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Systematic Toll Deduction Using Automatic Number Plate Recognition

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Abstract: *The motivation is a need for a more systematic examination of the use of Automatic Number Plate Recognition technology particularly with regards to crime investigations and intelligence development, in order to tackle crime and disorder more efficiently.This paper presents a systematic toll deduction system that utilizes number plate localization algorithm. It extracts license plate candidates using morphological operations. We have formed a rather complete database of all characters and numbers templates in different format. Once the number is extracted from license plate it deducts the toll amount from the account which can be recharged with RFID card, and using GSM module sends message to the account holder's registered mobile number from database about recharging and toll deduction.*

Keywords: *Toll Deduction, ANPR, Automatic, LPR, Character recognition, Segmentation.*

I. Introduction

The recent developments in automatic object tracking and the importance of traffic monitoring has risen the attention to intelligent transport systems (ITSs). The LPR system can be used for parking management systems, traffic control, ticketing, detecting stolen vehicles, and the forth.

Usually, an LPR system consist of three main parts: license plate detection, character segmentation, and character recognition. Among these the license plate detection (LPD) is the most important stage and also the most difficult part. This is mostly because during this stage the algorithm has to overcome various undesired input image conditions such as out of focus (blur) images, undesired illumination conditions, small size plates, rotations, shadows, and different weather conditions. Different LPD techniques are available, this includes different approaches base on edge statistics analysis, morphological filtering, Hough and radon transformbased, neural networks, and combination of plate features. As expected, using a combination of these techniques can yield better results. For example, just considering edge information is not a good approach in complex images with small license plates (as there might exist a number of undesired edges) [1].

Using serial communication, Real time SMS to owner is perform by GSM sim 300 modem. It is able to serially communicate at a baud rate of 9600bps.

Massive integration of information technologies into all aspects of modern life caused demand for processing vehicles as conceptual resources in information systems. Because a standalone information system without any data has no sense, there was also a need to transform information about vehicles between the reality and information systems.

The existing toll collection system is based on human offices set up at regular intervals for the collection of the toll. Officers are placed at the toll booths to collect taxes manually and passerby often suffer delays due to exact cash not available with them. This is a time consuming process and many unauthorized vehicles are run with the support of the officers. This causes a lot of unnecessary delay and problems like smuggling of banned products, murders, vehicle theft and others such crimes [2].

These things can be overcome with an automated system that collects toll and eliminating the human interference in the process.

II. Related Works

We primarily survey the existing toll booth system, there can be multiple booth on one toll plaza, each one has two officers one of them make a bill for respective vehicle and other one will collect money from residing people and then opens the gate electronically to pass the vehicle.

In India, people uses the number plate with different fonts and sizes not as per government rule defined for the size and font of plate, we have created database of all characters and numbers to support the system.

In the process of extracting numbers from number plate we studied following algorithms, out of which we use the morphological operation based localization method because it more advantageous in implementations aspects.

Table 1. Reference Documentation for Localization algorithms

Sr. no.	Different Matching Algorithm	Process	Limitations	year
1.	Features–Based License Plate Localization Method	In this, it finds out plate candidate by finding regions with many vertical edges, finding gray looking regions, and light background regions. Results of all three will merge together to get plate candidate.	>>Width to height ratio of plate region. >>Size and shape of plate region.	1994
2.	Morphological operations based Localization method	In this method, the noise in image is removed by median filtering and then dilation is performed to only separate the license plate area.	>>Entire image should have equal illumination to light.	1995
3.	Horizontal and vertical filtering	In this method, by performing filtering it finds out the max color variations rows and columns (high variation such as black to white and vice versa) and separate it as a number plate region.	>>The rectangular shape of the license plate area.	1999
4.	Feature Based ANN (Artificial Neural Network) Approach	In this method, training an artificial neural network system using back propagation algorithm.	>>Require large database. >>Very complex processing.	2000

III. Proposed Methodology

ANPR systems generally consist of a digital camera with an infrared ("IR") filter to capture images of license plates; a processor and application capable of performing sophisticated optical character recognition (OCR) to transform the image of the plate into alphanumeric characters; application software to compare the transformed license plate characters to databases of license plates of interest to law enforcement; and a user interface to display the information of the vehicle from the database, the results of the OCR transformation, and an alert capability to notify vehicle owner when a plate matching is observed; as well as when toll is deducted from the account by displaying on user interface application and by sending message to the vehicle owner.

The virtual account is used for the toll deduction purpose which can recharge with RFID Card at the respective office.

IV. Block Diagram

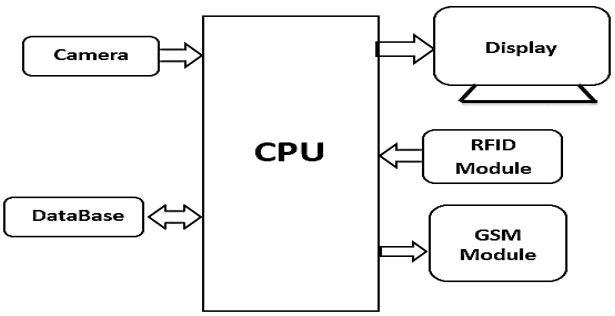

Fig. 1 Block diagram

The camera installed will be at a particular place where the angle and the distance from the road is correct and the image taken of the vehicle will give a proper image of the number plate. The processor will continuously scan for the number plate in the captured image using the edge detection technique. Once a number plate has been detected there are two possibilities either the number plate would had been registered in the data base or else it could be a new number plate. If the number plate is registered and the account associated with it is checked whether it has sufficient toll money. If so the toll is deducted and so is displayed on the screen and the same is sent via a sms using the GSM module. If the number plate is not detected further investigation is done. If the number plate is detected and there is not enough money the same is been informed to the driving party. The RFI D module is used to provide a virtual account. Once the account is recharged the user of the card is notified about the same using GSM module.

V. Algorithm

Toll Both Management

1. Start
2. Let the car to enter the area of interest so that the image of number plate is proper.
3. Once a car enters the number plate localization program is run and the car number plate is extracted.
4. Once the car number plate is extracted and available, segment the characters horizontally and vertically.
5. Once all the characters are segmented recognize the characters using template matching.
6. Once the characters are recognized save them into a text file.

7. Continuously monitor the text file.
8. As soon as a new entry is found check for the entry in the central database.
9. If match found deduct the toll and return the parameters.
10. If match not found return a message notifying the same.
11. If toll gets deducted set up the gsm module on the serial port and send the sms notifying the owner of the vehicle about the deduction.
12. Repeat this process.

Card Recharge System

1. Start
2. Place the card near the RFID Module.
3. Once a RFID Card is read, check for the entry in the central database.
4. If match found return the parameters and provide options for recharging the account.
5. If match not found return a message notifying the same.
6. If account gets recharged set up the gsm module on the serial port and send the sms notifying the owner of the vehicle about the recharge.
7. Repeat this process.

VI. Flow Chart

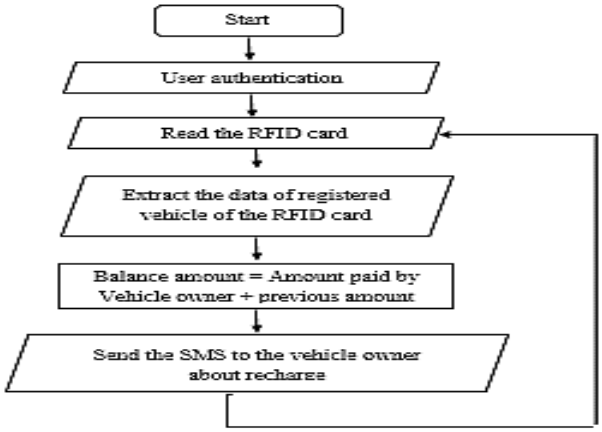

Fig. 2 card recharge system flowchart

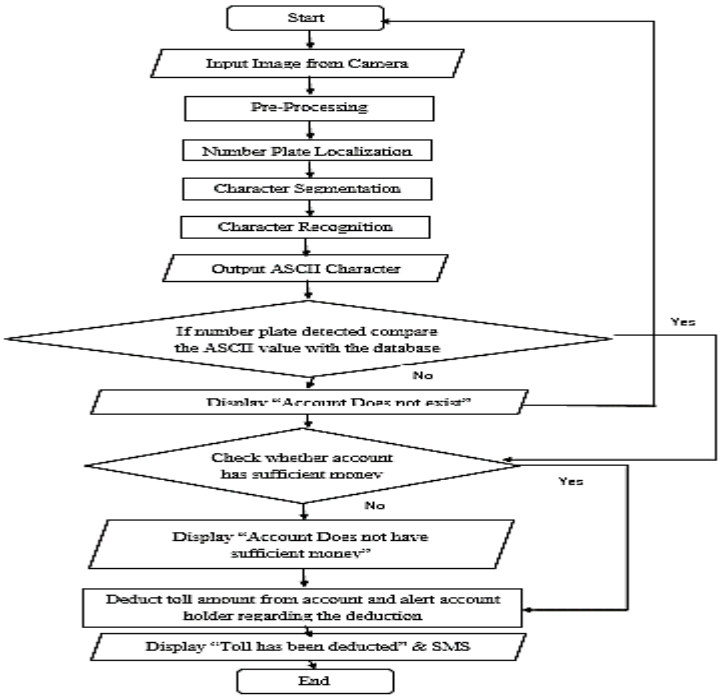

Fig. 3 Toll booth deduction flowchart

VII. Implementation

It consists of two parts as software coding and hardware configuration. There are 3 software uses for programming. MATLAB is used for character extraction and JAVA is act as central processing who runs the MATLAB program by giving input for corresponding steps and also access the database of MySQL software.

VIII. Matlab Alphanumeric Characterextraction Processes

i Preprossesing

The input image is taken from the CCTV camera is primarilypreprocessed in MATLAB. This image is first converted into Gray scale image.Then this image is converted to black and white image to perform number plate localization. Thresholding method is used to separate object and background, which is divided image into two modes. Each point (x, y) which have value f(x, y) > T is called point object, and each point (x, y) which have value f(x, y) ≤ T is called background object. A thresholder image g(x, y) is defined as:

g (x,y) = Object if t1>g (X, Y)<t2

Background if g (X, Y) < T

T is a constant and is called global thresholding. Typically, an object pixel is given a value of "1" while a background pixel is given a value of "0." Then 2D median filtering is performed on this image where each output pixel contains the median value in m-by-n neighborhood around the corresponding pixel in the input image. Median filtering pads the image with 0's on the edge, so the median values for the points within [m n]/2 of the edges might appear distorted [1][2][3].

Fig. 4 Original image

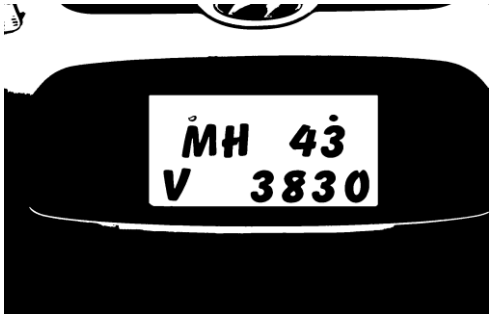

Fig. 5 Black & White image

ii Number Plate Localization

Morphological operators often take a binary image and a structuring element as input and combine them using a set operator (intersection, union, inclusion, complement). They process objects in the input image based on characteristics of its shape, which are encoded in the structuring element. It is shifted over the image and at each pixel of the image its elements are compared with the set of the underlying pixels. The dilation is given by,

$$A \oplus B = \left\{ z \mid (\hat{B})_z \cap A \neq \varnothing \right\} \forall z \in E$$ --eq. no (1)

Where, A= binary image

B=mask, or a structuring element

E= Euclidean space

Z is a set belong operation between A & B [11].

If the two sets of elements match the condition defined by the set operator (e.g. if the set of pixels in the structuring element is a subset of the underlying image pixels), the pixel underneath the origin of the structuring element is set to a pre-defined value (0 or 1 for binary images). the erosion operation is stated as,

$$A \otimes B = \left(A \Theta B_1 \right) \cap \left(A^c \Theta B_2 \right)$$ 2)

A morphological operator is therefore defined by its structuring element and the applied set operator.

$$A \circ B = (A \ominus B) \oplus B, \quad (3)$$

$$A \bullet B = (A \oplus B) \ominus B \quad 11]$$

These operators, which are all a combination of erosion and dilation, are often used to select or suppress features of a certain shape, e.g. removing noise from images or selecting objects with a particular direction. Morphological operations are applied onto the black and white image in our processing but morphological operators can also be applied to gray level images, e.g. to reduce noise or to brighten the image. Dilation - grow image regions. Dilation is an operation that "grows" or "thickens" objects in a binary image. The specific manner and extent of this thickening is controlled by a shape referred to as a Structuring Element (SE) [4].

Fig. 6 Dilated Image

This dilated image is then AND with the original one to get Number plate part from the image of vehicle which is then cropped as shown below.

Fig. 7 Cropped Image

This cropped is then cleaned to perform the segmentation operation [5].

iii Character Segmentation

The segmentation is one of the most important processes in the automatic number plate recognition, because all further steps rely on it. If the segmentation fails, a character can be improperly divided into two pieces, or two characters can be improperly merged together. We can use a horizontal projection of a number plate for the segmentation and vertical segmentation, or one of the more sophisticated methods, such as segmentation using the neural networks. If we assume only one-row plates, the segmentation is a process of finding horizontal boundaries between characters. For two rows of number its useful to have horizontal segmentation and separate that both rows and by vertical segmentation separate each character of number plate [6].

We can mathematically define the horizontal and vertical projection as:

$Px(x) = \Sigma f(x,j)h-1j=0$ $Py(y) = \Sigma f(i,y)w-1i=0$—eq. no(5)

Where w and h are dimensions of the image& x, y and i, j are rows and column for conditions.

Firstly, the image is horizontally segmented using continuation process:

Fig. 8 Cleaned image

Consider the above example:

Primarily, the rows with the characters are found out:

Fig. 9 Horizontal segmented 1st row

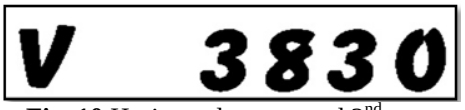

Fig. 10 Horizontal segmented 2nd row

Then vertical segmentation is carried out to find out each character:

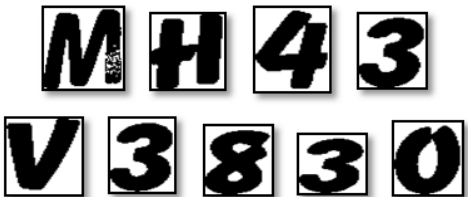

Fig. 11 Vertically segmented characters

iv Principle Component Analysis

Principal component analysis (PCA) is a technique used to emphasize variation and bring out strong patterns in a dataset. It's often used to make data easy to explore and visualize.

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. The principal components are orthogonal because they are the eigenvectors of the covariance matrix, which is symmetric. PCA is sensitive to the relative scaling of the original variables [7].

v Elastic Matching Algorithm

Elastic matching (EM) is also known as deformable template, flexible matching, or nonlinear template matching. Elastic matching can be defined as an optimization problem of two-dimensional warping specifying corresponding pixels between subjected images.

Deformations in handwritten characters have category-dependent tendencies. In this paper, the estimation and the utilization of such tendencies called eigen-deformations are investigated for the better performance of elastic matching based handwritten character recognition. The eigen-deformations are estimated by the principal component analysis of actual deformations automatically collected by the elastic matching. From experimental results it was shown that typical deformations of each category can be extracted as the eigen-deformations. It was also shown that the recognition performance can be improved significantly by using the eigen-deformations for the detection of overfitting, which is the main cause of the misrecognition in the elastic matching based recognition methods [8].

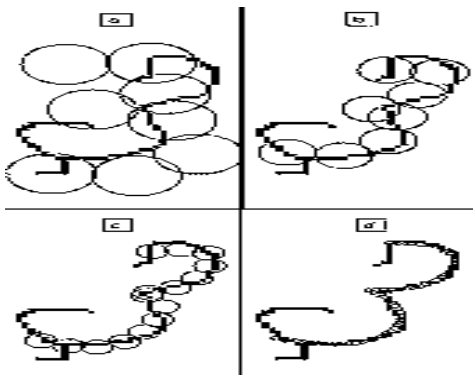

Fig. 12 Elastic matching

IX. Core Study

i. GSM SIM 300

SIM300 MODEM WITH RS232. This is a plug and play GSM Modem with a simple to interface serial interface. Use it to send SMS, make and receive calls, and do other GSM operations by controlling it through simple AT commands from micro controllers and computers.

Setting up the modem

If the modem contains a SIM card with is secured with a PIN code, we have to enter this pin code first:
AT+CPIN="0000" <ENTER> (replace 0000 with your PIN code).

Please note that in most cases it gives only 3 attempts to set the correct PIN code. After setting the PIN code, wait some seconds before issuing the next command to give the modem some time to register with the GSM network.

In order to send a SMS, the modem has to be put in SMS text mode first using the following command:
AT+CMGF=1 <ENTER>
AT+CSMP? <ENTER>
Sending the message
To send the SMS message, type the following command:
AT+CMGS="+31638740161" <ENTER>
Replace the above phone number with the own cell phone number. The modem will respond with:
>
Now type the message text and send the message using the <CTRL>-<Z> key combination:
Hello World!<CTRL-Z>
After some seconds the modem will respond with the message ID of the message, indicating that the message was sent correctly:
+CMGS: 62
The message will arrive on the mobile phone shortly [9].

ii. RFID READER & CARD

RFID stands for (Radio Frequency Identification). In this system EM-18 RFID reader uses as a receiver for RFID cards or tags. It reads out the data of cards when card is near about this and transfer data to its TX UART pin at 9600 baud rate. This have TTL output level so it can be directly connected to the microcontroller RX UART pin. RFID Reader EM18 - Low Cost, RFID Reader - Serial Out, RFID Reader - Serial Out, RFID Tag Key (125kHz)[10].

X. Lesson Learnt

Once characters are segmented the main mistake is that these are distorted or incomplete. Adding a process of reconstruction and the calculation of Hough transform increases the success rate.

Parametric models describe edges more precisely thansimple edge magnitude and direction and are much more computationally intensive. While these advanced algorithms provide better results, a common challenge among these techniques is the increasing computational cost as the complexity of the algorithm increases. FPGAs are good alternatives, which can be used to off-load these computationally-intensive and repetitive functions as co-processors. Custom implementation in FPGAs, using a combination of hardware and software co-design, allows real-time processing, providing a good trade-off between performance and flexibility.

XI. Results

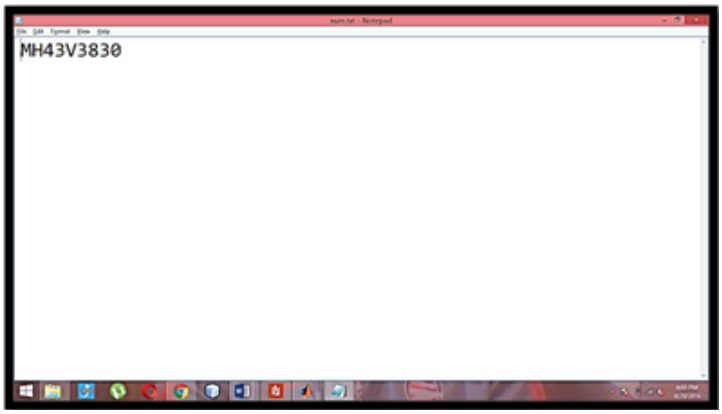

Fig. 13 Number extracted from number plate

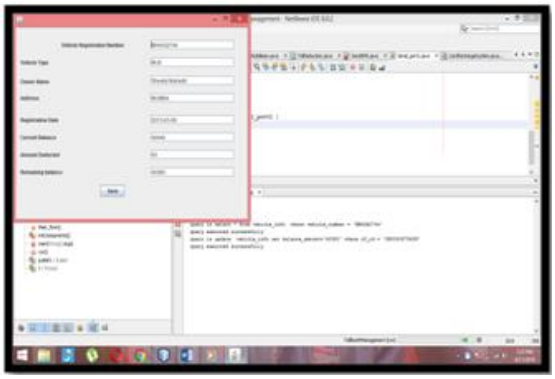

Fig. 14 Toll deduction user interface

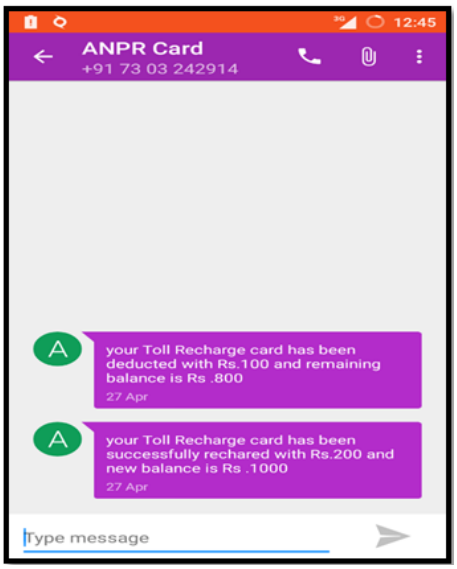

Fig. 15 Message sent from GSM Module

XII. Conclusion

In the current work, we have developed a simple and effective scheme for localization of license plate regions for Indian commercial vehicles. In some of such images the output is wrong localization, in some cases the plate region is detected as very large locality and in some of the cases other regions are falsely detected as license plate. Despite these difficulties, the technique fares well in most of the vehicle images, even in darker lighting conditions. Apart from the salt and pepper noise, motion blur and other types of noises often degrade the image quality. Specific image enhancement algorithms may be employed in future to improve the overall performance of the developed system.

XIII. Future Scope

To improve the success of program is needed small improvements at each stage.The image must be centered, fixed and evenly illuminated during the catch. Differentiate car color of image under study, i.e. to adapt the preprocessing at car color because of several problems appear in the plate location when the cars are white and silver. Also is possible to do an adaptive mask depending of picture.

Improve the choice of level to threshold and not lose information about the shape of the characters found. Through an adaptive threshold that divides the image into sub images and chooses the most appropriate level in each case, this solution is associated with a significant increase in execution time.

There are several solutions that can be applied but keep in mind what you want to sacrifice, if the run time, the quality of image objects, the degree of difficulty of implementation or the hardware and quality cost, between other.

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