Automated Toll Booth using Optical Character Recognition and RFID System

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ABSTRACT

Looking towards India's rapid increase in the number of personal vehicles, it has become really difficult to manually collect the toll fee which generally results in a long traffic jam. A lot of fuel is wasted in this process. An Automated Toll Booth can be implemented which increases the efficiency of the process to save the time and bottle neck scenario at the toll booth. Optical Character Recognition for license number plates can be implemented for the same. To make sure that the number plate is detected correctly, cross-checking it with the RF-ID tags issued by Indian Government in the number plates will be done.

Key words: Electronic toll collection, OCR, RFID Tag, Motorists.

1.INTRODUCTION

Toll booths, plazas, stations, toll houses, bars, or gates are the stops where the fees are collected. In developed countries, many toll collection booths are automated where the user deposits the fee in a machine which opens the access once the correct toll has been deposited. To minimize time delays and long traffic jams, nowadays many tolls are collected by different types of automatic or electronic toll collection systems which communicate electronically with the user and collect the fee accordingly. Although, manned toll booths are still in use for some users who might not have access cards to the toll system. The fees for the toll are often paid beforehand or collected "automatically" from an authorized banking service, usually credit card. For security purposes, many toll booths have cameras installed along with toll enforcement systems that are used for taking photos of vehicles and drivers who skip to pay the tolls and also the pictures of their license plates. Such drivers are fined along with the original toll fee [1][3].

In India, Tollbooths and other related operations are controlled by the National Highways Authority of India (NHAI). It was formed under the Act of Parliament (National Highways Authority of India Act, 1988). It takes care for the construction, renovation, development and management of Highways in the country. NHAI take parts into Concession contracts for design, construction, operation and maintenance of highways by DBFOT Concessionaires. The Concessionaire builds NH stretches and during operation and maintenance of the said stretch collects and retains the toll (user fee). In case of stretches developed on Govt. / NHAI Funds, NHAI engages OMT Concessionaire / User-Fee Collection Contractors [4]. With time, the increasing number of personal vehicles as well as commercial vehicles makes the scenario of transport systems worse [1][2]. A report from the Ministry of Road, Transport and Highways extensively focuses on the Traffic jams on national highways, delays at toll booths, frequent accidents and political rallies and marches. Such disturbances annually cost the economy nearly Rs.40 billion. Time loss at toll booths gives the maximum loss when it comes to the trucking sector. This can be seen from the fact that on an average, a truck has to stop at 18 different stops and the average time delay at each stop is around 3 hours. Renowned professor from IIM-Calcutta Dr. Subrata Mitra suggested to look forward for systems and technology that are used by the other Asian developed countries. A self-sustaining regulatory authority should be implemented [5].

2.OPTICAL CHARACTER RECOGNITION (OCR)

Character recognition, usually abbreviated to optical character recognition or abbreviated as OCR, is manual or automated recognition of machine workable text from images of typed text, scripted material, printouts or human writing. OCR is part of understandings patterns and machine learning. Although OCR has undergone a lot of development, the center of interest has changed to usage of various techniques in character recognition rather than just simple plain recognition of text. OCR is the best possible technique to use for processes involving document input as it is time and cost saving. The best part about OCR is, one can get a lot of physical papers and notes by replacing them with digitized versions. Optical Character Recognition can be performed using clusters of pixels in an image to match with characters. There would be a stored data of templates and the image is checked with the templates using correlation technique. This method depends on the separation of individual block of character from the image and provided that the font of the character is present in the template [6]. This method works perfect when recognizing characters from the number plate where the fonts used in the image of number plate are same as fonts in the template[13] [7].

3. RADIO-FREQUENCY IDENTIFICATION (RFID)

Radio frequency identification (RFID) is one of the technologies that are in heavy research and exponential growth. This technology has capabilities to make powerful impact on businesses and industries of various backgrounds. RFID is a common term for the technologies that use radio frequencies to automatically identify objects and sometimes even human beings and animals. There are a varied range of processes for detection, but generally, it is the serial numbers and unique identification codes that are used to differentiate the products etc. form one another. This unique identification code is stored in a microchip embedded in a user friendly tag or card along with an antenna. The chip and the antenna together forms a RFID transponder[2]. The antenna helps the chip to transmit the unique codes in the range of radio frequencies to a receiver also called as sensor or a reader. The reader reads and decodes the radio waves coming back from the tag into digital information generally, in form of strings of hexadecimal characters that can then be further processed for different types of use depending on the type for which the identification was [Figure 1] used[14][15].

4. VIRTUAL PRIVATE NETWORK (VPN)

The Virtual Private Network does not actually have direct connections between two nodes but instead connects two remote entities which can be worked upon remotely. This aspect of networking can be applied to wired local area connections as well as wireless local area networks. Security is the primary concern of virtual private network. A private path is constructed to obstruct the hacking. To acquire this secure path information at one end is encoded and passed through a secured tunnel which is decoded at the other end. We can implement the virtual private network using two techniques namely point to point Virtual Private Network and remotely accessed Virtual Private Network [10][11].

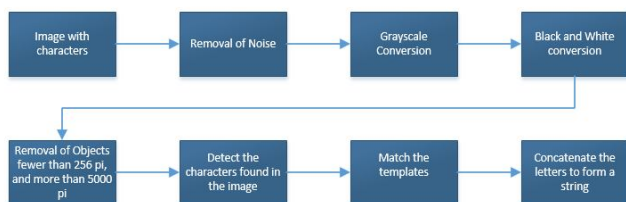### 5. DIGITAL IMAGE PROCESSING THROUGH MATLAB

Figure 1: Digital Image Processing through MATLAB

Capturing the image

When the vehicle is passing through the toll-booth, the camera associated with the toll-booth captures the image of the license number plate of the vehicle. The resolution of the image is specified as 640x480 [12][18].

Removal of noise and Gray scale conversion

Since the image is taken in real time, it has a lot of unwanted noises. For the removal of noises, Gaussian filter is used. It is used to blur images and remove redundant aspects of the image. Filtered image is achieved by convolving the 2-D Gaussian distribution function with the image. The image is blurred and the noises are partially removed. The Gaussian filtered image is then converted to gray scale form. The major motive of the process is character detection [8][9]. Hence, the image is converted to gray scale and then further to black and white form.

Black and White Conversion

Figure 2: Captured image of License

Figure 3: Noise removal and Gray scale conversion

The black and white image contains a matrix of 0's and 1's. 0's represent black part of the image and 1's represent the white part of the image. When seen in a matrix form [Figure 2] , it is observed that there are clusters of 1's formed in a pool of 0's. Apart from the important characters there are also some unwanted clusters of sizes outside the range of characters. Such clusters are removed by setting a threshold to the clusters. Clusters with more than 5000 pixels and less than 350 pixels are removed from the image [Figure 3, Figure 4, Figure 5].
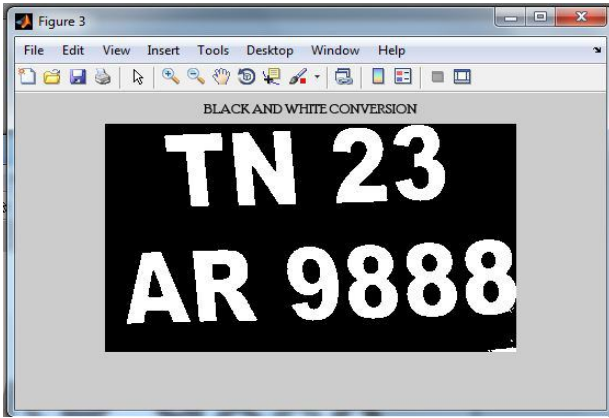
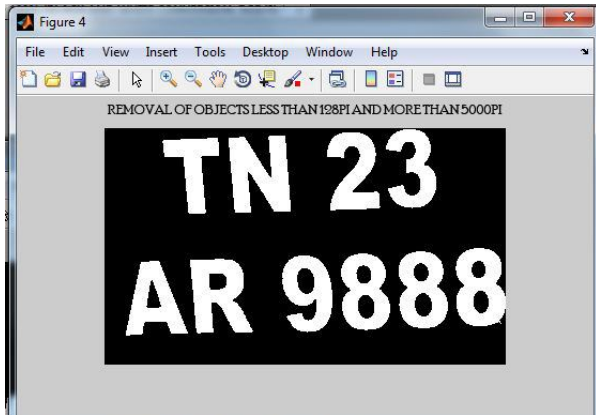**Figure 4:** Black and White Conversion

Figure5: Removal of unwanted clusters

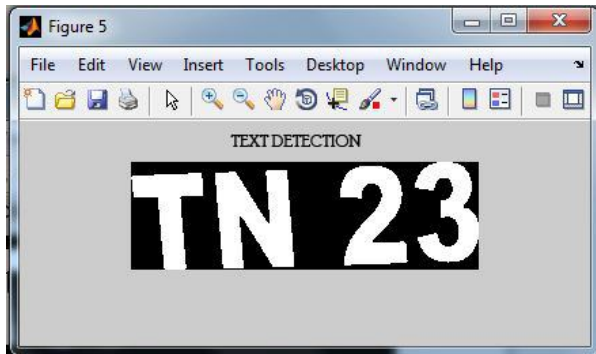## 6.MATCHING OF CHARACTERS AND CREATING A STRING

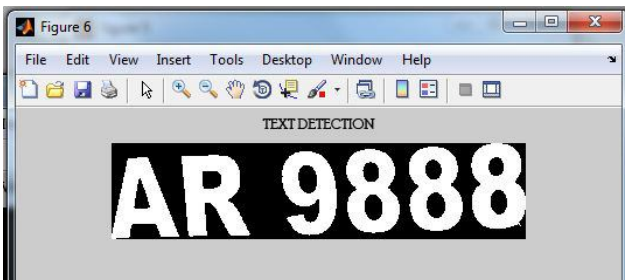**Figure 6:** Matching of Characters and creating a string

Figure 7: Cluster and character recognition by convolution method

The clusters are then separated from the image and formed into single blocks for character recognition of the cluster. These blocks are then matched with already fed database of the characters. Matching is done by convolving the cluster blocks with all the templates of the characters stored in the database [Figure.6]. The template which matches the most with the cluster is selected and the letter or number associated with the template is sent as recognized character[10]. Once all the characters are recognized successfully, the letters are concatenated into the string and the whole license number of the vehicle is obtained in the form of a string. This string is then matched with the available database of all the license number plates available on the server and then it can be processed accordingly [Figure.7] [16][17].

7. SENDING AND RECEIVING DATA THROUGH SECURE CHANNEL THROUGH VPN

Once the string is created for the License number, it is sent to the main server where all the database of the registered license number plates are stored [19]. The server is linked to all the toll booths in the country via secured links created under a virtual private network (VPN). The string is matched character by character in order to get faster recognition of the number. Once the number is matched, the whole data associated with that license number i.e. vehicle type, driver's details toll fee and associated account number etc. are sent again through the server [Figure 8].
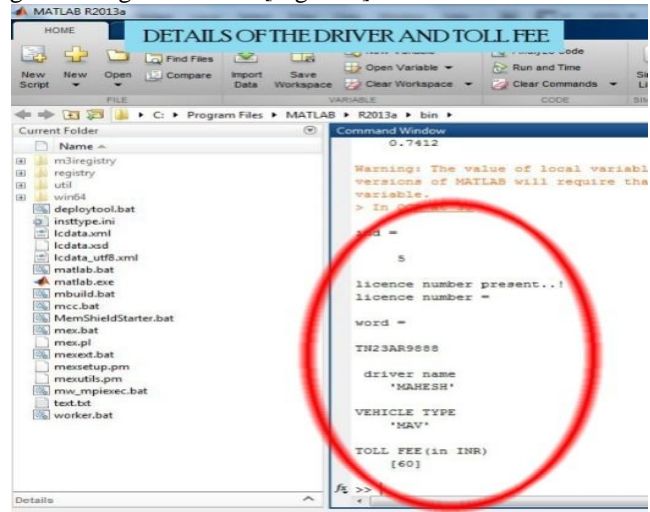

Figure 8: Association of owner with vehicle

The same secured server is used to access the account of the vehicle owner. The toll amount is deducted from the account and the receipt details are sent to the toll booth. All the relevant details are submitted to the toll booth and hence, the receipt is generated for the same. Driver is also intimated for the receipt with the help of a display[20][21].

8. RFID DETECTION

Sometimes, due to improper text format of license number text or mud on number plate or inappropriate weather, the license number is not detected properly using digital image processing. Alternatively, RFID tag sensing for vehicles is

used. The plates have a radio frequency activated chip commonly known as RFID tag. These chips store a unique ID code which is stored in hexadecimal format. The tags can be detected with the help of RFID sensor circuit, which sends radio-frequency signals to the tag and receives its information that is stored in the chip[16] [22]. The code is then sent serially to the server and then the related information can be retrieved from the server. Here, RFID MRC522 sensor circuit is used for sensing the code from the tag [Figure .9, Figure 10, Figure 11].
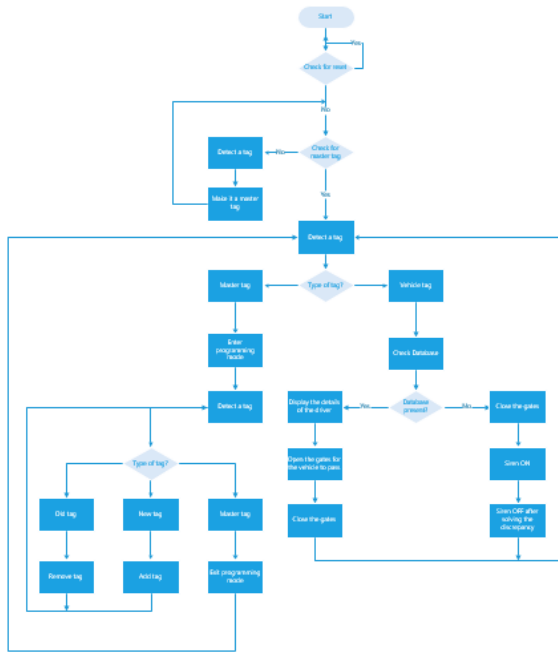

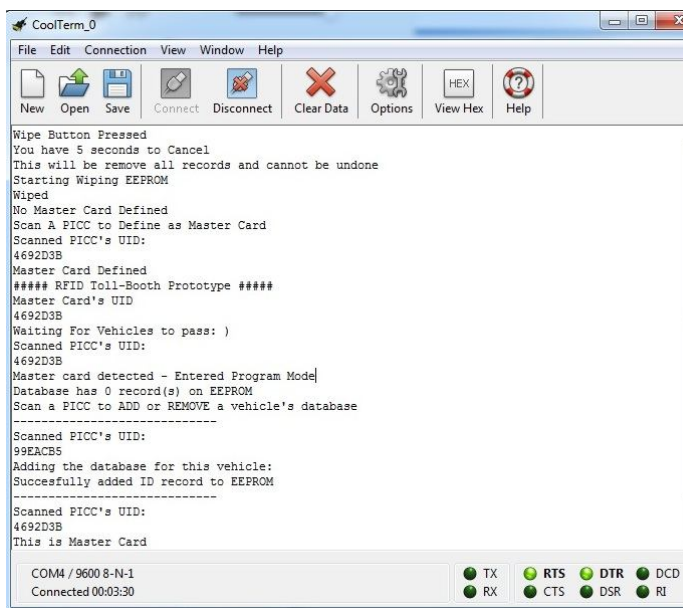**Figure 9:** Flow-chart for RFID detection of vehicles

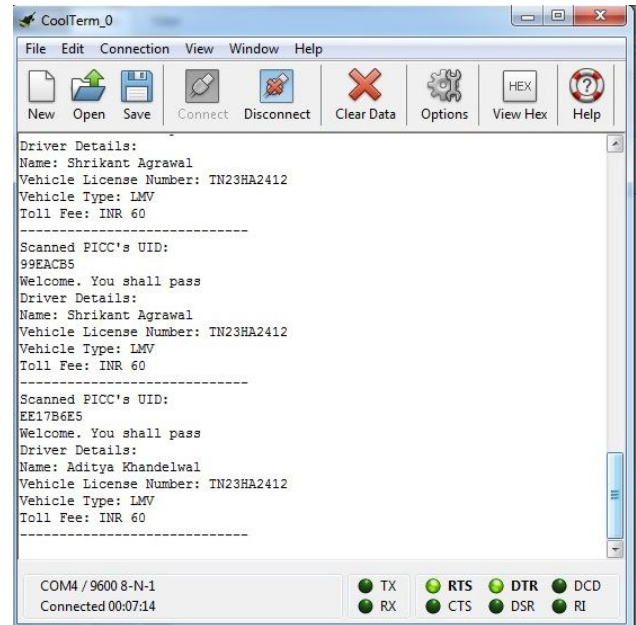**Figure 10:** Setting up the circuit for RFID detection using the master card

Figure 11: Detection mode of RFID sensor; Displaying all the details of the driver and the toll fee

9.DISPLAYING THE DETAILS OF THE DRIVER ON DISPLAY
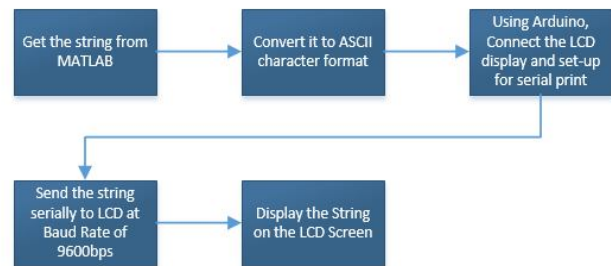

Figure 12: Block Diagram for displaying the details of the driver on display

Once, all the details of the driver are obtained and the fee deduction process is done, the display is given on a LCD board with the help of an Arduino board. Here we use Arduino ATmega 328 microcontroller for display and scrolling of the driver details. One the string is obtained from MATLAB software to Arduino IDE, the string is converted into ASCII character format. This format is recognized by microchip system embedded with LCD functioning[5]. Using Arduino [Figure 12], LCD is prepared for serially printing the data. Once the LCD is set for the print, the String characters are sent one by one to LCD at a Baud rate of 9600bps. The bits are transferred to the screen and the character is displayed accordingly [Figure 13, Figure 14]. Once the whole string is displayed, a marquee function can be implemented in order to fit large strings [11] [23].

Figure 13: -Displaying The Details of The Driver nn Liquid Crystal Display
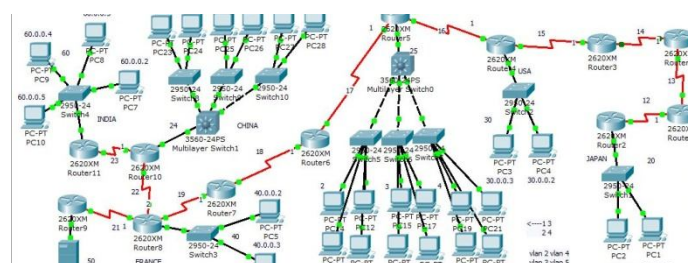

Figure 14: Snapshot of the network spread across tollbooths

10. CONCLUSION

The paper demonstrates complete working of a prototype of an Automated Toll-Booth. Implementation of the optical character recognition on actual number plates of vehicles has been successful. The scanning of RF ID takes place within a range of 1 - 4.3cm. The database of 150 vehicles is available in the system. The paper implies for working of a better alternative for current scenario of Toll systems in India. Several state governments are planning and working on such automated systems for Toll systems along with NHAI. Government of Maharashtra is seeking the automation of toll booths based on the request from Member of Parliament Mr. Sachin Ramesh Tendulkar.

11. SCOPE OF DEVELOPMENT

The prototype gives a basic functioning of how the Toll systems in India can be automated. There is a lot of scope for development of this paper. Better detection systems can be implemented. Higher resolution cameras with autofocus on license number plates can be installed for quick and better response of detection using DIP. Active RFID sensors can be implemented in place of passive ones for increasing the distance of RFID detection which will result in smoother process of Toll collection. Back-up LAN can be installed for uninterrupted services in case of network failure. Better schematics can be implemented for Hub, Switch and Router configuration.

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