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EATS: Enhanced Automatic Tollgate System Powered by IoT and Big Data

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Abstract-

Enhanced Automated Tollgate System aims to eliminate the delay on toll roads by collecting toll fees electronically. EATS determines whether the cars passing are enrolled in the program, alerts enforcers for those that are not, and electronically debits the accounts of registered car owners by reducing the stopping time at the toll gates .The primary technologies used are Image Processing, Big data analytics, Vehicular Sensing and Complex Encryption systems. EATS minimizes the traffic density which is expected to be a huge burden to the government by 2030.The EATS algorithm is a smart learning machine which could detect frauds and handle huge chunks of traffic in a very short period of time. We also designed the EATS system which could be of great help to the Police Department for nabbing criminals and speedsters. EATS may be of great help to government to support Digital Economy, since it avoids the use of cash transactions. Complex gateway encoding strategies is applied to detect and verify respective vehicle without human intervention.

Keywords- Android Application, Big Data, Chips and Sensors, Encryption, Image Processing

I. INTRODUCTION

The Enhanced Automated Tollgate System is an essential stage in today's fast – growing digital world which is accumulated with intelligent machines and systems. This system allows efficient tollgate transactions and reduces corruption to some extent. This system also makes a nature friendly environment as process is digitized and have a better improvement in the processing of the tollgate fee. Since this system involves a lot of digital components it has a lot of complex gateway encoding and cyber security for the better preservation of data from getting lost.

Comparative Study:

The Recent Tollways process the following way, we have a set of lanes different categories of vehicles (which most of us do not follow), where we make payments either through cash or card. Payment through card takes much time to process than payment through cash with subject to practicality. There is a separate lane for Fast Tag users who need not wait in the long queues to make through the toll gates, but in reality we don't follow such rules, even non-fast tag users make use of the Fast Tag lane. The average duration for processing in the toll gates is about 4 minutes (which includes traffic too). Therefore it leads to Highway Traffic and the intensity of the traffic increases during festive seasons.

So our project deals with practical issues that the current tollways are facing. Any category of vehicles can pass through any lane and the average processing time would be around 45 seconds as this would minimise the traffic time to a greater extent. Due to demonetisation a lot of problems have arisen to the toll way authorities like providing appropriate changes to the users, payments through cash takes a lot of time as it includes a lot of process time around 30 seconds which is a huge lag time in highways. EATS is also economical for many users, in cases like users pay for two-way usage (they could pass through that particular toll gate multiple times within 24 hours of check-in) and they change minds to return the next day. Here the user again needs to pay for single way, but with our project (in this case) the user will be paying for 2-single way payments. As our project includes data about speeding of vehicles so it may encourage users to abide by the Highway rules and drive their vehicles with respect to the Speed Limits. When we detect a relative displacement of sensor chips (in the number plate) from the car, there could be two cases, either the driver may try to change number plates of the car or the car may have undergone an accident so that immediate response would be provided during an accident. Since you get a digitised receipt it is also environmental friendly.

II. CHIPS AND SENSORS

There are three main sensors used in ATS. They are Video Image Processors, Microwave/ Millimetre wave radar and piezoelectric detectors. Video Image Processors are used for imaging the number plate of the vehicle. They must be attached to the blockade to get a clear picture of the vehicle. These Processors must be incorporated inside the

Automatic Number Plate Recognition [ANPR] cameras. Microwave radars are placed at the toll gates to record the number of vehicles crossing the toll gates during a period of time. They can be useful to the law and Enforcement department in nabbing a criminal. Piezoelectric detectors are detectors placed at the pavement of the tollgates. These are used for detecting whether a vehicle has crossed the toll gate. This is done by placing a piezoelectric material under the pavement. As soon as the vehicle steps in the pavement the material is pressed which in turn generates a voltage [5]. This can be used to alert the brigade to stop the vehicle. As soon as the vehicle has crossed the blockade can be removed.

Considering chips, we embed a microchip on the chassis of the vehicle at the point of the Centre Of Gravity(COG).This chip can be very useful in detecting frauds and also helping the vehicles in case of traumatic experiences such as accidents. In case of accidents the ambulance is alerted and made to hustle to the exact location by tracking the GPS of the damaged vehicle. The difference between fraud and accidents is identified by the extent to which the microchip is damaged or tampered with. If the chip is made to move or in motion away from the COG then we can identify that there is some kind of a mischief going on [8]. On the other hand if the microchip is damaged very hard then we can recognize that there is an accident and need to be attended. So this microchip can be very useful not only in fraud detection but also be of great use to the welfare of the public.

2.1 Encryption

The image of the number plate of the vehicle can be used for encoding and decoding purposes. The number plate consists of two state initials, two district numbers, three division initials and four registration numbers.

(eg) TN 99 ZZZ 9999

We encode these different characters into a single 35-bit binary code.

TN-5 bits, 99-7 bits,zzz-9 bits, 9999-14 bits.

This 35 bit is matched with each vehicle's unique microchip number, which also in-turn contains a 35-bit binary digit. These two bits are encoded and stored in the database. On returning, the vehicle's encoded key is decoded to find out the number of times in case of a double or multiple passes through the same toll gate and will be charged accordingly. If any error is observed during decoding then the vehicle will be stopped for inspection. This is of great use in detecting the frauds. There are microchips embedded inside the vehicle for measuring further frauds and felonies.

III. BIG DATA

ATS requires a huge database for analysing, tracking and updating details of the vehicles crossing the toll gates. This database includes the vehicle's registration details, Driver license ID, driver's Phone no, smart card key. These details can be used to infer about a vehicle's frequent choice of toll gates and toll gate previously passed [6].

These details can be useful to the Police Department to nab a criminal by tracking the toll gates crossed and keeping a tracking GPS on the vehicle. We can perform analysis on the data collected to better understand the travel pattern of specified vehicles. Higher sized RAM computers must be stored at the respective toll gates to permit quick imagery and accessing the database for the vehicle's toll charges. These data can be further manipulated to reveal hidden patterns, trends and opaque associations. We prefer to use a mongo DB to manipulate this level of high voluminous data.

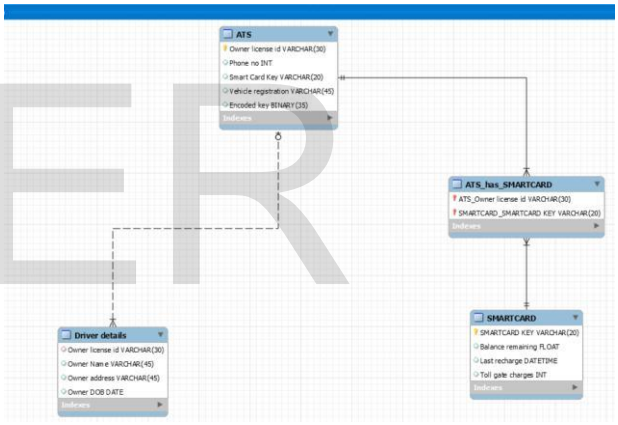
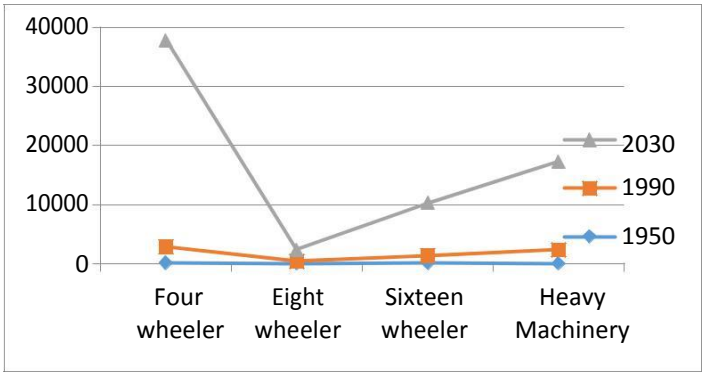


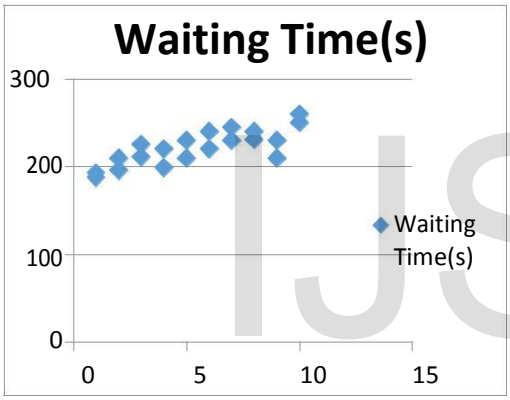
Fig 1. Database Architecture



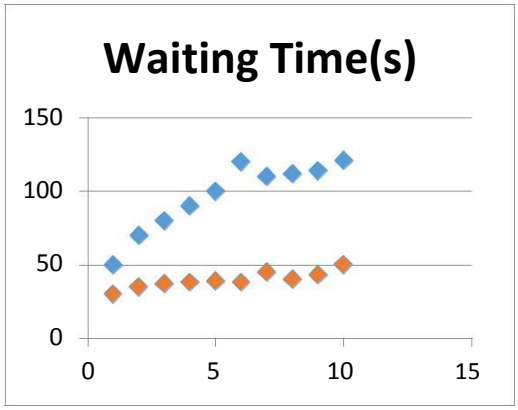
[1] Fig 2. Statistics of Number of Vehicles in each category

IV. SMART CARD

Smart cards are provided to all individual vehicles to uniquely identify the vehicle. It consists of a magnetic strip that consists of alphanumeric characters for uniquely identifying the vehicle. We can recharge the amount in the smart card so that the toll gates can be allowed to withdraw the balance. There is a provision in the toll gates to recharge the smart card. Every vehicle is allowed to proceed in any of the lanes. This card key is linked to the databases so that they can be updated for respective vehicles. Every owner must maintain his smart card for transportation services. During the initial application of the smart card we can apply it through the app or through services at the toll gates. With the use of smart cards the delay at the toll gates can be significantly reduced.



[2] Fig 3. Before ATS



[2] Fig 4. After ATS

V. DATABASE

5.1 Database plays a major role. Database of this system is divided into three parts:

a. Database Admin

b. Centralized database

c. Integrated database.

The central database is major part of this database system. Admin database contains the details of all toll booths under particular Construction Company. Centralized database consist record of all tollbooths under that specific construction company. The Central administrator will manage the central database. The customer has to be registered for this account to use this system. The RTO database will be stored with this account information. When the registered customer pass through the particular toll booth, then toll-charge will deducted from customer's account automatically and the Central database will updated with this information parallel. After the charge is applied to the vehicle, the customer will receive the information through SMS. The customer can see all transactions on his email account.

Integrated database will be connected to the central database of the system. Integrated database consist of both the Police database and RTO database. Police database contains all stolen vehicle records along with their FIR number. This database will be update automatically at frequent intervals. RTO database includes all registered vehicles including details like vehicle owner, vehicle number, license number, account ID, account balance, current charges, etc. At customer account registration time, get vehicle information from RTO. When the vehicle's number plate is captured, then that number will be checked with the police database and customer database. If the number plate is valid and no stolen vehicle record in the police database(stolen records) then automatically charges will be deducted from customers account and respected person will be notified through SMS. All these records are maintained at corresponding toll-booth and central database of toll construction Company and can be seen by account ID, Customers name or number of the vehicle. All toll-booths records stored at central server and these records could be seen and printed by day, date, month, and year.

VI. IMAGE PROCESSING

6.1 License Plate Number Extraction:

The method is for real-time Indian license plate extraction. Input is an image with the license plate, at a distance about 4 meters away by a digital camera of the front or rear of the vehicle and the

output is the license plate region. The method comprises the following major stages : [3]

1. RGB to gray-scale conversion
2. vertical edge detection and image binarization
3. analysis and dilation, vertical projection and thresholding
4. extracting the accurate location of the license plate
5. filtration and image enhancement
6. binarization and smoothing process and
7. Character segmentation for horizontal and vertical

6.2 RGB to Gray-Scale Conversion

In this method, RGB to gray-scale conversion is adopted, in order to facilitate the plate extraction, and increase the processing speed. Color image (RGB image) captured by the digital camera is converted to gray-scale image based on the RGB to gray-scale conversion method. The below equation shows an optimal method for conversion of RGB to gray-scale, as follows

$$Lu = 0.299 * R + 0.587 * G + 0.114 * B \quad (1)$$

6.3 Image Binarization and Filtration

The gray-scale image which is the output of the previous stage is converted to binary image (Black & White).The foreground and background colours of vehicle license plates are quite distinct. However, input images often contain unevenly distributed gray intensities or all the intensity values could be within a small range such as poor contrast images. Thus, it is important to use an effective technique for binarization. Otherwise, the method would not extract the license plate region from the vehicle image correctly. To overcome the illumination problems, our method performs this task. As a result, the plate characters will appear clearly after binarization. The next step removes any object contiguous to the border of the image. Thus, unnecessary objects will be removed and since they are surrounded by a black background the plate characters will not be affected. After the unwanted objects are removed, a specific filter is used for illuminating the very small objects based on the size of each object.

6.4 Analysis and Dilation

The principal objective of this stage is to find out the rough location of the license plate. This is achieved by the analysis of connected components (objects), which finds objects having an appropriate size and aspect for each connected component in the image, the height and width values are calculated[7]. For instance, according to height values, only the objects with a height greater than Tmin_h and less than Tmax_h are retained, and eliminate the other objects. After that, if the width values of the retained objects are greater than Tmin_w and less than Tmax_w, the objects are retained; otherwise, the objects are removed, and so on. Where:

- Tmin_h : Minimum height of the object.
- Tmax_h : Maximum height of the object.
- Tmin_w : Minimum width of the object.
- Tmax_w : Maximum width of the object.

Then, the result of this is an image containing only the plate characters and a few small objects. The morphological operation (dilation) is used for combining the closed objects, by use of a structure element (SE) value equals to 7×28 pixel. The purpose of the dilation process is to obtain the rough location of the license plate region. As mentioned previously, Indian license plates are composed of single or double row(s) of characters. So, the first value of the SE is used for joining the two sets of characters in license plates with double rows style; and the second value is used for joining the sets of characters in license plates with a single row style.

6.5 Accurate Location of License Plate and Extract the Plate Region

The aim of this stage is to obtain the accurate location of the license plate region. It is proceeds as follows:

- Find starting and ending position of the plate region by counting number of ones in each row.
- Extract that region only from the image.

6.6 Plate Candidates Rectangles Filtering

After identifying of plate candidates, we should realize some special filters before optical

character recognition stage. Below we give a short description of filtering,

Step 1. Apply low frequency filter with convolution matrix.

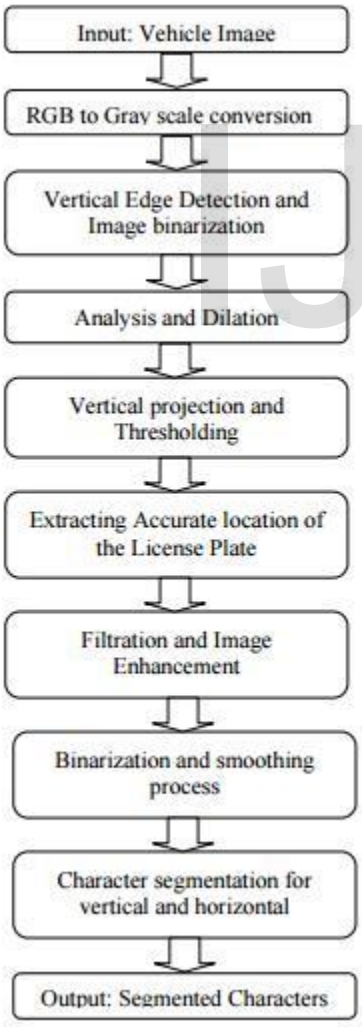
Step 2. Apply image enhancement filter using convolution.

Step 3. Apply image binarization filter. I.e. Find out average of minimum and maximum pixel in the image.

Step 4. Apply the contour of the binary image to obtain the contour with one pixel thickness.

Step 5. Using the horizontal and vertical projection removes the false piece on the plate and defines also the number of rows and symbols in the plate.

Step 6. Defining the chain code of symbols and its recognition. To create chain code of symbols first symbols are approximated by linear segments.



[3] Fig 5. Flowchart of Proposed method

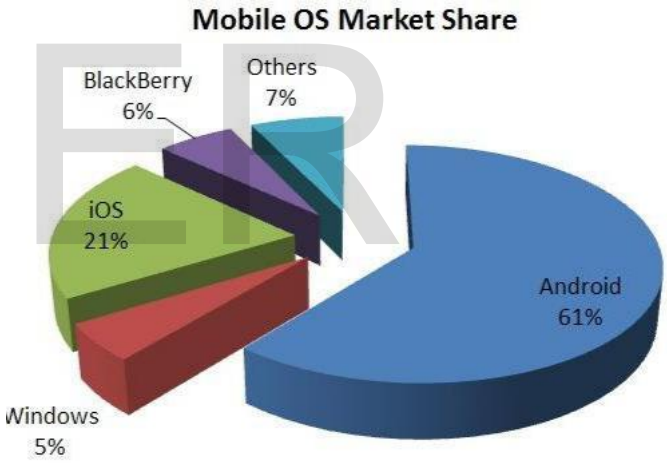
VII. ANDROID APPLICATION

7.1 Mobile App:

The App is designed for the convenience of the people. You can view the detailed summary of your travel tour, your balance, and other details (such as Defaulters if any).

Through the app you can even top-up your smart card. The Gateway for all the banks will be provided so that you can make cashless payment. If you are a driver and if your owner asks for the travel summary you could just send the details with the press of the button. Other details include your average speed to make sure that you don't cross the speed limits. If you're a defaulter of any case regarding to tollways, the corresponding list would be provided.

Even though we have automated deposit machines in each and every toll gates, it will not be much easy to access it, as it may take a while in the queue to deposit. So an alternative method is to digitise your payments.



[4] Fig 6. Mobile OS Market Share in 2016

V. CONCLUSION

Thus the ATS will create a user friendly environment to the users. Statistics reveal that there are only 3.8 km road length per 1000 people in India which would be little difficult to control the traffic whereas in USA there are 21 km road length per 1000 people which is more sufficient. In the near future the number of vehicles would grow exponentially with respect to expansion of roads in India. As a result the ATS would be very effective for Indian users to control the traffic. Since the payments and the Transactions are centralised, the respective Toll Plazas would get their payments at

the end of the month by excluding the taxes. This helps in bringing down the usage of Black Money to an extent as each rupee an user pays is accounted and digitised.

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