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Electronic Toll Collection System for Efficient Traffic Control System using ANPR

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Abstract - There are huge amount of vehicles passing through Toll Gate Stations every day. The automatic toll booth would pay the toll automatically. In this system camera is used for capturing the image of the vehicles number plate. The captured image would be converted into the text using ANPR [1] and the toll would be cut from the user's account and then the gate is opened. The system is divided into the design of three modules, Vehicle Module and the Central Database Module, Tollgate station. The three modules communicate via GSM modem connected to each module, stolen vehicle are also identified and alarm would be buzzed. For the identification of the vehicles, the information of the vehicles is already stored on the central database. Data information is also easily exchanged between the motorists and toll authorities, thereby enabling a more efficient toll collection by reducing traffic.

***Keywords* - OCR, ANPR, HSRP, AVC.**

1. Introduction

Electronic toll collection system is a technology enabling the automated collection of toll payments from the user. It has been studied by researchers and applied in various highways, bridges, and tunnels [3] requiring such a process. The purpose of the automatic toll booth is collecting the toll according to vehicles and builds the real time application which recognizes vehicles [1] licenses number plate at entry gate. Automatic toll collection is considered as one of the intelligent transport systems. It is aimed at making toll taxation more efficient, reliable, and safe and environment friendly. In the past, customer would have to wait at the toll booth to pay the collector, creating traffic congestion, pollution and of course of a lot of frustration. Today Automatic toll collection successfully removes unnecessary traffic delays; keep track of on any car that might not be correctly registered and also find the stolen vehicle.

The upcoming sophisticated technology related to wireless communication has been emerging the automated system to avoid the human errors and also save the time. The most obvious advantage of this technology is the opportunity to eliminate traffic congestion in toll station, especially during festive seasons when traffic tends to be heavier than normal. Other than this obvious advantage, applying automatic toll booth could also benefit the toll operators. This automatic system used the technology of ANPR [1]. Hence this system works very fast with the best results.

2. Existing System Problems

The Exiting system having all components is centralized with FPGA SPARTAN and 3AN Circuits [2]. Every vehicle must have a unique RFID Tag for storing both the Vehicle name and user's details, there is an RFID reader, and the tax collection is manual and not automated.

And also there is no security features for finding a stolen vehicle etc. The existing system consists of a microcontroller [2], RFID reader, RFID Tag, stepper motor, and bill printer. The RFID reader retrieves the Vehicle and user details and identifies the vehicle. Then here billing system can be used after the billing process then only the gate is opened by using the stepper motor earlier.

3. Proposed System

The proposed system makes sure that the traffic at the toll gates is streamlined and security is also present [2]. Through this system we can also identify stolen vehicles.

Automatic Number Plate Recognition (ANPR) [1] system is very much useful in applications like, automated traffic surveillance and tracking system, automated highway/parking toll collection systems, automation of petrol stations, travelling time monitoring. In this paper, introduction of number plate segmentation, feature extraction, recognition of character based on Neural Network and syntax checking analysis of recognized characters is described.

3.1 Automated Number Plate Recognition

ANPR [1] can be used to store the images captured by the cameras as well as the text from the license plate, with some configurable to store a photograph of the driver. Systems commonly use infrared lighting to allow the camera to take the picture at any time of the day [6]. ANPR technology tends to be region-specific, owing to plate variation from place to place. ANPR uses optical character recognition (OCR) on images taken by cameras. Some license plate arrangements use variations in font sizes and positioning ANPR systems must be able to cope with such differences in order to be truly effective. More complicated systems can cope with international variants, though many programs are individually tailored to each country.
The cameras used can include existing road-rule enforcement or closed-circuit television cameras, as well as mobile units [6], which are usually attached to vehicles. Some systems use infrared cameras to take a clearer image of the plates.

There are seven primary algorithms [6] that the software requires for identifying a license plate:

1. Plate localization – responsible for finding and isolating the plate on the picture.
2. Plate orientation and sizing - adjusts the dimensions to the required size.
3. Normalization – adjusts the brightness and contrast of the image.
4. Character segmentation – finds the individual characters on the plates.
5. Optical character recognition.
6. Syntactical/Geometrical analysis – check characters and positions against country-specific rules.
7. The averaging of the recognised value over multiple fields/images to produce a more reliable or confident result. Especially since any single image may contain a reflected light flare, be partially obscured or other temporary effect.

The complexity of each of these subsections of the program determines the accuracy of the system. During the third phase (normalization), some systems use edge detection techniques to increase the picture difference between the letters and the plate backing. A median filter may also be used to reduce the visual noise on the image.

3.2 Number plate Segmentation

Segmentation [7] is the process by which we separate each number or letter in the number plate so as to process them further one by one. There are different methods that can be used for the achieving the segmentation process. Create bounding boxes such that the areas containing connected objects are separated, since a letter or a number would represent a connected object, a bounding box is created around each object. To prevent small or too large connected objects to be part of a bounding box a condition regarding the minimum size and the maximum size of a bounding box are defined. These conditions were found by trial and error to select the optimum values so that only the numbers and letters are selected and nothing else.

Once these bounding boxes [7] are created sub images are created from the black and white image corresponding to each number or letters. These sub images are used in the further processing of the images to find out the text equivalent of the image.

3.3 Feature Extraction

Feature Extraction [9] is OCR without strict matching to prescribed templates. Also known as Intelligent Character Recognition (ICR), or Topological Feature Analysis, this method varies by how much "computer intelligence" is applied by the manufacturer. The computer looks for general features such as open areas, closed shapes, diagonal lines, line intersections, etc. This method is much more versatile than matrix matching. Matrix matching works best when the OCR encounters a limited repertoire of type styles, with little or no variation within each style. Where the characters are less predictable, feature, or topographical analysis is superior.

Feature extraction [10] is a special form of dimensionality reduction in image processing. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

3.4 Neural Network Usage in Character Recognition

The neural net approach [8] utilized three separate steps. The first step simply translated the binary character data into a friendlier form. The second step took the output of the first and trained a backpropagation network on it, outputting all the resulting weights and general network information. The third step took the output of the second and created a network. It then ran a full character set through the network and output identification information for all the characters the set contained. The reasons for implementing the neural net OCR as three

programs were all practical. By keeping the first step separate, the preprocessing code from the feature extraction OCR program could be used, eliminating this one area of difference between the two algorithms. The second step was separated just because learning was such a slow process. Several machines could thus be dedicated to nothing but learning while a different machine was used to analyze the results.

Optical Character Recognition [7] is the process of converting the images into appropriate ASCII characters. There are various methods can be used for applying OCR. This technique uses neural net to find the character it likely is. And also the matrix matching is used for the recognition of a number plate. Hence the character is selected and this process is repeated for all the characters in the number plate and one by one all the characters are recognized.

The result of the OCR is a string of characters and is to be stored in a format that can easily be viewed and is also usable by other applications that would require using the results. For the purposes of this project the results are stored in a text file that is named "text.txt" [7]. In the working directory of the project and is opened once the computation is finished by the main program for the viewing of the user.

The conversion of image to text provides a very high compression ratio. An image file containing the same information would be of the size of a few hundred kilo bytes but the text file containing the same information will be only of a few bytes and hence can be much easily transferred [7] to a remote location. The text file is appended every time such that the record of the previous transactions is maintained.

3.5 Syntax Checking

The Character in the number plate are recognized and the syntax checking process is carried out. It checks the recognized character according to the syntax rule HSRP [12] which can have unique symbol and character based on the Indian number plate rules. Then the syntax rules similar to the recognized image and the number plate image are stored in the database with the appropriate user details for the verification.

4. Components Used

This new toll system depends on four components [1]. And this component is used for the identification of a Number plate using the ANPR techniques.

4.1 AVI (automatic vehicle identification)

AVI [6] is the process of determining the identity of a vehicle subject to tolls. The majority of toll facilities record the passage of vehicles through a limited number of toll gates. At such facilities, the task is then to identify the vehicle in the gate area. Automatic vehicle identification systems are used for the purpose of effective control. License plate recognition (LPR) is a form of automatic vehicle identification. It is an image processing technology used to identify vehicles by only their license plates.

4.2 AVC (Automatic Vehicle Classification)

In this system, AVC [6] automatically verifies the classifications of vehicles. The classification of vehicles is already done at the time of a registration. Automated vehicle classification is closely related to automated vehicle identification (AVI). Most toll facilities charge different rates for different types of vehicles, making it necessary to distinguish the vehicles passing through the toll facility.

4.3 Traffic Controller System

Traffic controller system is a computer system which manages the traffic in a single row or line by using Traffic signals and sensors.

4.4 Central Server

For more security and maintain records of each toll and customers Central server is required. A central server stores the data which comes from different toll plaza. A local computer of every toll plaza is connected to a central server through Internet.

5. Benefits of the Electronic Toll System

Electronic toll systems [13], like conventional toll systems, generate funds for building and maintaining roads. They also offer a number of additional advantages. For example, they improve traffic flow by significantly reducing delays at the toll booth. In one hour, an electronic system allows 500 vehicles per lane to pass (1,800 in free flow) compared with just 200 for conventional systems. In addition, the transaction is much simpler for the user because it is entirely automatic. Electronic toll collection systems used today are very reliable: they have an error rate of less than 0.01%. By making traffic more fluid and avoiding bottlenecks, electronic toll collection helps reduce the number of accidents and improves the environmental impact. It also eliminates risks inherent in transferring funds because no cash is involved.

- Fewer amounts of queues at the toll station.
- Quick and more efficient service.
- The ability to make payments by keeping a balance on the register account [1].
- The use of prepaid as well as postpaid toll payments.

- Cheaper toll costs.
- Avoidance of traffic congestion.
- Time Saving.

6. Traffic-Arrival Analysis

The traffic-arrival patterns [4] were analyzed by forming frequency distributions of the number of vehicles arriving in 30-sec intervals at various volumes. Observations were formed into 200 vehicles-per-hour groups, and in each group the number of occurrences of arrivals of 0, 2, 3, etc. vehicles were counted and organized into a table.

The empirical frequency of occurrences of each arrival class was computed as a percentage of the total number of intervals observed. These percentages were then plotted against the arrival classes, and frequency polygons were drawn. These frequency distributions have rather good resemblances to the distributions one would expect with pure-chance traffic. One feature to be noted, however, is the tendency for the right-hand tails of the distributions at the higher volumes to be somewhat prolonged. The extension of the distribution for the highest volume shown out to 28 along the abscissa should be noted in particular. Comparison for the same volumes of traffic can be made with the theoretical distributions. The similarity to the actual distributions is quite evident; however, it will be noted that the right-hand tails are not as prolonged. These theoretical distributions are Poisson at the lower volumes and normal at the higher volumes.

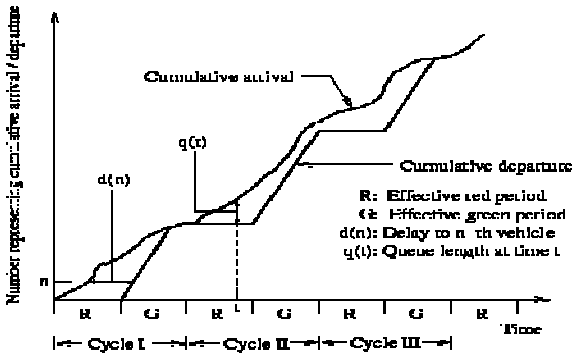

Fig. 1: A typical plot of cumulative number of arrivals and departures on an approach to a signalized intersection [5].

In this section [5] the delay faced by vehicles at signalized intersections and the queues developed at signalized intersections are studied. Consider the plot shown in Fig 1. In this figure, the abscissa is time and the ordinate is the cumulative number of arrivals as well as the cumulative number of departures for a given stream (or approach) at an intersection. There are two lines in the figure. One shows a typical graph for cumulative number of arrivals on the given approach at a signalized intersection, the other shows the cumulative number of departures from the given approach at the signalized intersection. On the abscissa, the time is divided into slots named Cycle I, Cycle II, and so on. These slots represent the cycles at the intersection. Each cycle is further subdivided into R and G. The R represents the duration of effective red (i.e., the time during which no vehicle on this particular approach crosses the intersection); similarly the G represents the duration of effective green (i.e., the time during which vehicles on this particular approach crosses the intersection). Fig 1 gives a reasonably complete picture of the arrival and departure processes at the intersection. From such a plot, we can obtain information about both delay and queues. The horizontal distance at a value of n on the ordinate, for example, will give the delay faced by the n^{th} vehicle to arrive at the intersection. Hence summing all such horizontal distances (or equivalently the area between the two lines) will give the total delay faced by all the vehicles arriving at the intersection. The Total delay divided by the total number of arrivals will provide the average delay. Similarly, the queues on the approach can be easily determined from this figure. For example, the vertical distance between the two lines at time t will give the queue length at the intersection approach at time t. This implies that the queue lengths at any given time can be obtained easily from the figure and hence the parameters such as average queue length, variance of queue lengths, and the like can also be obtained. However, obtaining such graphs for each and every intersection at all times are not feasible. Hence it is imperative that we analyze the delay to vehicles and queues with an aim to derive equations which can give these quantities once data on arrival rates, cycle lengths, green times, red times, etc. are known.

7. Working of the System

"License Number Plate Recognition for Use in Different Countries Using an Improved Segmentation" [1] focus was given on the segmentation algorithm that was based on tagging the pixel cluster and a region growing approach. In this System two fastest algorithms is used are the Edge Finding Method and Window Filtering Method for the better development of the number plate detection system. An image of a vehicle number plate is captured and processed using algorithms and detection of stolen vehicles process are carried out. Number plate extraction is done using a Sobel filter, morphological operations and connected component Analysis.

Character segmentation is done by using connected component and vertical projection analysis. Character recognition is carried out using a Support Vector machine (SVM) [1]. ANPR system is very much useful in applications like, automated traffic surveillance and tracking system, automated highway/parking toll collection systems, automation of petrol stations,

travelling time monitoring. In this System, introduction of number plate segmentation, feature extraction, recognition of character based on Neural Network and syntax checking analysis of recognized characters.

7.1 Edge Finding Method

Edge detection [11] method is used to identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection examples of operators such as Canny, Sobel etc. and feature extraction.

The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to:

- Discontinuities in depth,
- Discontinuities in surface orientation, and
- Variations in scene illumination.

In the ideal case, the result of applying an edge detector to an image may lead to a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well as curves that correspond to discontinuities in surface orientation. Thus, applying an edge detection algorithm to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplified. However, it is not always possible to obtain such ideal edges from real life images of moderate complexity. Edges extracted [11] from non-trivial images are often hampered by fragmentation, meaning that the edge curves are not connected, missing edge segments as well as false edges not corresponding to interesting phenomena in the image thus complicating the subsequent task of interpreting the image data. Edge Finding is one of the fundamental steps in image processing, image analysis, image pattern recognition, and computer vision techniques.

7.2 Window Filtering Method

The window Filtering method is used to reducing the blocking effect of an image. The image is composed of blocks to perform the gradient operation on each pixel and then the threshold values are calculated. Then the resulted image blocking noise is eliminated. The filtered image can have the new pixel values.

8. High Security Number Plates Registration India 2014

The New Age Number Plates [10] which are non breakable and built on 1mm thick aluminium sheet having 7 digit lasers imposed unique code with a Chakra image having 'Ind' - depicting India on left side along with non removable snap lock. High Security Plates are meant to curb thefts of car. As of now, it's easy to change the number plate of the car by the anti-social elements and drive it easily in inter-state But, when this high security plates will come into existence, it will be almost impossible to change number plate as these high security plates comes with snap lock and any tampering will lead to breakage failing any number plate to remain affix on the car. The major benefit is hence - these high security plates will end up identifying the stolen cars - as in absence of change of registration plate, it would be quiet difficult for running a stolen car. This HSRP number plate will be fixed using Non Re-Usage Snap Lock system to prevent theft. HSRP also will come with Hologram Sticker.

These registration plates will be fixed in RTO Office and there are no independent agencies or brokers who can affix this.

The HSRP rule should overcome the theft of vehicles, because the Non Re-Usage Snap Lock System is used and there is no chance for the morphing of an illegal number plate.

9. System Design

The System design can be highly reliable and the system architecture can record the image and recognize it. And the OTP module can be capable of using the login session with security for the toll operators. And the toll operating software uses the TTV for high security.

9.1 System Architecture

The process starts when a sensor detects the entrance of a vehicle and signals the camera to capture an image of the vehicle. The image is passed on to a computer where software running, on the computer extracts the license plate number from the image. LPN [1] (License plate number) can then be verified in a central database. If number valid for this system then LPN recorded in a database with other information such as vehicle number, time, balance, personal details. The licence number is used to open the toll gate.

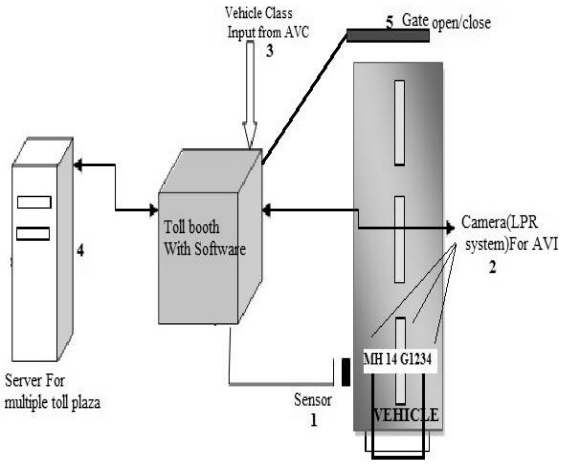

Fig 2: Structure of the system [1]

The Fig 2 [1] illustrate the overall system architecture in which the vehicle can enters the toll gate at that time the sensors are activated and the license number plate are recognized then the processing of an vehicle classification are carried out and the recognized number plate image are verified in the database for the stolen vehicle identification using the syntax rules. Then the account of a user is updated with the current details.

9.2 High Resolution Camera Usage in ANPR

It captures the license plates flawlessly in any weather condition in even the dark night and up to speeds of 120 mph [1].

Fig 3- High resolution camera [1]

The Fig 3 [1] illustrate the high resolution camera which can capable of take an image even in rainy dark night and the clarity are high compared to normal cameras.

9.3 Rules For Indian Number Plate

The Indian number plates following the new format can be off lengths 8, 9 or 10. Format of the registration [1] is as shown below.

AA 11 BB 1111

Where AA is the two letter state code; 11 is the two digit district code; 1111 is the unique license plate number and BB are the optional alphabets if the 9999 numbers are used up.

9.4 One Time Password Security

In this system as toll operator point of view provide OTP [1] system. OTP is a password that is valid for only one login session. OTP generation algorithms make use of randomness.

It can provide the security for the toll workers to enter their private details with separate ID and password, any toll workers knows ID and password but when enter the private details for login then generate OTP and send to the toll operator register mobile and then login with OTP, ID and password if all details are valid and correct then only login to the toll system.

9.5 Toll Operating Software

When vehicle enter in the toll booth then toll software automatically start its process first by using the sensor. This application firstly recognizes vehicle licence plate number then check if number is valid then using TTV [1] (text to voice) read the vehicle number in a speaker for driver confirmation. Also check the balance in customer account and at the same time check licence number in police database to identify the vehicle is a stolen vehicle.

The TTV can read the number using the speaker which has presented in the recognized number plate it does can be done for the user's verification, of their number plate. And provide the high security feature.

9.6 Database Maintanance with RTO and Police Databases

The central database or main database is the heart of the whole database maintenance. Admin database contains details of central database administrator and also the details of all toll station under Construction Company [1]. Centralized database consist record of all toll plazas under that specific construction company. This central database will be maintained by a central administrator. The User or the Customer has to be registered for this account to use this system. This user information is stored along with the RTO database. When the registered customer will pass through the specified toll plazas then automatically toll will deducted from customer's account. And Central database will update with this current information at a same time it includes the details of a present toll amount are added to the previous toll details. After toll amount applied to the vehicle, the customer will receive the sms using GSM

modem. The customer can capable of see all their transactions on his email account.

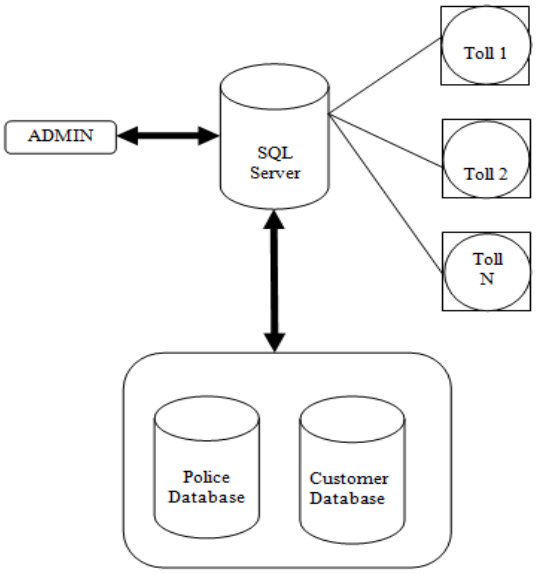

Fig 4- Database view with multiple tolls [1]

United database connected to the main database or the central database of the system. United database consist of Police database and RTO database. Police database contains all stolen vehicle records with their FIR [1] number. This database will update automatically during every process. RTO database is maintained by RTO office and it encompasses the all registered vehicles details like vehicle owner, vehicle number, licence number, account ID, account balance, current charges, etc. Retrieve the vehicle information from RTO Database and during recognition of a vehicles number plate it will match with customer database and police database. If the vehicle number plate is valid and also find it's an original vehicle of an owner not a stolen one, then automatically the toll is deducted from user's account and the sms intimation is carried out for the user verification. All these user's records are maintained at appropriate toll station and main database of toll construction Company. And these details can be seen by the toll operator by using the account ID, Customers name or number of the vehicle. All toll station records stored at central server and these details could be seen and will be printed at anytime based on the user needs.

10. Types of Toll Payments

There are two types of toll payment are as follows:

- Prepaid payment
- Postpaid payment

10.1 Prepaid Payment

The vehicle owner or driver has to pay the amount in advance by using their account id and the RTO office can keep track of this user details and the central database can maintain the account deduction and balance of every user.

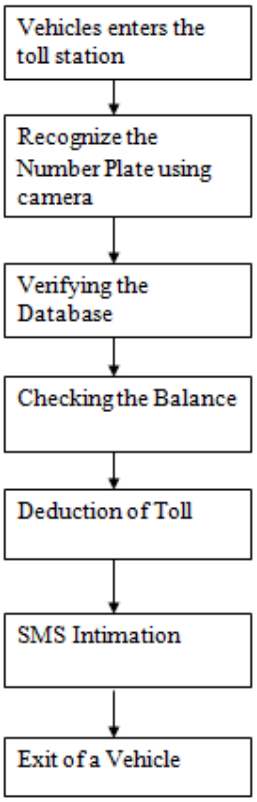

Fig 5: Flow chart of prepaid payments

The Fig 5 illustrates that the vehicle are identified first and the number plate are recognized (ANPR) using the high resolution camera [1] then the recognized number are verified in the central database then the user balance are verified and the toll are deducted from their account and the sms are intimated which have the current toll details and also the remaining balance.

10.2 Postpaid Payment

The vehicle owner or driver has to pay the amount after instead of before. The payment details are received through the sms and mail then the customer has to pay the bill. These details are also maintained by the central database.

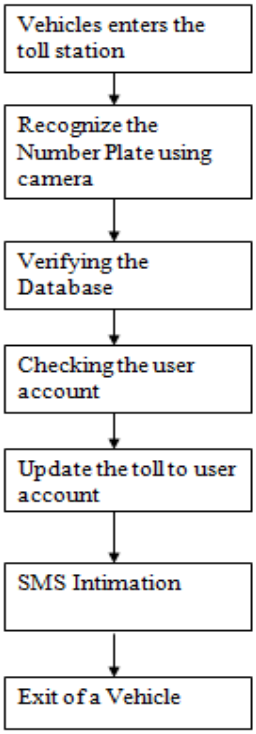

Fig 6: Flow chart of postpaid payments

The Fig 6 illustrate the vehicle are identified first and the number plate are recognized (ANPR) using the high resolution camera [1] then the recognized number are verified in the central database then the user details are verified and the toll are updated to their account and the sms are intimated which have the current toll details and also the remaining balance amount which have to be paid by the user.

11. Security in Electronic Toll Collection System

The Following security [14] is achieved by using this system is as follows:

- Automatic vehicle identification system.
- License Number plate recognition
- Zoom capability on recognized images
- Toll Audit Systems using Laser

12. Conclusion

Thus a system for Electronic Toll Collection system for efficient traffic control system using ANPR [1] based on Indian Condition which is highly reliable and also achieves high security. And this system can remove the traffic congestion by analysing the traffic prior, and it can be used to remove all drawbacks with doesn't require any tag only required best quality camera and fixed font number plate with condition of HSRP [12].

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