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An Intelligent and Real Time System for Automatic Driven Toll Gate System under Complex Scenes

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Abstract

Intelligent transport systems play an important role in supporting smart cities because of their promising applications in various areas, such as electronic toll collection, highway surveillance, urban logistics and traffic management. One of the key components of intelligent transport systems is vehicle license plate recognition, which enables the identification of each vehicle by recognizing the characters on its license plate through various image processing and computer vision. With almost 15 Crore vehicles using national highways across India, a 10-minute idling per vehicle at toll booths result in huge traffic every day. The reason why vehicle stand at toll gates are due to the need of exact change for an absurd amount of Rs. 27/- or Rs. 54/- etc, malfunctioning of the system, changeover of staff, taking two minutes to log off and log in as per the attendant and balancing cash, drivers chatting with attendants too and manual collection of tolls. Thus we like to proceed with the idea of automated toll gate with no manual power. This paper presents a robust and efficient method for license plate detection with the purpose of accurately localizing vehicle license plates from complex scenes in real time. A simple yet effective image downscaling method is first proposed to substantially accelerate license plate localization without sacrificing detection performance compared with that achieved using the original image. Currently world is trending with Internet, so with the help of that the toll amount is deducted from the owner's bank account and a SMS notification is sent to their phone. The detection ratio from 91.09% to 96.62% while decreasing the run time from 672 ms to 42 ms for processing an image with a resolution of 1082 ×728. The executable code and our collected dataset are publicly available.

Key Words- *Raspberry Pi 3, Raspberry Pi camera, MobaX Terminal, Redis Desktop Manager, Licence Plate Detection, Image Processing.*

I. INTRODUCTION

Considering the issues mentioned above, this paper develops an efficient and robust approach to license plate detection that is able to accurately localize one or multiple vehicle license plate(s) with diverse variations from complex backgrounds in real time. To speed up the detection algorithm overall, we first investigate how to reduce the size of the original high resolution image without decreasing license plate detection performance. Note that because of the negative effects that are generally introduced by the down-sampling method that is commonly used in image processing, most previously developed methods perform license plate detection using the original image. Then, we analyze the common characteristics among diverse license plates and their major differences with respect to background regions to serve as a basis for designing a region filter to exclude irrelevant regions in the image. Furthermore, we study which features are most discriminative for license plate detection and then propose an efficient and robust classifier to ultimately localize the exact position of the license plate in the image.

Following the licence plate detection, the other process is vehicle detection and identification; this is to know about the type of vehicle. Because in India the toll pay varies for every vehicle. For example if it is a government vehicle there is no toll pay, and if it is school or a college vehicle they renew the toll pay for every month, similarly the four wheelers has less toll pay vary from Rs. 30-50/-, and heavy vehicle has little bit more toll. Thus the vehicle crossing the toll, the amount should be correctly deducted. Hence this vehicle identification helps in accounting the correct toll pay for a vehicle to be deducted.

The process of licence plate detection helps in accessing the vehicle owners' toll pay account. Initially the number plate consists details like the name of the owner, the date when car purchased, the bank from which loan, the insurance claimed date, etc. Thus on detecting the number plate it gives a direct accessing to the owner's details which is in a format of database and deducting the amount from there.

II. HARDWARWE AND SOFTWARE DESCRIPTION

a)Raspberry Pi 3- The Raspberry pi 3 is a board that includes a microcontroller and some integrated modules created by Raspbian Foundation extending its usage in various applications such as Wi-Fi, Serial communication-UART, Camera module, General I/O Pins(40 pins), USB ports and Ethernet compatibility. The figure (1) shows the major blocks in Raspberry Pi 3 board.

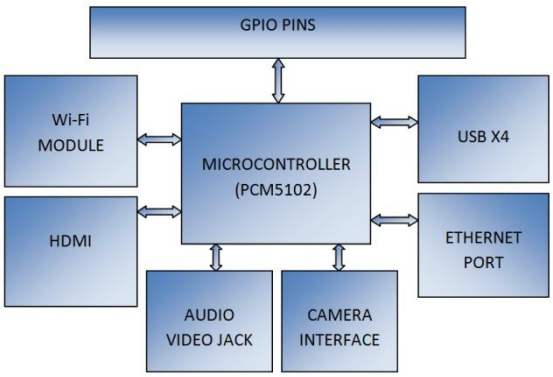

Figure (1) - Blocks in Raspberry Pi Board 3

b) Raspberry Pi camera- The camera is used in wide applications mainly for the image processing. This is a high quality 8 Mega Pixel Sony IMX219image sensor which is exclusively designed adds on board for Raspberry pi. It also features a fixed focus lens and can acquire static images of resolution 3280 x 2464 pixels. It also supports 1080p30, 720p60, 640 x 480p60/90 video. The board is very tiny, typically of dimensions at around 25mm x 23mm x 9mm and weighs around 3grams. It connects the Raspbian board through a short ribbon cable.

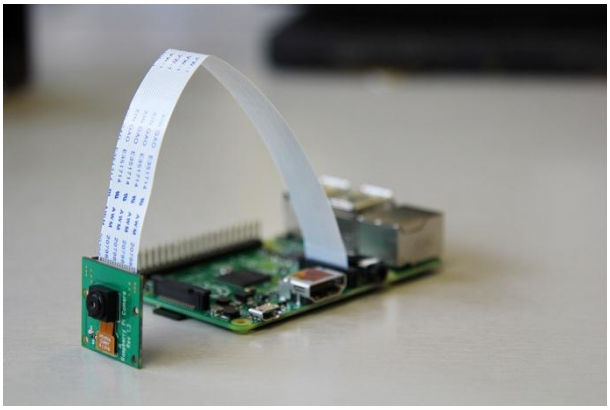

Figure (2) - The Raspberry Pi Camera

c) Redis Desktop Manager: Redis is an open source in-memory data structure store, used as a database, cache and message broker. It supports data structures such as strings, hashes, lists, sets/sorted sets with range queries, bitmaps, hyper logs and geospatial indexes with radius queries. Redis works with an in-memory dataset. Redis is written in ANSI C and works in most POSIX systems like Linux, *BSD, OS X without external dependencies.

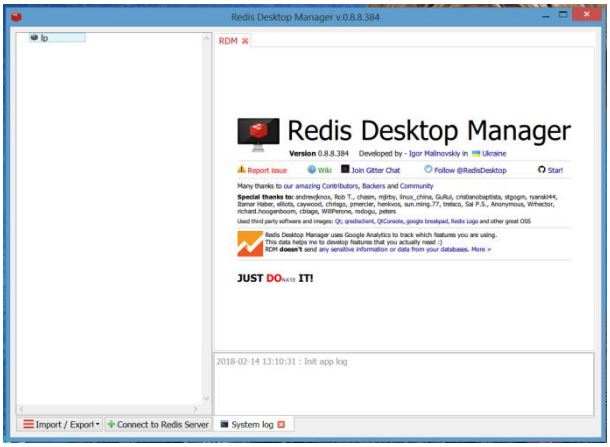

Figure (3) – The Redis Desktop Manager

d)MobaX Terminal- MobaXterm provides remote network tools like SSH(Secure Shell Host), FTP(File transfer Protocol), MOSH, RDP, VNC, etc. It provides Linux Compatibility in Windows which also available in portable software.

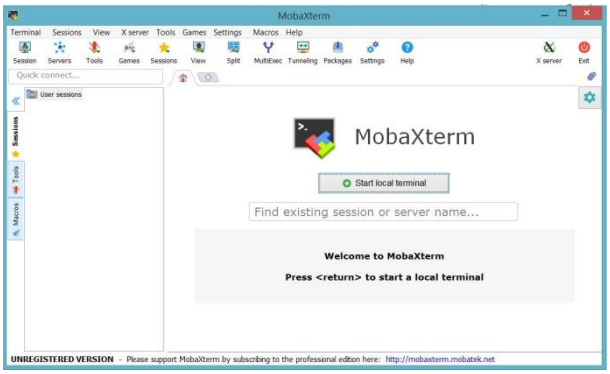

Figure (4) – The MobaXTerm for Local Session host

e)Ethernet(RJ-45)- A Registered Jack(RJ) is a standardized telecommunication network cable used for providing connectivity via cable such as fibre optic or twisted pair.

f)Raspbian OS(Operating system)-Raspbian stretch- Raspbian OS is a Debian - based OS for Raspberry Pi. The stretch is the latest version or an upgrade for Raspberry Pi which is a development codename for Debian 9.

III. RELATED WORK

As the key step in a license plate recognition (LPR) system, Licence Plate Detection methods gave a maximum opportunity these years [9][10]. Basically the number plate characters are recognised by edge detection. In [1], the magnitude of the vertical gradients is used to detect candidate license plate regions. Shapiro et al. [8] applied

Robert's edge operator to emphasize vertical edges and used the projection of vertical edges to detect license plates. Zheng proposed a license plate extraction method [7] that searches for a license plate in a convolution output image using a rectangular shift window. Although this method is sensitive to window size, only a single license plate can be detected in any given image. Jia et al. [36] proposed a region-based method for LPD that uses the mean-shift approach to segment a colour vehicle image and uses edge density information for license plate verification. Anagnostopoulos et al. [35] proposed an adaptive image segmentation technique to accelerate license plate detection. In [6], a block-based edge density prediction method was used to find candidate license plate regions, and a voting method based on multiple features was used for license plate verification. Although the detection step of this method is fast, its location accuracy primarily depends on the block size. Lalimi et al. [20] modified the region-based method of [36] and used morphological filtering to extract candidate regions. Ghaili et al. [13] proposed a vertical edge detection algorithm to speed up LPD methods. However, the improved computational efficiency is achieved at the cost of reduced edge information. In [37], edge clustering was exploited for license plate localization. Wang et al. [21] used gradient information and a trained cascade detection model for license plate detection.

The connection of character regions is another important cue for license plate extraction. Donoser et al. [12] proposed an LPD algorithm based on the maximally stable extremal region (MSER) concept [11], which enables the simultaneous localization and segmentation of individual characters. Li et al. [4] also used the MSER approach to detect character regions by exploiting bright and dark MSERs to handle all kinds of Chinese license plates. These MSER-based methods can achieve high localization accuracy in relatively simple scenes. However, they have difficulty detecting character regions in more complex ones, e.g., scenes in which some areas of the license plate are contaminated.

The morphology technique [15], an important tool that is widely used in image processing tasks such as salient region detection [24] and object segmentation [31], has also been successfully applied for license plate detection by many authors. The morphology technique is typically used to detect the structural information of license plates. Hsieh et al. [17] used the differences between a 7×1 open operator and a 7×1 closed operator to locate license plates. In [5], a morphology gradient method for extracting license plate candidates was introduced that achieves an impressive average extraction ratio of 96.6%. However, the morphology technique is time consuming and is not suitable for license plate detection against complex backgrounds.

A number of previous approaches have extensively exploited colour features for LPD, based on the observation that a license plate usually exhibits a regular colour appearance of both its background and its characters. In [18], a neural network was applied to extract colour features from the hue, saturation and lightness channels separately. Kim et al. [34] proposed combining colour and texture features for the detection of license plates in images. In [23], Tian presented a license plate localization method based on a fixed colour pair for the characters and background regions of a license plate. In [19], an edge-based and colour-aided algorithm for

license plate detection was proposed. Ashtari [38] introduced a method based on the modified template-matching technique for localizing an Iranian license plate in an image through an analysis of target colour pixels. In this paper, we exploit colour saliency and edge features for license plate detection.

IV THE PROPOSAL APPROACH

License plate recognition and detection:

The first module of our project is license plate recognition and detection. In order to acquire the characters inscribed in the license plate, we have to first locate the license plate. In order to first locate the license plate the acquired image from the raspberry camera is first converted into a gray scale image. Once the image is gray scaled, thresholding is done. Thresholding is necessary because, the license plate characters are black in colour after gray scaling the image. Since the characters are black in colour, by the process of thresholding, we can make the characters appear white and the unwanted information can be made black. In thresholding process, a pixel value is chosen based on the pixel value of the characters in license plate and they are made fully white by changing those pixel values to a higher one (255 being the maximum value, white colour). Once these pre-processing is done, using suitable algorithm, the license plate is located from the image. Also to recognise the characters, training data set is fed to the raspberry pi so that, the accuracy rate is high. We use ANPR technology (Automatic Number Plate Recognition) to read the characters from the license plate. The ANPR technology uses optical character recognition on images to read the characters from the license plate. The various process involved is shown in the figure(5).

There are various algorithms used for ALPR (Automatic Licence Plate Recognition). The algorithms varies for segmentation, greyscale conversion, conversion of image into binary(Thresholding), comparing the images with trained bits.

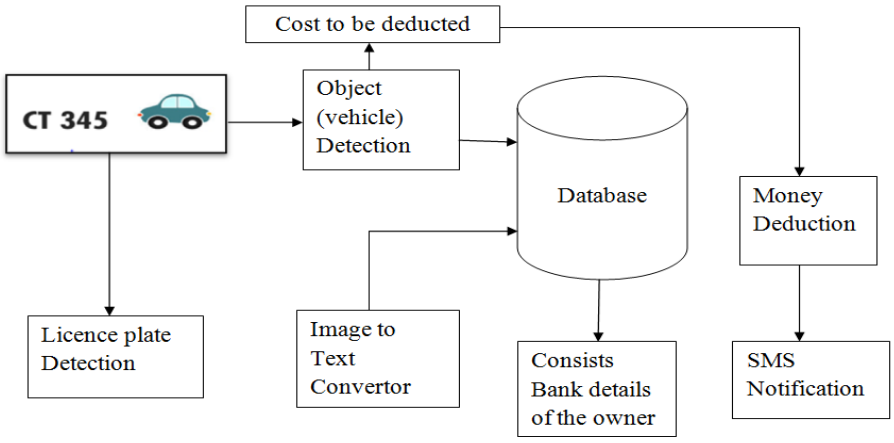

Figure (5) - The Block diagram

1.Image pre-processing

The image captured by the camera is of high image size, hence in order to reduce the size of the image downsampling is performed. We all know the height of the number plate is less than the width of the number plate, thus the image is downsampled with the downsampling factor, d. The height of the plate is denoted by h and the width of the image is denoted by *w*.

$$w_s = w_i / d_w \qquad (1)$$

$$h_s = h_i / d_h \qquad (2)$$

The equation(1) is used to down sample the height of the image and the equation(2) is used to down sample the width of the image. Where w_i and h_i denote the width and height, respectively, of the original image, whereas w_s and h_s represent the corresponding downscaled dimensions, and d_w and d_h (s.t. $d_h < d_w$) are the downscaling factors for width and height, respectively. The figure (6) shows the various steps involved in the image pre-processing.

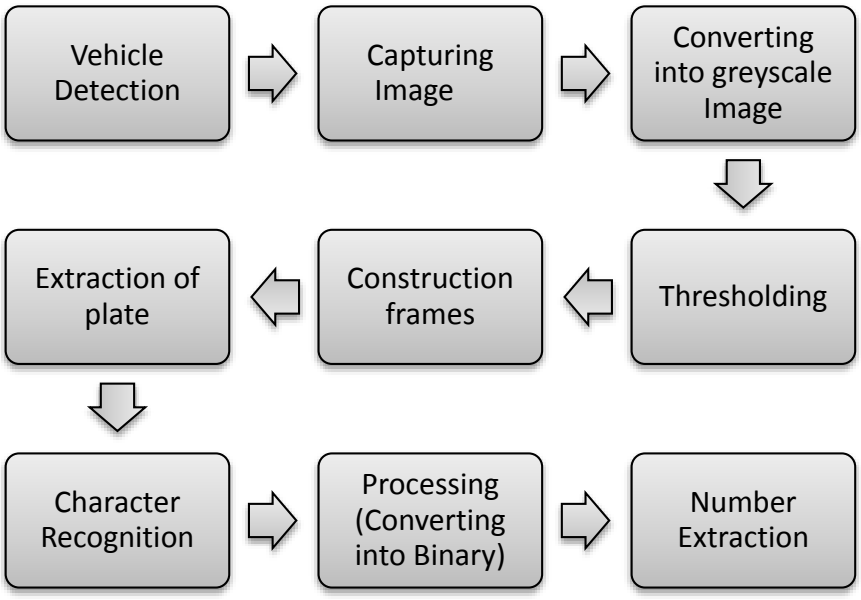

Figure (6) – Steps involved in Image pre-processing

2. Candidate Extraction

The candidate extraction method consists of edge detection, edge image binarization via adaptive thresholding (AT) and the proposed novel line density filter. The edge detection is important as to recover the licence plate and thus can be moved to further process. The Sobel filter is used for edge detection. The adaptive threshold removes the weak edges and generates a binary image. The candidate for the captured image is calculated by the following equation (3)

$$C_{wd} = 1 - (1 - C_w)/(l_w * 3) \qquad (3)$$

Where C_{wd} indicates the candidate value and C_w indicates the image pixel value of captured image and l_w indicates the value of camera pixels. The following figure (7) illustrates the capturisation of Licence plate.

Figure (7) - Capturing Number plate with Pi Camera

The following figure (8) shows the output of the licence plate image captured. The output consists of the number generated from the image of licence plate and the candidate accuracy.

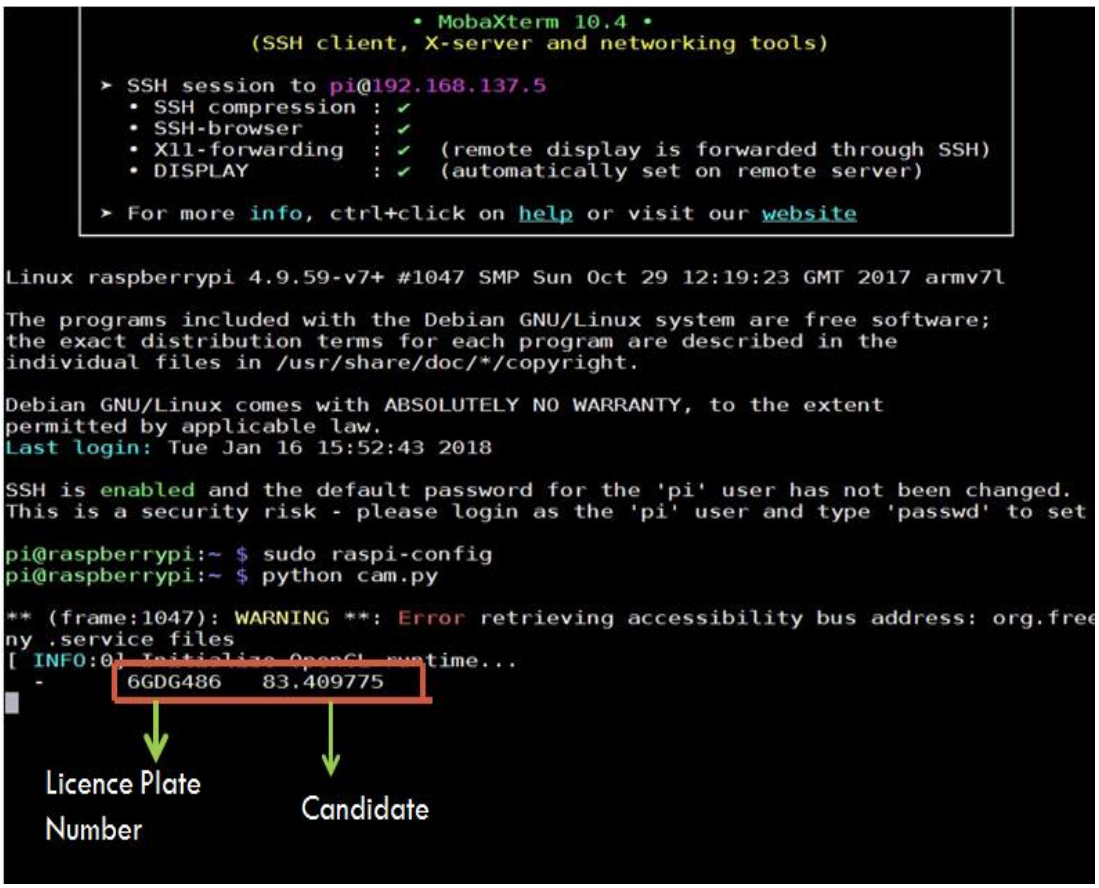

Figure (8) - Output of the captured Licence plate Image

Creating a repository using Redis:

Once the license plate is being detected and recognised, we create a repository of data, where a list of license plate and its associated owner details are being stored. This database is managed using Redis software. Here, we take some samples of license plate details and store it in a database. Redis software provides a compatibility to store and manage data and access these details through python environment from MobaXterm. The MobaX Terminal allows us to edit database and quickly updates the details stored in Redis Desktop Manager.

Vehicle Classification

Since the toll pay varies for different vehicle, the vehicle should be identified while deducting amount. Hence the vehicle should be classified and maintained a database to identify the vehicle. The process includes image capturing and comparison. The database will be stored with images of all kind of vehicles and the image captured from a vehicle is compared with the image in the database and depicts what kind of vehicle it is. It also responds with the probability comparing the originality in the database image and captured image. The figure (9) shows the comparison of the image and the output probability.

Figure (9 (a)) – The captured image

Figure (9 (b)) – The image stored in database

Figure (9 (c)) – output of the Vehicle identification

Dedicated application for toll gate deduction:

In order to provide the user to view his money deduction and balance amount in his account, we create a dedicated application (a web page) for each and every user so that he could keep track of his money deduction details. Here an online web page is being used so that, whenever a user feels like checking his account details, he can login with his username and password.

SMS notification:

Once the amount is being deducted based on the vehicle size (heavy, light, etc), we ensure that the user gets to know that the money is being deducted. The notification mechanism we use here is through an SMS message, figure (10).

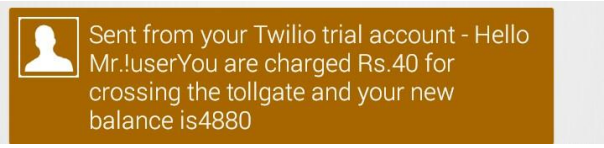

Figure (10) – SMS Notification to the User's registered mobile Number

V CONCLUSION AND FUTURE APPROACH

Thus this approach is an efficient way to pay the toll amount at toll plaza. This approach consists of various processes like simple way of down sampling, image pre-processing, segmentation, efficient way of licence plate verification, vehicle identification and managing database and dedicating the application through SMS notification and particular users Web application. Though there are negatives like glaring while capturing of image, damage in the licence plate can be overcome by MSER or Hough Transform approach.

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