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DYNAMIC TOLL COLLECTION SYSTEM

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Abstract: The implementation of a Dynamic Toll Collection System using Number Plate Recognition (NPR) represents a transformative advancement in toll booth management and fee collection. The main parts of this system are the following: a large database with vehicle and toll rate information; automated payment gates; secure payment processing mechanisms; high-resolution cameras strategically positioned at toll booths; and NPR software that reliably recognizes vehicle number plates. The cameras in the system record the license plate of a car as it approaches the toll booth. Based on camera quality, distance can be measured. We can capture number plate at day or night time and analyzed the data as image. Number plate data Comparison done with help of character segmentation and character recognition using Optical Character Recognition algorithm. After successful comparison, one time password generated and automatically verify that send to user mobile. The automatic payment gate opens and permits uninterrupted vehicle passage if the car's number plate is connected to a working payment method using OTP verification system. The user receives a payment confirmation after a toll fee is automatically subtracted. By doing away with the necessity for cash transactions, this method not only improves security but also drastically cuts down on the time and effort needed for toll collection. And can also add other number as secondary access in toll entry system. After adding number, OTP can be sent to secondary person. If there is delay in OTP or wrong OTP means, automatically send alert to police about Theft vehicle. This Dynamic Toll Collection System provides an efficient, scalable, and user-friendly solution for contemporary toll booth management with the integration of secure payment processing and the capacity to manage an extensive database of cars and their associated toll fees. Experimental results shows that proposed work provide high level accuracy in number plate recognition.

Keywords - Character segmentation, Number plate Recognition, One time password, Toll collection system, Video surveillance

I. INTRODUCTION

Governments are currently dealing with an escalating problem of traffic congestion in urban areas. A variety of approaches have been proposed to alleviate road congestion, with electronic toll collection (ETC) being reported to be effective in many countries and areas. The main benefit of the ETC is that it ensures continuous travel near the toll plaza. Furthermore, because there is no need for staff in the booth, the toll booth's maintenance costs are reduced [1, 2]. It is a fully automated technology that speeds up transactions. One of the primary reasons for implementing the electronic toll system is to reduce traffic congestion near the toll plaza. In emerging nations, traffic congestion is a typical phenomenon on the highways. Therefore, putting in place ETC is a demand-driven necessity to lessen congestion [3, 4].

In addition to capturing number plate numbers in real time, automatic number plate recognition systems also give a comprehensive picture of traffic patterns. Both photo and video recordings are commonly used in automated license plate recognition systems. Some are set up to take pictures of a car as it turns, accelerates, or runs a red light. In a range of camera locations and angles and weather situations, the recording remains steady. Both traffic departments and legal counsel can benefit from

video footage. Repeat traffic offenders can be identified by license plate recognition technology. The technology also helps with security that is reactive. This covers forensics, investigations, inspections, and court cases. Regardless your perspective, automated license plate identification seems to be a need. There are a few drawbacks to this. Sometimes inclement weather and other obstacles might make automated license plate recognition systems useless [5].

Three processes make up the ALPR approach: obtaining a moving vehicle's picture, extracting the licence plate, and recognising the licence plate. The first stage is picture capture, which may be done in a number of methods; such creating a sensor system using two charge coupled devices (CCDs) and a prism, or using an image acquisition card to transform video data into digital images [6]. The sensor devices are able to take sharp photos in a variety of lighting circumstances [7]. The most crucial part of the ALPR technique is licence plate extraction.Since many colours are allowed for the same vehicle, India has more restrictions on size and colour than other nations [5]. Scale-shape analysis is one of several features that can be used to recover the vehicle number plate [8]. Figure 1 depicts the identification of license plates.

Figure 1. Camera based number plate recognition

II. RELATED WORK

Gui et al. [9]used a bi-modal travel equilibrium model to study and compute the capacity of highway toll plazas in a traffic system where roadways and public transportation options coexist and compete. In order to maximize the toll plaza's profit, minimize the overall cost to society, and break even, we calculated the capacity proportions required in each scenario. We achieved this by taking into consideration the operating costs of the toll plaza. The findings of the analytical analysis were validated by the numerical analysis. This research has important administrative ramifications. For instance, by modifying the toll plaza's capacity, a highway management department might regulate traffic flow and enable the traffic system to meet different objectives. Based on our findings, there are several things to highlight.

Shasi et al. [10] installed a wireless system that enables the electronic and smooth payment of tolls collected from cars utilizing roads, toll bridges, toll tunnels, and so on. ETC systems do away with the need for cash or credit cards to pay for tolls by facilitating financial transactions between a car going through a toll plaza and a toll collecting agency via vehicle-to-toll plaza communication technology. It makes it possible for toll collecting to be completed quickly, effectively, and cashlessly. The Roadside Unit (say Reader) and the On-Board Unit (OBU, commonly known as Tag) individually identify and classify each vehicle as it passes through the toll gate.

Khorshadul et al. [11] implemented in place of ETC that required congestion reduction. Because this digital technology employs Short Message Service (SMS) in place of receipts and eliminates the need for cars leaving the booth to stop and pay the toll, it saves time. This study provides an overview of several Electronic Toll Collection (ETC) technologies and their implications for the transportation

industry in developing nations like Bangladesh. This report began by listing the pertinent ETC technologies that have been identified and are widely employed in industrialized nations. Bangladesh is a developing nation without a reliable transport system.Still, the relevant body is trying to introduce ITS in Bangladesh. In Bangladesh, RFID-based ETC are comparatively inexpensive and simple to set up in the short run. In the long term, nevertheless, the authority and the public may find that the wisest course of action is to install satellite-based Electronic Road Pricing System (ERP), mobile phone tolling, and other such technologies. Every day, there are more and more cars on the road. It's past time to think about how Bangladesh's socioeconomic situation will change over the next ten years and to start putting the ETC system in place.

Sudhir et al. [12] testeda trained YOLOv3 algorithm in metropolitan areas, roads, and toll booths. At the toll plazas, the average recall was 86.3%, while the average precision was 94.1%. The algorithm can be used with good precision and recall for AVI and AVC in a toll management system at toll plazas, but more research is required to see if it can be applied to ATMS and urban area applications. Another advantage was that the AI-based approach just needed a camera with a mounting framework, as opposed to traditional approaches, which require several hardware/devices such inductive loops, axle detectors/treadles, and height sensors. Because of this, we were able to avoid having to install a variety of hardware and gadgets at toll plazas in order to execute automated vehicle recognition and categorization. In addition to a combined category of two- and three-axle buses and trucks into two-axle and three-axle vehicle classes from the non-exempted category, further work will involve the identification and classification of ambulances, fire trucks, and army vehicles from the exempted category. Additionally, studies on AVI and AVC in urban areas and on highways will be conducted. The other subtask will be counting vehicles on highways and at toll booths.

Kajal et al. [13] designed to show how safe toll transactions can be made with better user involvement through websites and Android applications, perhaps increasing the amount of toll collected. As a consequence of this deployment, transparency will be upheld with regard to all consumers and toll agents. The fundamental concept is that when a user with an Android phone that supports NFC taps on an NFC-enabled toll tab at the toll booth, the device reads information such NFC ID and instantly notifies the owner of the car and makes a request to the server. A high degree of transaction and money received transparency was offered by the system. For the benefit of the toll station client, the system was able to provide an automatically created message as an acknowledgement. This system was necessary to enhance administration of the motorways. Automobiles equipped with NFC tags that the Android app can scan. A certain amount of toll is taken from the card when the tag is read and the data in the online database is confirmed where the database's data is accessible to the administrator. Blacklisted automobiles are likewise monitored by the database. Currently, every highway route has a large number of toll collecting locations. In addition to having to pay a tollgate charge and wait in queue, users run the danger of having their money misappropriated by tollgate staff. Under the current setup, a driver must stop at a charging stall and pay the requisite amount to a collector in accordance with the manual toll collection protocol. Each vehicle's obligation to pay is based on its categorization or features. Manual toll payment methods take a lot of time, and mistakes can be made by people that could lead to mischief.

Penglinsong et al. [14] proposed a modified traffic conflict indicator to assess the safety risk at a tunnel toll plaza by taking into account vehicle length and width, angular and longitudinal movements, and conflict type (i.e., sideswipe and rear-end). Drone footage has provided high-resolution vehicle trajectory data, which is the basis for this indication. Then, the correlated grouped random parameter multinomial logit approach is used to measure the association between conflict risk at tunnel toll plaza and potential factors like vehicle class, vehicle speed and acceleration, toll collection type, and spatial characteristics, accounting for the effects of unobserved heterogeneity and correlation among random parameters at the road user level. This study uses high-resolution drone trajectory data to investigate the safety risk related to a tunnel toll plaza. The correlated grouped random parameters multinomial logit model with heterogeneity in the means is used to account for the effects of repeated observations, unobserved heterogeneity, and random parameter correlation at the level of road users. The frequency and severity of traffic conflicts at the tunnel toll plaza are assessed in relation to possible contributing factors.

Nazmul et al. [15] created an automated and digital toll collecting system using RFID technology based on Arduino, helping to reduce road congestion. In addition to using a credit/debit card or Bkash to pay the toll, travelers may also have the money taken out of the vehicle owner's bank account. In recent years, Bangladesh has witnessed an IoT revolution. Technology is advancing in Bangladesh at a never-before-seen pace, yet there is virtually little IoT application in the toll management system space. Bangladesh is also a digital nation, with the majority of its economic support coming from toll collecting.

The application of digital systems and associated technologies in the toll management system industry is still missing. If the toll management system site is to expand in parallel with IoT, more IoT applications ought to be added in this domain. In this industry, conventional approaches to issue detection and possible solutions identification are very intricate. They will be able to identify the automobile more easily thanks to AI technology. With the use of AI and RFID, this application aimed to completely transform the toll management system, helping the government collect toll in a simple and effective way.

Tanim et al. [16] showcased an automated toll collection system based on image processing and RFID technology, as well as a road zipper device. By utilizing its unique features, a road zipper device may ensure a traffic-free and hazard-free road transportation system. Road zipper devices, which divide the traffic lane, can allow emergency vehicles to pass. This technique prioritizes clearing each specific road lane to allow for seamless vehicle flow. The automated toll collection system reduces lost time, traffic, and fuel consumption in all vehicles by establishing a rush-free toll plaza through automatic toll amount reduction. By entering the license plate number into the database, it is possible to identify the vehicle that has been reported stolen or used illegally. Making full use of all the features on this device would reduce corruption in the toll plaza and save a substantial amount of time. The road zipper technology allows you to change the number of lanes as needed by using the road zipper GUI. This part of a road zipper mechanism accomplishes the desired results. The system for automatically obtaining tolls is highly effective. Once the camera snaps a photo of the license plate, it recognizes the car and deducts the toll amount. The RFID card is used to identify the car in the event that the camera is unable to capture a picture. This process produces accurate results when this equipment is tested. This proposed methodology has the potential to offer a more secure and effective examination of the transportation system.

Sabbir et al. [17] can be used in the creation of a sophisticated, fully digital toll collection system. Manual toll plazas are a key source of traffic in our country. Furthermore, the toll plaza is rife with corruption. The proposed toll collection plan can effectively address these issues. RFID tags and RFID sensors are the key parts of this RFID-based toll collection system. Since most license plates on cars in Bangladesh have already been digitalized, the government may identify the car and collect tolls without stopping it by using the RFID tags on these license plates. To ensure transparency in toll collection, the owners will receive information on account balances and toll bills. This would eliminate corruption in the toll plaza and save a substantial amount of time. Furthermore, the system's intelligence and security may be improved by future enhancements that include overspeed detection and prevention, overload indication and prevention in bridges, tracking stolen or accident-related objects, and more. Therefore, the proposed model can support the creation of a digitally intelligent road transport network.

Chandrappaetat et al. [18] evaluated the effort to cut down on the amount of time spent on human labor and manual transactions. The proposed effort aims to create an RFID-based automated tolling system that collects tolls. Radio frequency identification, or RFID, is a relatively new technology that has communication and tracking applications. This area of automatic identification has gained a lot of attention lately and is currently regarded as a cutting-edge technique to enhance data management; it is a great complement to bar coding and other technologies used in data gathering. This topic of automatic identification has attracted a lot of attention in the past few years. The automated toll collection system is a relatively new technological development that could improve the timeliness and efficiency of toll collection. It's a terrific alternative to waiting in line for a long period at manual toll booths.

III. EXISTING METHODOLGIES

To manage traffic and collect fees at toll booths, existing toll collection systems use a combination of traditional and technological methods. Traditional toll booths rely on manual toll collection, with operators interacting with drivers to collect toll fees. During peak hours, this manual process can cause congestion and delays. Electronic Toll Collection (ETC) [1] systems, which use RFID and transponder technologies, offer a more efficient solution by allowing for automatic toll deduction as vehicles pass through designated lanes. Physical barriers and gates restrict access to toll booths, which are lifted after payment or authentication. For monitoring and security, some toll collection systems use coin or token-based methods, ticket-based systems, and video surveillance. While existing systems are adequate, there is a growing interest in incorporating advanced technologies such as number plate recognition to further automate and optimize toll collection processes, thereby contributing to increased efficiency, reduced congestion, and improved overall traffic management. This shift reflects a broader trend toward modernizing transportation systems in order to provide a more seamless and technologically advanced experience. In addition to traditional toll collection methods, recent

advancements aim to address inefficiencies and improve the overall tolling experience. ETC systems, particularly those based on RFID technology [3, 4], provide faster and more convenient transactions, reducing the need for manual toll collection. The widespread use of ETC systems has helped to improve traffic flow and reduce toll booth wait times.

IV. NUMBER PLATE BASED TOLL PLAZZA SYSTEM

Each vehicle will be assigned a unique ID along with a license plate number. There is video footage of this license plate. As the vehicle approaches the toll booth, the webcam records the license plate number. This image is received by the system. Now, the PC interface device is used to transport the collected data to the PC via serial port. With the suggested method, license plate numbers can be converted to text format. ANPR may record text from license plates, pictures taken by cameras, and in certain cases, even a driver's picture. License plate identification technology is usually region-specific due to plate variety. All of the vehicle's details will be shown on the screen by the produced software. Date, time, and ID will all be stored in the access database. If the user is valid, the system will generate the bill in an online transaction. If not, it will determine this. SMS web services are used to communicate the vehicle information, including the main account balance and the amount withdrawn, to the user's mobile phone. An image-processing technique called license plate recognition makes use of license plates to identify automobiles. A license plate reviewer device extracts characters from an image. This image processing method can be applied in a variety of settings, such as parking lots, toll plazas, border control, and law enforcement. Therefore, the goal of this study is to design a license plate recognition system in order to address the challenge of observing a large number of vehicles for law enforcement and security. The goal of our system is to recognize and classify license plates without requiring constant human assistance. The organization will gain from this because it will save money and time. Fig. 2 depicts the suggested task.

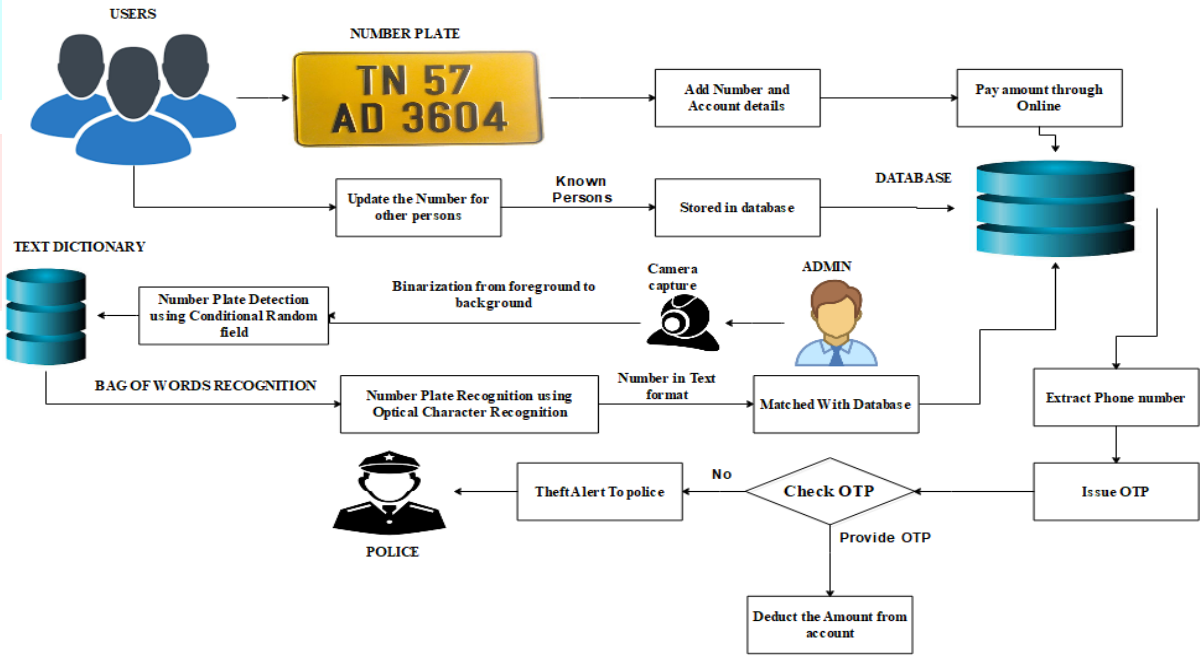

Figure 2. Proposed Work

IV. OPTICAL CHARACTER RECOGNITION

For a long time, optical character recognition, or OCR, has been of interest. The dictionary defines it as "the process of digitizing an image of a document into its individual characters." Even after decades of hard research, producing OCR with human-like skills remains a challenge. Owing to this difficult characteristic, academic and commercial researchers have focused on optical character recognition. The quantity of university labs and businesses conducting character recognition research has skyrocketed in recent years. The goal of this study is to provide an overview of the OCR research conducted to date. To enable computer editing, printed text and images are converted into digital format using optical character recognition (OCR) software. The human brain is able to recognize letters or characters from a picture with remarkable ease, however robots are not intelligent enough to understand the information that is there in pictures. Consequently, a number of research initiatives have been put forth in an effort to transform a document image into a format

that can be read by machines. OCR is a challenging task due to the wide range of languages, typefaces, and writing styles that might be used, as well as the intricate linguistic regulations involved. Therefore, methods from many computer science fields—such as image processing, pattern recognition, and natural language processing—are used to tackle various problems. Pre-processing, segmentation, feature extraction, classification, and post-processing are the stages of the multi-phase OCR process. It takes more than one step. In this document, each stage is covered in detail. In further research, an effective OCR system can be created by combining these methods. Numerous real-time applications, like smart libraries and number plate recognition, are among the practical uses for the OCR system. The following are the steps of the algorithm:

Image Preprocessing:

- Noise Reduction: The algorithm begins by removing noise and unwanted artifacts from the image, such as dust, scratches, or background interference. Common techniques include median filtering, Gaussian smoothing, and edge detection.
- Image Enhancement: The image may be enhanced to improve contrast, brightness, and sharpness. Histogram equalization and contrast stretching are commonly used methods.

Text Detection:

- Localization: OCR algorithms locate areas in the image that potentially contain text using techniques like edge detection, contour analysis, and connected component analysis.
- Text Region Segmentation: Once potential text regions are identified, the algorithm segments these regions into individual lines or words. This is important for character recognition.

Character Recognition:

- Feature Extraction: For each character or symbol within a segmented text region, features like the shape, size, and relative positions of individual components (strokes, loops, dots, etc.) are extracted.
- Pattern Matching: OCR algorithms compare the extracted features to predefined templates or models of characters in a reference database.
- Machine Learning: Many modern OCR systems use machine learning techniques, including neural networks, to improve character recognition accuracy.

Post-Processing:

- Contextual Analysis: Some OCR algorithms perform contextual analysis by considering the surrounding characters to improve character recognition. For instance, recognizing "i" next to "j" or "u" next to "v" can be contextually corrected.
- Dictionary Look-Up: In cases where words or phrases are recognized, the OCR system may consult a dictionary to correct or verify the recognized text.

Output Formatting:

- The recognized text is formatted and structured according to the desired output, such as plain text, searchable PDFs, or structured data.

From the above definitions, number plate can be recognized, then automatically convert into text format. Finally, OTP based verification can be done for improve the security in toll application.

V. SIMULATION RESULTS

In this simulation, implement number plate recognition in toll applications using Python framework. The results can be shown as follows:(from fig 2 to fig 6)

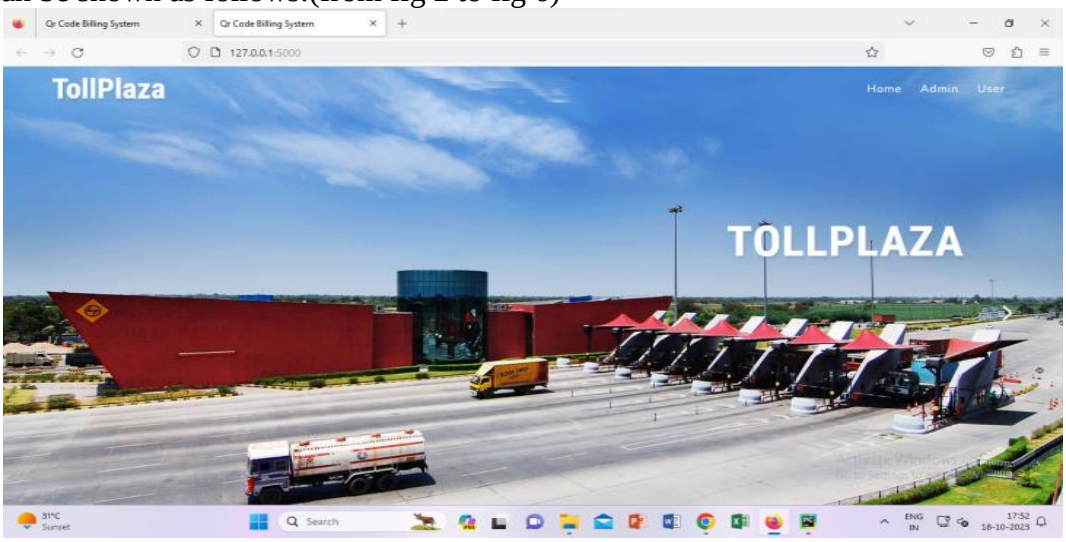

Fig 2: Home page

Fig 3: Number plate detection

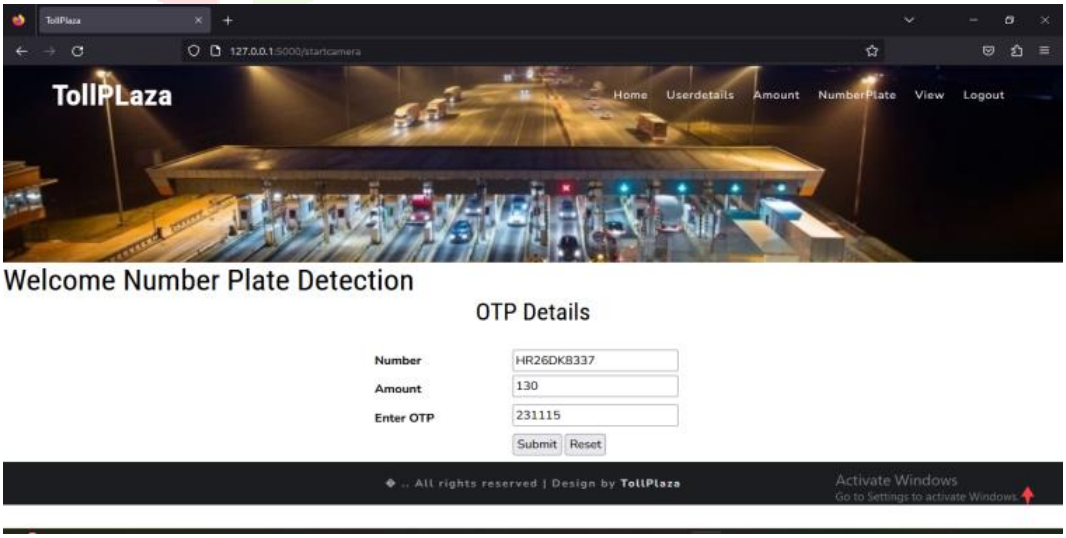

Fig 4: OTP based verification

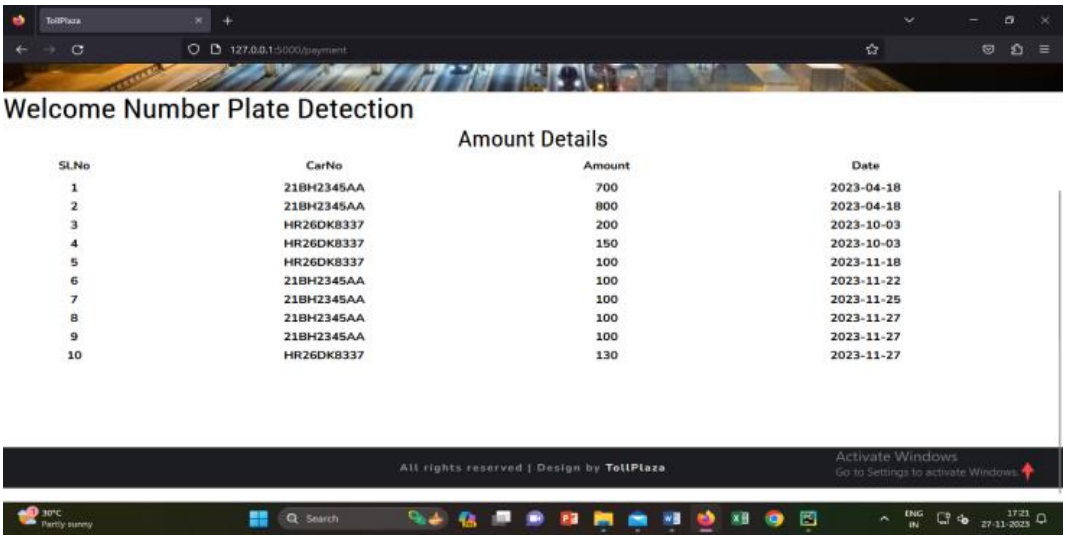

Fig 5: Amount details

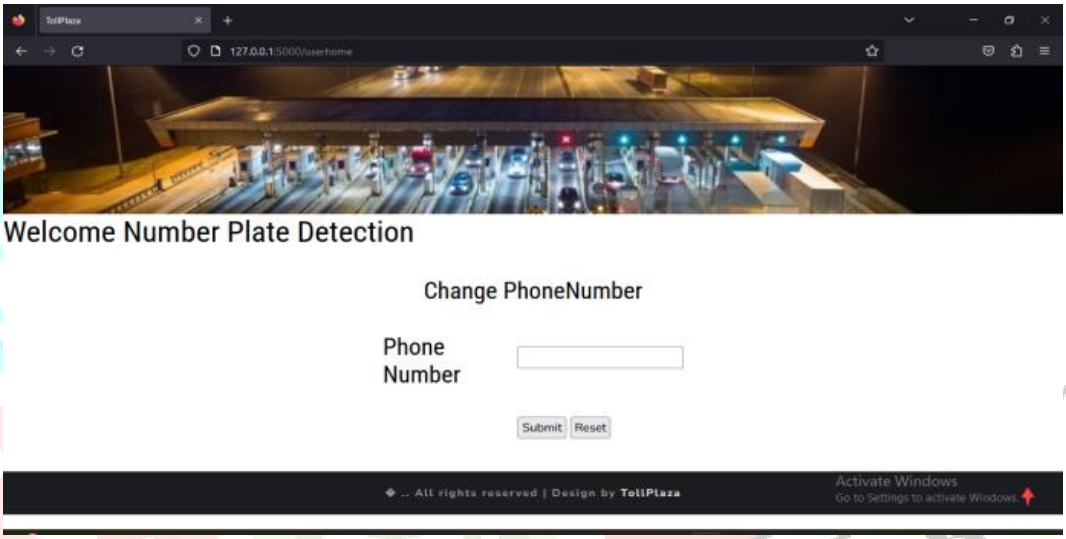

Fig 6: Secondary access system

After then, accuracy measurements may be used to assess the performance. The measurement of precision is assessed as

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} * 100$$

Where as,

TP – True positive rate

TN- True negative rate

FP – False positive rate

FN- False negative rate

Table 1: Accuracy rate

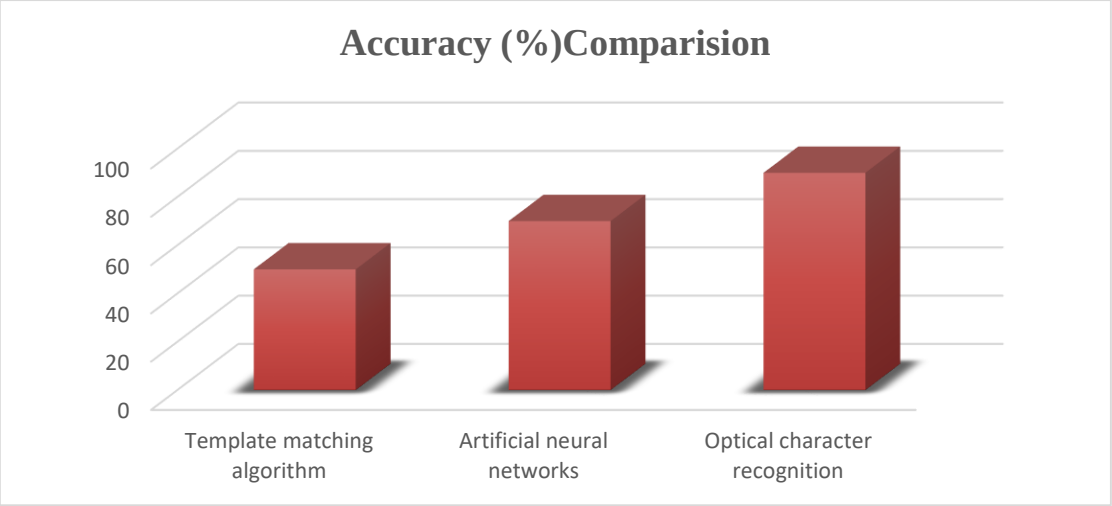

Fig 7: Accuracy

From fig 7, comparing the suggested algorithm to machine learning techniques, the accuracy rate is higher.

VI. CONCLUSION

To sum up, the toll tax system's use of number plate recognition has increased security and accuracy. The outcomes of the simulation then demonstrated that as a web-based platform.The suggested method is less expensive to implement and calls for less changes to the current system. It provides a reliable and safe car tracking option for vehicles that have been stolen. E-toll systems are capable of providing sufficient security, traffic control, and toll collecting. Consequently, an automated toll collection booth that employs an image-processing-based system saves time at the toll booth and uses less fuel when a vehicle is in good condition. It can also be used as a trustworthy and secure tracking system for cars that have been reported stolen. It can be used to eliminate all of the current system's drawbacks, including labor- and time-intensive jobs. It does not require any tags; all that is needed is a fixed-font number plate and a high-quality camera on each vehicle.

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CONFLICT OF INTEREST: There are no conflicts of interest in present study.

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