IOT and Machine Learning based Automatic Toll Collection System

Anupriya Mandal, Divyansh Singh, Rachel Shukla, M.V.Patil

Abstract- Automatic Toll Collection System is a wireless system which autmomatically collects the toll charge to vehicle at various toll booths in many metropolitian cities. It is very efficient and fast processing technology which will eliminate heavy congestion and over crowding of vehicles in cities. It accelerates hassle free toll collection system and traffic monitoring. This system detects the arrival of vehicle and then captures the image of number plate. Vehicle number plate is located, and characters are segmented. The captured image is then converted into gray scale as system can process only gray scale images. Optical character recognition technique is used for template matching. The result is then compared with our database and gives extracted information to the user. Toll chage is deducted from e-wallets and the system opens the barrier. The vehicle information, time passing, date, toll amount is also stored in the database to maintain the record.

Index Terms— Automatic toll tax collection system, image processing, IOT, pi camera, raspberry pi, vehicle number plate recognition, machine learning

1 INTRODUCTION

Electronic toll collection technology was first presented in Bergen, Norway in 1986, working together with traditional toll booths. Automated vehicle identification (AVI) systemis the most early used technology in toll collection system.AVI is the method for controlling the identity of a vehicle when it is in the toll gate area.Previously, bar codes were installed to each vehicle, which were read optically at the toll booth. However, optical systems were found to have poor reading reliability, especially during bad weather conditions and in case of dirty vehicles. AVI systems mostly depend on radio frequency identification (RFID), where an antenna at the toll gate communicates with a transponder fitted on the vehicle using dedicated short-range communication (DSRC). These have exceptional accuracy and can be read at high speeds.

The next technology used is Transaction processing system is used for maintaining customer accounts, posting toll transactions and customer payments to accounts, and handling customer inquiries. Customer accounts may be postpaid or prepaid. Postpaid accounts are where toll tax are periodically allocated to the customer. Whereas prepaid ones are those where the customer funds a balance in his/her account, which is then depleted as toll transactions arise.
A prepaid system is more frequently used, as low amounts of most tolls make follow up of uncollected debts expensive. A postpaid account usually contends on a security deposit, effectively rendering it prepaid. Transaction processing function is also described to as customer service. In many ways, transaction processing function is like standard banking—at times, toll agencies contract out transaction processing to a bank.

The next technology is Violationenforcement system(VES) An unmanned toll gate represents an interesting target for toll evasion. VES is used for reducing unpaid tolls. Several methods are used to detect and discourage toll violators. Administration guards are often deployed effectively at toll gates. However, this can be quite expensive. The barrier, such as a gate arm, can be employed to ensure that all vehicles passing through the toll booth pay the required toll. Violators get identified immediately, as the barrier does not allow them to proceed. However, barriers also require authorised customers, which are most vehicles passing through, to slow down to a near-stop at the toll gate, adversely affecting many of the benefits of electronic tolling.

This system uses automated toll collection technique where collection of tolls can be done automatically using image processing technique where we can detect the number plate of a vehicle and there by deduct the toll amount. Vehicle Number Recognition (VNR) is an image processing technology which uses efficient algorithms to detect the vehicle number from real time images[1]. The objective is to design an efficient Vehicle Number Recognition System & to implement it for automatic toll tax collection. The vehicle's number plate images are kept in the database, with the help of those images the image processing technique will be implemented to extract the registration number of the car from the number plate, with the help of this extraction the details of the vehicles owner will be taken from the database and particular amount will be deducted, if the vehicle owner acquires an e-wallet, even that information will be taken from the database because that person has already paid the toll amount in advance for a respective duration and the toll amount won't be collected from him/her[2]. In [3], according to conventional toll tax collection system, to overcome the biggest issues of vehicle congestion and time consumption, the e-wallet system is used . In the proposed system image will be passed as an input or can be browsed from any location. Using this image, the number plate is detected, and further process continues. In [4], Various modules of this system are RTO admin, Toll admin, Police admin, Super admin, and the public. The role of the Super admin is to register toll centres at various locations using Username and password.

Toll deduction takes place through e-wallet designated to the concerned number plate of the vehicle that belongs to the owners' account. The main motivation of this system is to provide a base for building automatic number plate detection using image processing for toll collection at toll checkpoints[5]. This system will help to save time as well as help to reduce congestion at toll barriers. This system will also help in monitoring any dishonest behaviour that takes place at the toll checkpoints. The proposed system will maintain the database of captured images placed at the toll checkpoint and will perform certain procedures to detect the number plate of a vehicle[6]. Using this image, the number plate is detected, and further process continues.

According to author [7], The goal is to design and implement an efficient Vehicle Number Recognition System for automatic tax collection. The computer first detects the car and then pictures the vehicle's front view. The number plate of the car is placed, and the characters are segmented. The system is designed to detect the number plate regardless of colour for gray images. When digital camera advanced and processing speed increased, various groups of scientists became interested in VNR after the 1990s. VNR is an imaging technology that enables digital images to be retrieved from the vehicle's license number[8]. Template matching technique is used for character recognition. The resulting vehicle number is then compared to all available vehicle records for collecting vehicle type information and paying the toll tax accordingly. The machine is then allowed to open the vehicle's road barrier and produce the receipt of toll tax. The specifications of the car are also contained in the database. the record.

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2 PROBLEMS IN EXISTING SYSTEM

According to author [9], there is need of a new toll collection system to eliminate the existing problems:-

1.Corruption in money collection at toll booths: - On the toll-booth corruption is occurred at the time of paying the toll tax, the toll cashier collects the correct amount of money but not give the collected count of money to toll admin at that time mostly chances of corruption.
2.Increasing rate of stolen vehicle: - In previous system, there is not any mechanism to detect the stolen vehicle which is pass through toll this increases the rate of stolen vehicle.
3. Vehicle congestion at toll booths: - In the existing system, the owner passes the vehicle through the toll then the cashier was giving the receipt to every owner and by this the existing system is got slow and by this lots of vehicles is get waiting in the queue and by this vehicle congestion is occur.
4. Toll deduction is time consuming: - In the existing system, the payment of toll tax is as manual process, the toll payment is done by hand, giving cash due to the manual process the system is time consuming.
5. Manual system and Wastage of paper: - The payment process of existing system is manual process not an automatic process and the user of the vehicle pay the toll tax by hand and the cashier provide the paper receipt as the payment acknowledgment to the user by this the paper waste is more.
6. Handling cash and carrying credit cards: - The previous system is manual system, and the payment of tax was the manual process hence a user always had to carry cash or the credit cards for the payment of toll.
7. Fuel consumption: - In previous system the vehicle got congested in queues and waiting for the toll tax payment in that case many more users do not turn off the vehicle by this the fuel got waste

3 LITERATURE SURVEY

Previous research papers were surveyed, and a table is formulated describing the drawbacks and need of a newer and better system for toll collection.

Name Of Author and Title	Description Of Research Paper	Drawbacks
Automated toll booth system by Rama Takbhate, Prof. S. D. Chavan[11]	Number plate detection is done with the help of camera and process by using the image processing.	Disadvantage of ANPR parking systems is that they rarely consider human error and behaviour. ANPR systems do not usually consider giving a grace period when you enter a car park.
Number plate detection with application to electronic toll collection system by Kannan Subramanian	The purpose of this system is to create a real time application of number plate detection and tagging can be made for car parking sys-	The fact that images and records are kept and stored raises some privacy concerns. People are usually afraid that the records of someone's whereabouts in all these footages might be misused. It can become a subject of data thefts or people with all kinds of ne-

[12]	tems.	farious intentions.
Image Sentiment Analysis Using Deep Learning by Mittal, N., Sharma, D., & Joshi[6]	Determining the image sentiment is a tedious task for classification algorithms, owing to complexities in the raw images as well as the intangible nature of human sentiments.	In the field of sentiment analysis are some challenges in a range of scenarios, in terms of architecture and application domains with unclear or scarce datasets. Also, there is a lack of labelled data, which can pose a barrier to the advancements in this area
Vehicle number recognition system for automatic toll tax collection by Shoaib Rehman, Soomro Mohammad Arslan Javed, Fahad Ahmed Memon [2]	In proposed system image is captured through camera and processed. Image is converted into text form, by converting RGB image into grayscale and then grayscale into binary.	RFID technology is harder to understand, can be less reliable RFID tags are usually larger than barcode labels, Tags are application specific. No one tag fits all, Possibility of unauthorized reading of passports and credit cards, more than one tag can respond at the same time
Optimizing the vehicle plate recognition using the mathematical morphology by Saiyadi, Parviz[7]	In this paper the author has attempted to apply a combination of edge detection method, histogram analysis, and morphological operation	The first disadvantage is that matlab is an interpreted language and, therefore, may execute more slowly than compiled language. This problem can be check by properly structuring the MATLAB program. A full copy of MATLAB is five to ten times more costly than a conventional C or FORTRAN compiler.

4 PROPOSED SYSTEM

This system uses automated toll collection technique where collection of tolls can be done automatically using image processing technique where we can detect the number plate of a vehicle and there by deduct the toll amount.

Step 1: Number Plate Detection:

The system uses a pi camera along with an IR sensor and LCD display circuit interfaced to a Raspberry Pi. The vehicle will cross the barrier one and at the entrance of the barrier the pi camera and infrared sensor will detect the vehicle and capture the image of the vehicle numberplate. The system constantly processes incoming camera footage using pi camera to detect vehicle. On sensing a number plate in front of the camera, it processes the camera input, extracts the numbers and characters from the image.

Step 2: Image Processing using Python and Raspberry pi:

The Raspberry Pi has a dedicated camera input port that allows the system to capture high-resolution photos. Using Python and specific libraries written for the Pi, system can create tools that take photos, and analyse them in real-time or save them for later processing. This creates a self-reliant system which works as an item identification tool, security system, or other image processing application. The goal is to establish the basics of images onto the Pi using Python and statistics to analyse those images.

Step 3: Verification and Authentication of the User

The system contains a database that stores the information of all the registered number plate user where all the processed images are sent for verification. The system checks that the processed image number plate is within the directory and process the information and checks whether the vehicle is authenticated and registered. If the information matches with the database, the toll tax is sent to the vehicle driver.

Step 4: Barrier will operate after cross check with database.

The system verifies the information from the database and sends the toll tax record to the user. Then after verification the system sends information to the barrier and the barrier opens and deducted the toll tax amount is displayed on the LCD. In case of unregistered vehicle "INVALID" is displayed on the LCD.

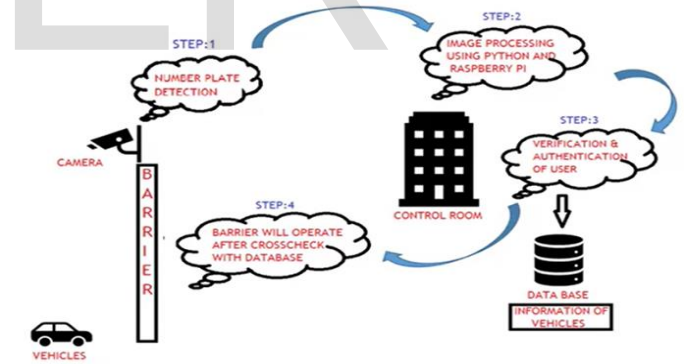

Fig.1- Block diagram of proposed system

5. System Implementation

5.1 Image Processing:

Python is an excellent language for these types of image processing tasks due to its growing popularity as a scientific programming language and the free availability of many state-of-the-art image processing tools in its ecosystem. Image processing allows us to transform and manipulate thousands of images at a time and extract useful insights from them. It has a wide range of applications in almost every field python is one of the widely used programming languages for this purpose.

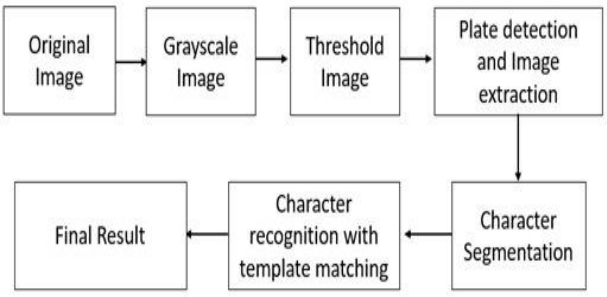

Fig.2- Block diagram of image processing

I. Original image: The real images from the pi camera is uploaded on the server which will be then used to extract the information of the owner's vehicle. Fig.3 shows the original test image.

Fig.3- Original image

II. Grayscale image: The captured image is then acquired converted into grayscale. Fig.4 shows the converted grayscale image (a series of regularly spaced tones ranging from black to white through intermediate shades of gray also : an image composed solely of grayscale tones). Fig.4 shows the conversion of original image to its grayscale.

Fig.4- Grayscale image

III. Threshold image: Image thresholding is a simple form of image segmentation. It is a way to create a binary image from a grayscale or full-colour image. This is typically done in order to separate "object" or foreground pixels from background pixels to aid in image processing. The main purpose is to separate the number plate from the other existing objects in the image. Fig.5 shows the separation of number plate from the other objects in the image.

Fig.5- Threshold image

IV. Plate detection and image extraction: this is used describe a set of algorithms and technologies that attempt to analyse images and understand the hidden representations of features behind them and apply these learned representations for different tasks like classifying images into different categories.

V. Character Segmentation: Character segmentation is an operation that seeks to decompose an image of a sequence of characters into sub images of individual symbols. It is one of the decision processes in a system for optical character recognition (OCR) [10].

VI. Character recognition with template matching: The last step of vehicle number recognition is the template matching. For matching the characters with stored characters, input images must be equal sized with the stored characters. In the present work 50x30 pixel characters are used. When the extracted characters from plate and stored characters are both equal sized & each input character image is compared with the ones already stored in the database and the best similarity is measured.

VII. Result: At last, we get the extracted information from the input image and thus corresponding amount is deducted from the e-wallet.

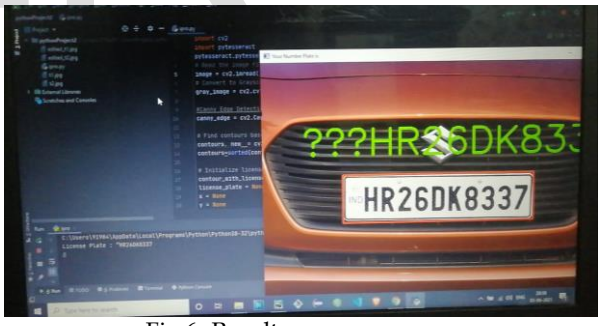

Fig.6- Result

5.2 Components used:

Fig 7 shows the circuit that consist of Raspberry pi 3 with built Wi-Fi capability and Pi camera that captures the images of vehicles. IR sensor is used to detect the arrival of vehicle at the toll booth. Besides that, the LCD displays information about authentication and registered vehicle, amount of tax deducted. The three-different colour of LEDs indicate three different conditions. Green led blink when any valid vehicle passes through gate as well as the yellow led blink when vehicle with insufficient balance arrives at the toll booth. Besides that, red led blink when invalid or unregistered vehicle approach toward the gate

and thus, the gate will be closed automatically by servo motor and the buzzer used to alert.

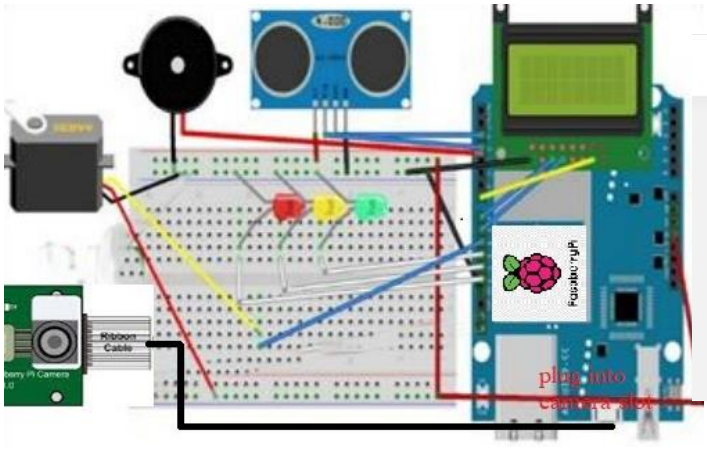

Fig.7- Layout of system

5.3 Website and server interfacing

- New user can sign up using website.
- User's details such as username, email id, password store in database
- Login with their username and password.
- Then after entering their details such as first name, last name, address, mobile no., DOB, license plate number and vehicle type.
- All these information gets stored in database and can be monitored by the admin.

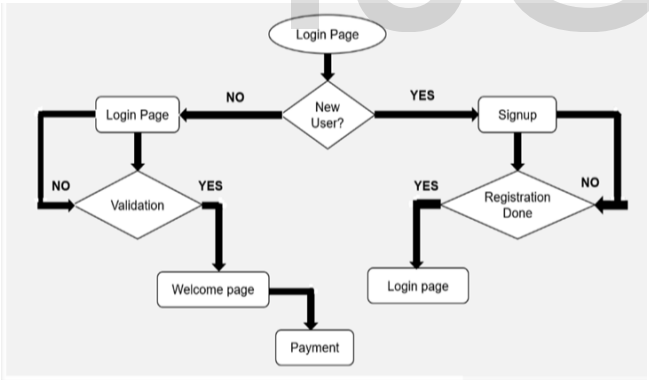

Fig.8- Flow chart

6 RESULTS

This system uses automated toll collection technique where collection of tolls can be done automatically using image processing technique where we can detect the number plate of a vehicle and there by deduct the toll amount. Vehicle Number Recognition (VNR) is an image processing technology which uses efficient algorithms to detect the vehicle number from real time images. The objective is to design an efficient Vehicle Number Recognition System & to implement it for automatic toll tax collection.

- Fig 9 shows the login page and registration form of the web server. If the vechicle is registered, then the user has to login into this page.

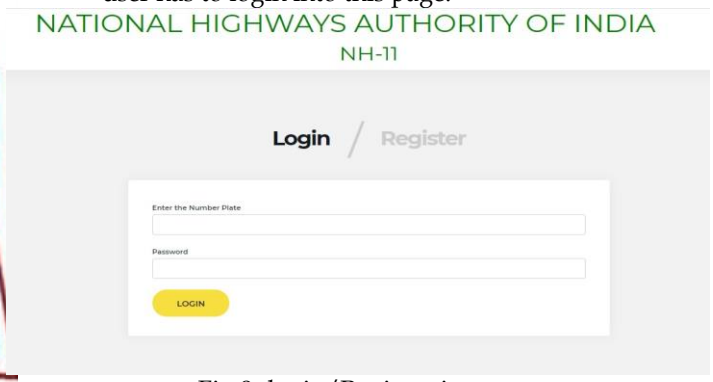

Fig.9- login/Registration page

- The captured vehicle number is checked in the database and the information is then estracted and the amount of toll is sent to the user phone.Fig 10 show the captured number plate.

Fig 10 Captured number Plate

- If the number plate is recognized, then the output would be shown as in fig 11

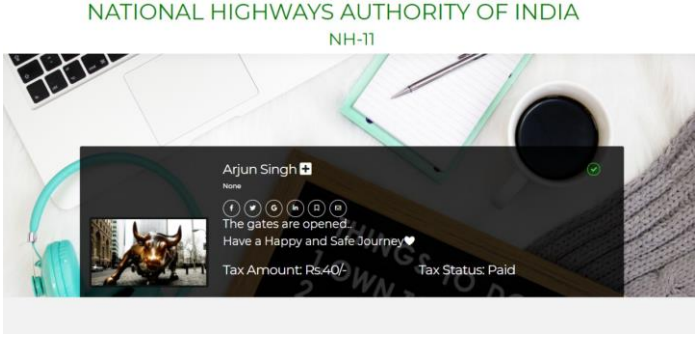

Fig.11- Result

- If the number plate is not recognized by the system, then the system will display as number plate not registered as shown in fig 12.

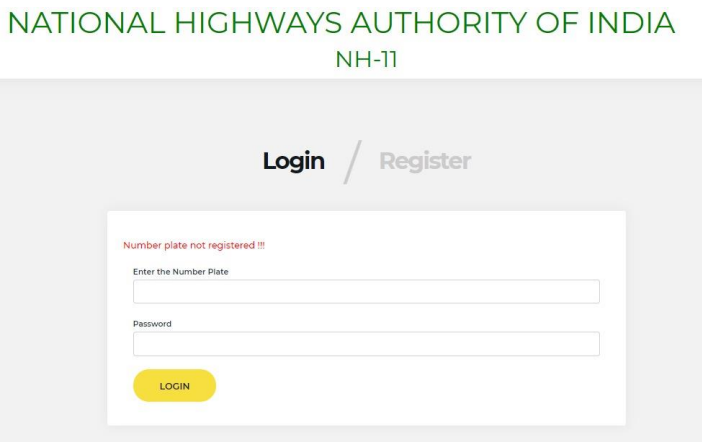

Fig.12- not registered

7 Conclusion

The purpose of the research was designing an integrated electronic toll collection system using raspberry pi and IoT to connect entire system with office database in real time. The integration of the system is enhanced by elaborating existing system with IoT to transmitting data received from Pi camera and then using image processing using python, extracting the information. Thereby increasing the efficiency of the system and eliminating drawbacks in the conventional system, with advantages of real time security on the roadways.

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