

# Design and Prototype of an Automated Toll Tax Collection System by using Raspberry Pi

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**Abstract** — Automatic Toll Tax Collection is a system which helps in the collection of toll taxes in a simple easy and time saving manner. It helps reducing heavy traffic congestion caused in cities by implementing an automatic gate which is controlled electronically. A car moves towards the booth at any type of roads, the system detects the oncoming vehicle through a camera and a pressure sensor. The system identifies the vehicle type, and an amount is deducted accordingly. The objective is to use raspberry pi as a controller for the system. Raspberry pi is a relatively inexpensive controller which is used for research purposes and demonstration of the technology. This whole system can monitor all incoming vehicles and records the vehicle information as well. The system can be used to detect theft by coordinating with the authorities responsible for traffic safety. The system helps reduce traffic congestion at toll plazas and help in reducing fuel consumptions for vehicles by reducing their idling times. The ATCS is an improved, faster, and better solution to the standard toll booths currently in service.

**Index Terms**— Automatic Toll Tax Collection System, Pressure Sensor, Camera Module, Raspberry Pi, Authentication, Toll Gate.

## I. INTRODUCTION

THE modern intelligent transportation system is the financial source of development of any country's economy. The amount of traffic system is increasing day by day due to the increasing in the number of vehicles. In a result, there are numerous problem which are creating hindrances in people daily life such as congestion, accident, air pollution and many other. For this reason, increasing transportation is an immediate impact on productivity of transporting resources at production side and transport completed goods to market is one of the important key factors in economic competition for the improvement in transportation system. The automatic toll collection system is introduced [1]. ATCS is the technology that allows the automatic electronic collection of toll cost and ATCS system is capable of eliminating congestion in toll

plaza, especially during those seasons when the traffic is seems to be higher them its normal, and is also capable of determining whether the vehicle is registered or not and then informing the management center about the process violation,

debits and participating account [2].

The manual and electronic tax collection are not so much efficient systems, and they are also having some involvement of human so there should be some human error collection and operation of toll gate. To overcome all issues which were presented in previous toll tax collection a new system was introduced which is automatic system. In this system everything will be control and operated automatically by using different microcontroller and by implementation of automatic system the efficiency of electronic collection system is increased.

## II. METHODOLOGY

The methodology design for automatic tax collection includes following processes:

### A. Data Collection Method

From the survey [3], a data can be collected in which it can be analysis how much vehicle passed in a day and the percentage of different types of vehicle that passed from the toll booth. The Table I show the data which was collected by a survey [3], which shows the types of vehicle in percentage that passed through toll booth in each day.

TABLE I: Vehicles by Percentage in Each Day

Types of Vehicle	Vehicle by Percentage in each day
Cars/Jeep	50%
Mini Truck	3%
Minibuses	5%
Intercity Buses	8%
Rigid Trucks	19%
Articulated Trucks	15%

The above Table I can be represented in pie chart Fig. 1, which show the percentage of different type of vehicles.

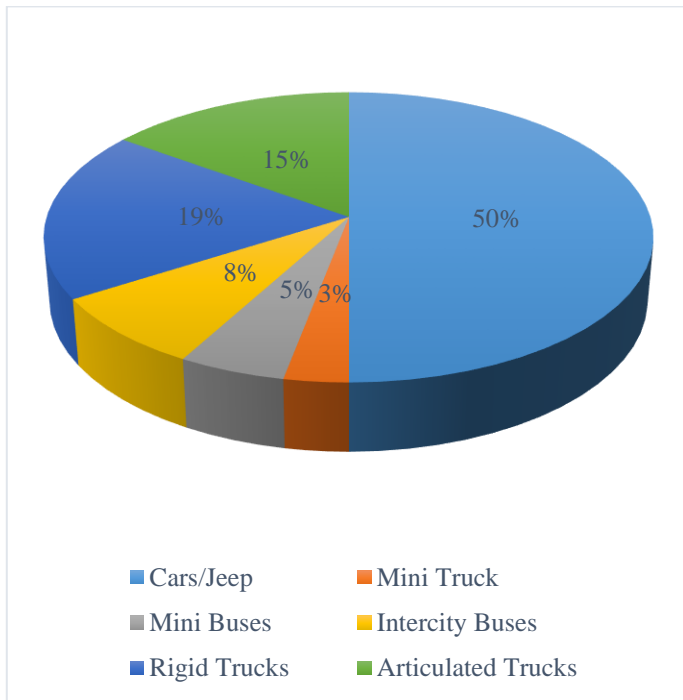


Fig. 1: Vehicles by Percentage in Each Day

### B. Image Processing

The image processing is the process in which the image is converted into text. In this paper, the image processing is used for license plate recognition which helps to controller for processing the data with the help of capture image that will be taken by camera module. The image processing was done by using Python program with OpenCV. The programming help to detect the number plate from the whole image and recognized it properly.

### C. ADC Conversion

As the raspberry pi is small board computer which have to operate the digital inputs pins so the text which is obtained by using number plate recognition method can be further proceeds toward the analog to digital converter because the results that are obtained from the image processing is analog results. So, the ADC is used to convert this analog text into digital output and then it can be easily proceeded toward the Raspberry pi.

### D. Tax Collection Method

In this process a database created in which all the information about the customer with their bank account inserted and after the image processing obtained data is matched with created database and then a signal proceed toward the motor for opening by using Raspberry pi as a controller. As concerned with tax payment method, database contain the information about customer bank account and have information about type of vehicle for payment of toll tax. Also, in this method there should be authentication that indicates about the theft of vehicle and then no signal send toward the motor for operating and toll gate will remain close. The tax payment method connect with database information by using server and a server link to provide connection

between license number plate recognition method with database so that the tax can be automatically paid.

### E. Toll Gate Monitoring

To operate the toll gate, a signal is sent by Raspberry pi when the image processing and comparison with database was done. As the signal is sent, the servo motor will operate, and the toll gate will be open so arrived vehicle is passes easily. The servo motor is operating with raspberry pi pin GPIO21 and the simulation is design on the proteus software with the help of visual designer as a flow chart. The servo motor is operating at any angle so for opening of toll gate the angle of operation of servo motor should be 90 degree.

## III. HARDWARE DETAILS

### A. Raspberry Pi

The Raspberry pi is known as minicomputer and it have 40 GPIO pins. The more specification and demonstration about shown in Fig. 2 below.

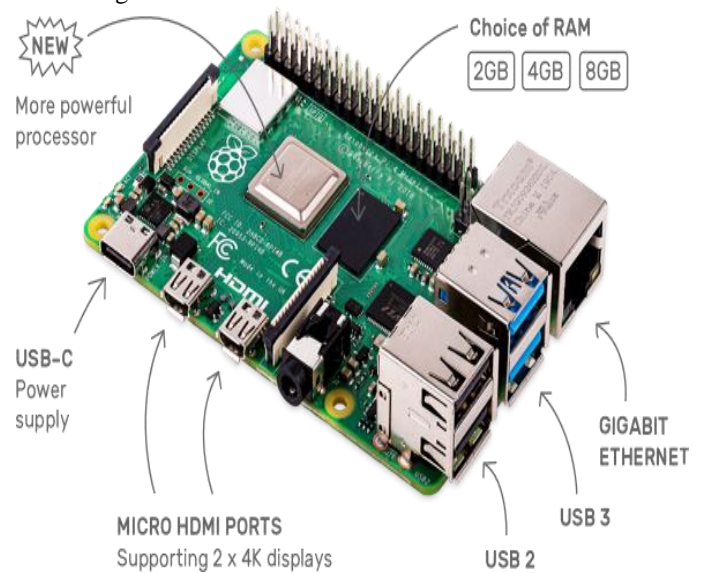


Fig. 2: Raspberry Pi

In the purposed system have some specification about Raspberry pi are as it contain 2GB, 4GB and 8GB RAM with 1.5 Giga Hertz running speed so it should be known as more powerful processor. Also, one USB-C port for power supply, two micro HDMI ports for Display, four USB ports for operate mouse and keyboard with any other USB, one Ethernet cable port for connection with computer and one microSD card port for provide memory to minicomputer for data storing.

### B. Analog to Digital Converter

As the raspberry pi is small board computer which have to operate the digital inputs pins so the text which is obtained by using number plate recognition method can be further proceeds toward the analog to digital converter because the results that are obtained from the image processing is analog results. So, the ADC is used to convert this analog text into digital output and then it can be easily proceeded toward the Raspberry pi. The Fig. 3 shows the analog to digital converter MCP3008 chip as follows.

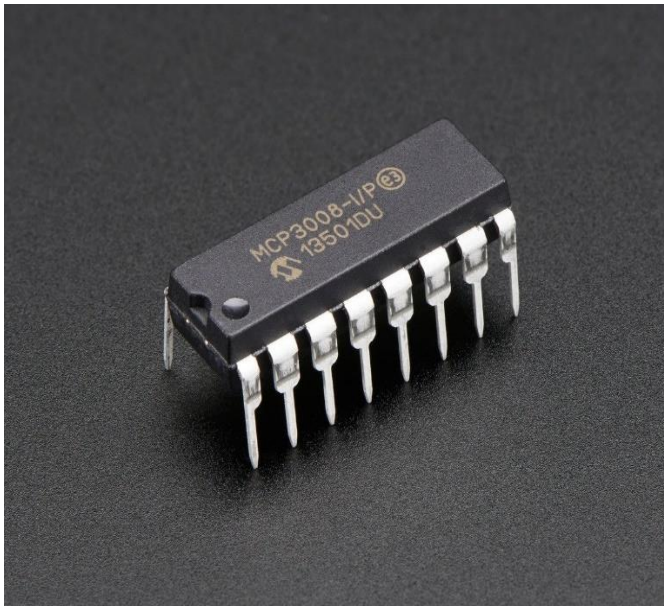


Fig. 3: ADC MCP3008 Chip

C. Servomotor

The servomotor used in many applications because of its small size and high efficiency. The main beauty of servomotor is that it can be operate at 90-degree angle and 180-degree angle. So, with the help of servomotor the toll gate easily operated, and system efficiency will be increased. The Fig. 4 shows servomotor.



Fig. 4: Servomotor

IV. SIMULATION

Fig. 5 shows simulation of Automatic Toll Tax Collection System.

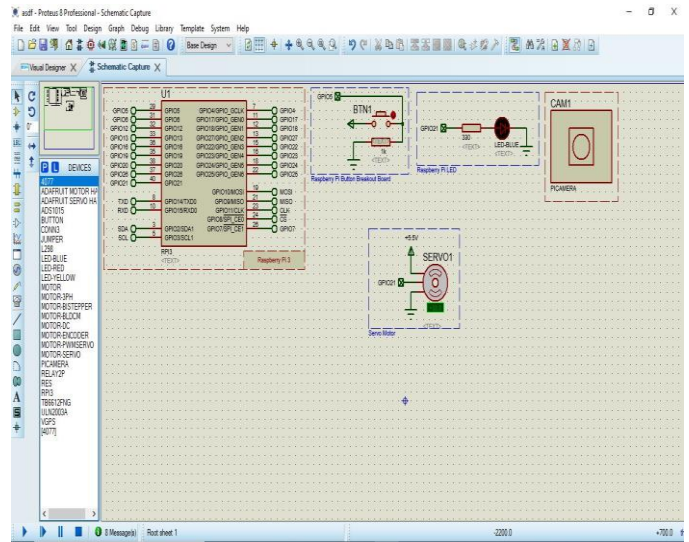


Fig. 5: Simulation of Automatic Toll Tax Collection System

Fig. 5 shows camera module which is interface with Raspberry pi and also have motor with LED indication for operation, but this all simulation is not done by electrical wiring connection this can be done by using Visual Designer flow chart. So, the main beauty of Proteus is that it can provide and alternative path for user that is Visual Designer. If any controller and processor was used in simulation and the user do not know its coding for operation so with the help of visual designer. The Fig. 6 shows the visual design of the project with help of flow chart.

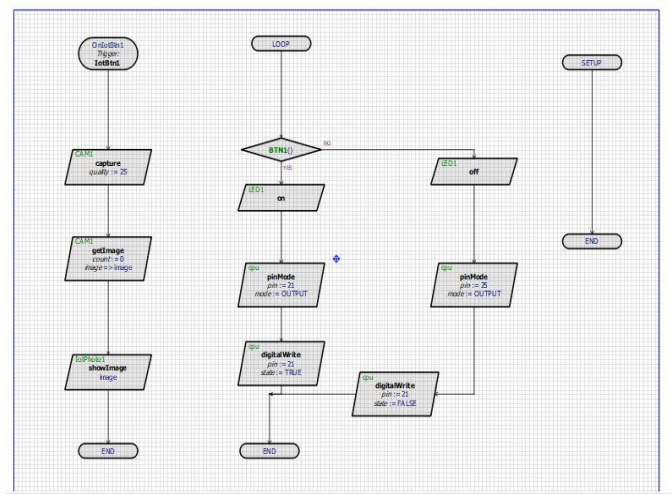


Fig. 6: Simulation with Visual Designer Flow Chart

V. FLOW CHART FOR SYSTEM

An automatic toll tax collection system shown in Fig. 7.

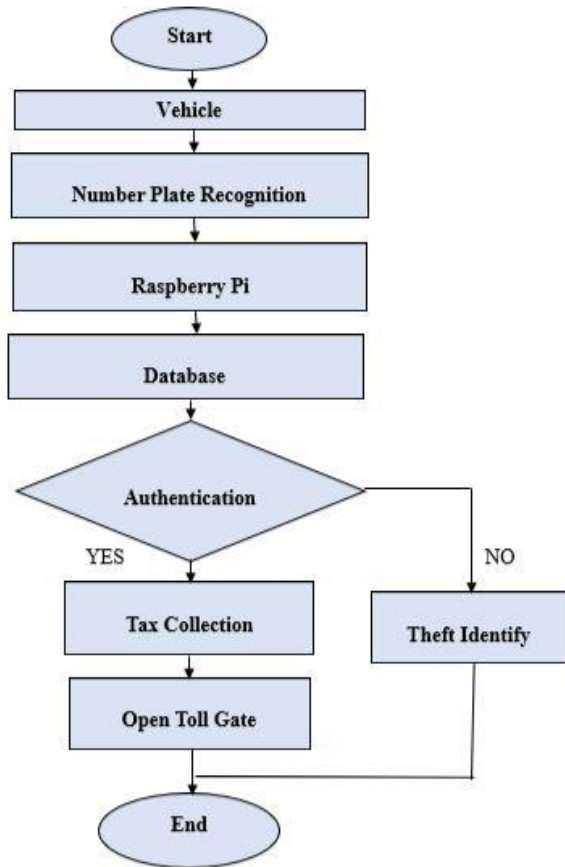


Fig. 7: Flow Chart for Automatic Toll Tax Collection System

VI. RESULTS AND DISCUSSION

A. Operation of Camera Module

The camera module is activated by pressure sensor but in the simulation demonstration the camera is interface with Raspberry pi by using proteus software visual designer for perform an operation to capture the picture of arrived vehicle.

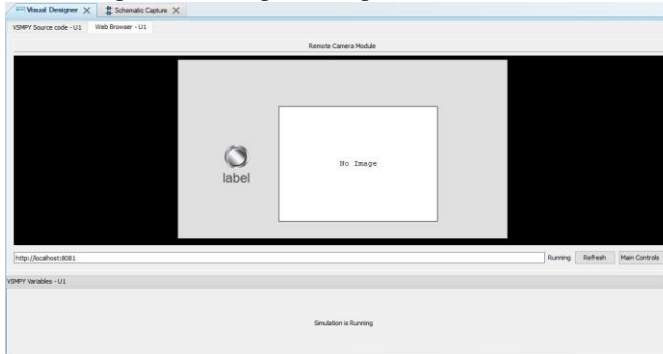


Fig. 8: Operation of Camera Module

Fig. 8 show the operation of camera module in which the camera capture the image when click on label and then this image will go for image processing.

B. License Number Plate Recognition

Image processing is known as the method of recognition license number plate. License plate can be detected and recognized by using python programming on OpenCV. After running the program, the image will be converted into text and the written text in the image can be detected easily.



Fig. 9: License Number Plate Recognition

Fig. 9 shows the number plate recognition method. In this process the image capture by camera module is proceed for image processing and then signal send to the Raspberry pi for comparison that is this number plate is present in database or not.

C. Connection With Database for Tax Payment

Fig. 10 shows the created database which include the all information about customer with bank account number.

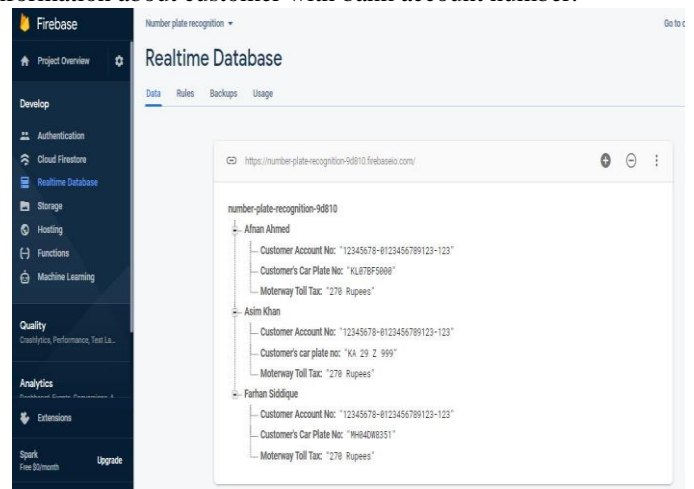


Fig. 10: Database

Fig. 11 shows a link of Realtime database which will be inserted in program to link the image processing with database for authentication and to identify the theft. Also provide an easy way toward the customer for toll tax payment.



## REFERENCES

- [1] V. Mithya, K. V. Dharani, A. Nivetha, G. Praveen Rajakumari, and M. Roshel Infan, "Smart highway toll collection system," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 5s, pp. 418–421, 2019.
- [2] P. Satyasrikanth, M. Penna, and D. R. Bolla, "Automatic Toll Collection System Using RFID", *International Journal of Computer Science and Mobile Computing(IJCSMC)*, vol. 5, no. 8, pp. 247–253, August 2016.
- [3] "Traffic Study for Karachi-Hyderabad Motorway (M9) Final Report," 2012.
- [4] Islam S, Nigar N, Ajagbe S, Adigun M., "Blockchain-enabled intelligent toll management system", *Journal of Intelligent Systems*, vol. 33, no. 1, 2024.
- [5] M. A. Talha, T. I. Anowar and S. Mondal, "RFID-Based Toll Plaza System For Developing Countries," *6th International Conference on Electrical Engineering and Information & Communication Technology (ICEEICT)*, pp. 236-241, 2024.
- [6] Chandrappa, S., et al. "An IOT-Based Automotive and Intelligent Toll Gate Using RFID", *SN Computer Science 4*, no. 2, 2023.
- [7] A. Chawade, O. Ganachari, H. Ahire, H. Hajare, and M. Paralikar, "Automated Toll Collection System Using QR Code", *International Journal of Innovative Research in Technology (IJIRT)*, vol. 6, no. 7, pp. 195–198 December 2019.
- [8] G. Sathya, K. Sangeetha, and S. Siddharthan, "Smart Way Toll Collection System", *Suraj punj journal for multidisciplinary research*, vol. 9, no. 3, pp. 39–43, 2019.
- [9] M. R. Mohite, V. R. Wadhankar, and D. S. Dabhade, "Automatic Toll Collection System based on Embedded system LINUX", *International Research Journal of Engineering and Technology (IRJET)*, vol. 6, no. 6, 2884–2887, June 2019.
- [10] P. S. Kishorekumar, "Toll Collection Automation", *International Research Journal of Engineering and Technology (IRJET)*, vol. 6, no.3, pp. 1187–1190, March 2019.
- [11] V. Mithya, K. V. Dharani, A. Nivetha, G. Praveen Rajakumari, and M. Roshel Infan, "Smart Highway Toll Collection System", *International Journal of Innovation Technology and Exploring Engineering (IJITEE)*, vol. 8, no. 5s, pp. 418–421, March 2019.
- [12] M. Pranali *et al.*, "Smart Toll Collection and Toll Booth Management System", *International Research Journal of Engineering and Technology (IRJET)*, vol. 5, no.3, pp. 3008–3011, March 2018.
- [13] Aishwarya D Shetty, Jasrin M.D, Jyles Benny, and Sumimol Sadasivan, "Automated Toll Collection System Using RFID", *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)*, vol. 5, no.5, pp. 5194–5202, May 2017.
- [14] A. Gamit, A. Vaniya, D. Daliya, D. Patel, and T. Naik, "Automated Toll Plaza Using RFID & GSM using PROTEUS Software", *International Research Journal of Engineering and Technology (IRJET)*, vol. 4, no. 4, pp. 1330–1332, April 2017.
- [15] J. Faria and A. Devkotte, "Vehicle Tracking and Toll Collection System", *International Journal of Engineering Research & Technology (IJERT)*, vol. 5, no. 1, pp. 1–3, 2017.
- [16] A. A. Chapate and D. D. Nawgaje, "Electronic Toll Collection System Based on ARM", *International Journal of Science, Engineering and Technology Research (IJSETR)*, vol. 4, no.1, pp. 46–49, January 2015.
- [17] M. Sumithra and B. Buvanewari, "Computerized Toll Collection System Using Smart Card With RFID", *Asian Research Publishing Network (ARPN) Journal of Engineering and Applied Sciences*, vol. 10, no. 21, pp. 9958–9961, November 2015.
- [18] K. Sanghvi and P. A. Joglekar, "Automating the Payment of Toll Tax at Toll Plazas", *International Journal of Computer Science and Information Technologies (IJSIT)*, vol. 6, no. 3, pp. 2884–2887, 2015.
- [19] K. Raihan, "Raspberry Pi Image Processing Based Economical Automated Toll System", *Global Journal of Researches in Engineering Electrical and Electronics Engineering*, vol. 13, no. 13, 2013.