pre-processing

1) Cropping the image

The assumption made here is that the license plate lies in the centre of the image. Accordingly the image is cropped. Cropping helps remove boundary region from the image. This reduces the amount of noise that we have to deal with.

2) Greyscale conversion

The image obtained is an RGB real-colour image. This image is converted to greyscale since an RGB image can increase time and space complexity. Hence processing time can be saved. The basic idea of this conversion is performed by eliminating the hue and saturation information while retaining the luminance. The following equation shows an optimal method for RGB to gray-scale conversion, as follows:

\[ L_u = 0.299 \times R + 0.587 \times G + 0.114 \times B \]  
(1)

3) Binary and negation of the image

The cropped image obtained is then converted to the binary format. Thus the image now consists only of black and white pixels. The plate region consists of characters written in black. We take negation of the image so that the characters are converted into connected white components.

4) Image filtration

We make use of median filters to reduce the noise in the image. Small connected components are removed from the image.

5) Removing license plate region from the image

The concept of connected components is used here. The characters of the license plate fall within a known range which is obtained through trial and error method. All the connected components which are less than or equal to the alphanumerics characters are removed from the image. The alpha-numeric size of character is determined using the range obtained.

6) Subtracting binary images

The binary image obtained in the previous step is subtracted from the binary image obtained in step 4. This is done by binary matrix subtraction. This helps us obtain only the characters used in the license plate.

7) Plotting histograms for license plate region extraction

The column profile and row profiles are plotted. The row profile is obtained by adding all the elements in each row of the matrix of the binary image. Region that
corresponds to the license plate lie above a certain threshold value. They display high amplitudes in the histogram. The row profile is thresholded. Similarly the column profile is plotted and thresholded. With the help of the obtained probable row and column ranges the license plate region can be extracted.

Hence we obtain the extracted plate region which can further be segmented.

V. CHARACTER SEGMENTATION

Traditional license plate character segmentation mainly includes segmentation based on vertical projection characteristic of grayscale characters, segmentation based on extraction of connected components and segmentation based on template matching. Segmentation based on vertical projection characteristic of grayscale characters is feasible and valid for image of good quality, but this method relies too heavily on previous results of license plate localization, and it is unable to obtain good segmentation results sometimes. Segmentation based on extraction of connected components is proved to be the leading research algorithm. It is feasible and effective because it takes full advantage of prior knowledge of the license plate. In most cases, the algorithm is good, but in some important occasions it relies too heavily on previous results of localization.

So, the algorithm presents a mixed segmentation method which take full advantage of segmentation based on vertical projection characteristic of grayscale characters and segmentation based on extraction of connected components.[6], [7], [9].

A. Segmentation Using Projection Characteristic and Connected Components

There are two types of character segmentation: horizontal segmentation and vertical segmentation. Horizontal segmentation is mainly used to filter disturbance of upper and lower borders, remove some rivets, and locate the upper and lower bounds of license plate character region. Vertical segmentation is mainly used to filter disturbance of left and right borders, remove some rivets between characters, and segment all the characters on the license plate without a mistake.

The method comprises of the following steps that:

a) Compute horizontal and vertical projections of the resultant image that was processed by the localization algorithm, and then further localize using texture characteristics and distinctive peak and valley distribution characteristics in the license plate image.

b) Do the open operation based on mathematical morphology to the resultant image which was obtained by further. Simultaneously, remove border of license plates and rivets by using not only texture characteristics of license plate image, but also horizontal and vertical projection.

c) Detect connected components in the above result image, and gather statistics of their area, centroid and maximal external rectangle.

d) Do smoothing process to curves of vertical projection and then gather statistic of beginning and ending by using peaks and valleys detection algorithm.

e) Remove some dummy valleys of vertical projection characteristics and some dummy connected components by using texture characteristics, area distribution and shape characteristics (aspect ratio) of license plate characters. Ordinarily, in the license plate characters, the number “1” will result in narrow projection but other width of characters is alike. The ratio of license plates’ height to characters’ width equal to about 1.9:1. If some connected components’ area is much smaller than others’ and they are out of adjacent valleys region in vertical projection, they must be noisy or dummy connected components.

f) Finally, do horizontal segmentation using connected components and do vertical segmentation of characters using vertical projection characteristics and connected components. Where, we take the minimal and maximal position of connected component of maximal external rectangle vertical direction as upper and lower border. Do vertical projection using connected components and verify the results of segmentation using projection characteristic. The algorithm has good results for several situations such as adhesive characters. The process of segmentation is showed in figure 5(a) and figure 5(b).

VI. CHARACTER RECOGNITION

The vehicle is uniquely identified by its license plate number. Methods such as template matching or neural networks can be used for character recognition. Using neural network has advantage over existing correlation and statistics template techniques [4] that allow it to be stable irrespective to noises and some position modifications of characters on license plate. The images of characters form the training set of neural network. The multilayer neural network is used for character recognition [10]. The training vector of neural network consists of 663 elements and it is created by vectors of image rows of the license plate characters in binary format.
The number of input layer neurons is 663. A supervisor sets the number of output neurons of neural network on the training stage. Each layer of neural network contains the matrix of weight coefficients $W$, vector of thresholds $b$ and vector of output values $a$. The output of each layer of neural network is presented by an overhead index and is calculated as following:

$$a_1 = f_1(IW_1, 1p + b_1) \quad a_2 = f_2(LW_2, 1f_1(IW_1, 1p + b_1) + b_2).$$

(2)

The neural network showed on Fig. 6 contains R1 inputs, S1 neurons of the hidden layer and S2 neurons of output layer. The outputs of every intermediate layer are the inputs of the next layer. Therefore, output layer 2 can also be considered as one layer neural network with the S1 inputs, S2 neurons, and weighted matrix $W_2 = S2xS1$. The $a_1$ vector is the input to layer 2 with $a_2$ outputs. The same approach is taken for any layer of neural network. Gradient descent back propagation method with momentum and adaptive learning rate is used for neural network training [5]. Back propagation is used to calculate derivatives of performance with respect to the weight and bias variables $X$. Each variable is adjusted according to gradient descent with momentum:

$$dX = mc*dXprev + lr*mc*dperf/dX$$

(3)

where, $dXprev$ is the previous change of weight or bias, $lr$ is learning rate, $mc$ is momentum constant.

VII. ELECTRONIC TARIFF COLLECTION

As mentioned above, the APMS is used for electronic billing. The Electronic Tariff Collection (ETC) System calculates the parking fee using the composite LPR software module. At the exit, the proximity sensor is triggered when the vehicle enters the parking lot. The triggering of the proximity sensor further initiates the camera to capture a picture of the vehicle and the license plate. The image of the license plate of the vehicle is used for the generation of the license plate module using the composite LPR system. The image of the vehicle which is captured by the secondary camera is stored alongside for security reasons. The license plate number generated by the LPR system is stored together with the entry records (i.e. date and time of entry) in an internal database which will be used to calculate the parking fee and other parameters including number of free parking spots, etc. Once all the details are stored, the entry barricade will be lifted and the vehicle will be allowed to pass. The barricade will then automatically close once the vehicle has passed.

When a vehicle reaches the exit to leave the parking lot, the same cycle will be repeated to capture the image and generate the license plate number. The ETC system will match the recognized license plate in its own file in the internal database for the entry records. The system will calculate the difference between the exit time and entry time and accordingly calculate the parking fee to be paid. On completion of the payment, the barricade will be lifted for the vehicle to pass by. It will automatically close and the system will be reset.

VIII. TESTING AND RESULTS

The proposed system was tested on different types of Indian number plates and was found to be efficient. The tested license plates included two line plates in addition to the conventional single line plates. The following table illustrates the results:

<table>
<thead>
<tr>
<th>Camera Alignment</th>
<th>No of trials</th>
<th>Correct results</th>
<th>Incorrect results</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>50</td>
<td>46</td>
<td>4</td>
<td>92%</td>
</tr>
<tr>
<td>Right Aligned</td>
<td>50</td>
<td>41</td>
<td>9</td>
<td>82%</td>
</tr>
<tr>
<td>Left Aligned</td>
<td>50</td>
<td>42</td>
<td>8</td>
<td>84%</td>
</tr>
<tr>
<td>Back</td>
<td>50</td>
<td>44</td>
<td>6</td>
<td>88%</td>
</tr>
</tbody>
</table>

TABLE I

TEST RESULTS OF THE PROPOSED SYSTEM
IX. TEST IMAGES

(a) Original Image

(b) Grayscale Cropped Image

Fig. 8 (a) Original Image
(b) Grayscale Cropped Image

X. CONCLUSION

Vehicle license plate intelligent system, as the core of traffic management system, will play an important role in the future traffic control. This paper studied the vehicle license plate recognition system based on image processing, proposed a character recognition solution based on neural networks to solve license plate recognition problem.

The plate extraction succeeds in 87% of the test images on an average and this is a very high success rate, thereby fulfilling the criteria of the task. We have successfully designed and implemented the key element of the system, the actual recognition of the license plate region. The goal of the project was to recognize the license plate, store it in the database along with the time in and time out of the vehicle and calculate the tariff. This goal has been accomplished in the project.

XI. ACKNOWLEDGEMENT

We would like to thank ‘Thadomal Shahani Engineering College, Mumbai’ for providing us with necessary research facilities. We would also like to thank our parents for providing us with their blessings and support.

XII. REFERENCES

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