Automatic Toll Collection System and Detection of Theft Vehicle by using RFID

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Abstract - The road transportation in India has growing day by day. The Indian road network carries about 65 percent of its Goods and about 85 percent of passengers. The national highways in India are now increased from 44,076 miles to 88,313 miles in 2018 to 2019. Along these road networks there are about 450 toll plazas totally in India. These toll plazas contribute some major part of India’s economy, it is estimated the toll revenue can swell up to 1 lakh crore rupees in next five years. In spite of this enormous growth the toll plazas have huge traffic during peak most of the time which incurs delay and loss human hours to surpass the toll. The proposed system focuses on an automatic toll collection system which will automatically debit the amount from vehicle owner’s bank. The automated registration and collection are based on using the RFID chip which is amalgamated in the vehicle’s windshield. By this method, the information about registration ID of the vehicle can be obtained therefore stolen vehicle can also be detected by this system as the vehicle ID is linked to the user’s account. Thus, this system provides fast and efficient surpassing of toll plazas without any delay.

Keywords - Toll plaza, Automatic toll collection, stolen vehicle, RFID.

1. Introduction
In India, the population inflation is numbering enormous every year due to which the transportation has become a basic necessity to run the day-to-day life. The road network is also increased since last decade. The national highways have been increased from 44,706 miles in 2010-2011 to 88,313 miles in 2018-2019. Along with the increased road network, the numbers of toll plazas have also seemed to be increased to 450 in 2019. The need for the government to increase the number of toll plazas establishment is due to the contribution of toll revenue in India’s economy. The ministry of road transportation in India has put forth that the toll revenue will swell up to one lakh crore rupees in next five years. Thus, one of the major contributions to India’s economy is toll revenue, therefore the transportation must be increased in the upcoming years.

The inflation in transportation statistics though advantageous for the government, it proves to be time consuming system for the vehicle users, due to the delay caused in the toll plaza for registration and payment. Therefore, it is an urgent need to develop a system which automates this process and reduces the time efficiently to surpass the toll plaza. An efficient and fast payment is indeed a major necessity. The proposed system thus develops the concept of automated toll collection which collects the rupees in digital form and the system registers the vehicle ID automatically once the vehicle enters the toll booth. The system uses RFID tag for reading the details about vehicle which is the user account linked to the vehicle’s registration number. After reading enough details about the vehicle, the toll amount is debited automatically from the user’s linked bank account. Once the completion of the payment is ensured, the toll gate is opened. In case, if the bank account has lower balance the vehicle is diverted to manual payment pathway. The system is thus reliable fast and reduces the delay caused by the toll gate surpassing process.

2. Proposed System
The time consumed by the toll booth to register to the user account sensed through the RFID chip is effectively reduced by this system. The system employs PIC micro-controller as the core processor for processing the data. Other components which are used are LCD display, IR sensor, RFID reader, buzzer, toll gate module, light system and power supply module. The RFID reader will read the RFID tag which is positioned under the windshield of the vehicle. Once the vehicle enters the toll pathway, the reading takes place. The RFID reader is placed on the entrance of the toll pathway. The LCD display is used to display the instructions as text message once the vehicle enters, when debiting the amount from the bank, after the completion of payment and finally instruct the vehicle to surpass the gate. The IR sensor which is interfaced with the PIC micro-controller detects the presence of object in the toll booth pathway. If the vehicle is present the output of the IR will be high else the output signal will be low. The IR will send the information on presence of vehicle.

If the payment is done, the toll opens, once the vehicle leaves the booth the IR sensor intimates the absence of the vehicle in the booth and closes the toll gate again. The toll gate module consists of a DC motor and a bar. The toll gate module will react based on the sensor outputs. The buzzer which is interfaced with the micro-controller PIC16F877 will be switched on when the vehicles stay still for some minutes. The light system is used to show the way for manual payment of the toll in case if the bank account has less balance. The proposed system is not just used for automatic toll collection, it is also used for stolen vehicle detection and signal breaking avoidance. The stolen vehicle can be detected by matching the information of the compliant registered in the website.
which contains the unique Radio Frequency Identification number, if the vehicle has surpassed any toll plaza. The signal breaking avoidance is implemented by using the RFID reader in every signal junction therefore any surpassing vehicles will get registered in the cloud system and the vehicle can be tracked and traced. Thus, the proposed system can be used for three applications and is most reliable and efficient. The below Figure 1 shows the Block Diagram of the Automatic toll collection and stolen vehicle detection system.

**Fig. 1: Block Diagram of the Automatic toll collection and stolen vehicle detection system**

3. Research Background
The paper [1] proposes the IoT based vehicle theft detection system. The system consists of Arduino UNO, DC motor, battery, GPS, GSM and Wi-Fi module. The system is just used to detect the stolen vehicle [2]. It is amalgamated in every vehicle. Once the vehicle is stolen, the DC motor turns off the key of the vehicle and sends the alert message through GSM which consists of location of the vehicle traced by the GPS [3]. Though the system proves to be effective in detecting the stolen vehicle, the cost of amalgamating the system independently in every vehicle is high. Moreover, the system has a single application. The paper [4] proposes a technology to capture the image of the number plate of the vehicles. The image is pre-processed firstly using techniques like grayscale and binarization. The ensuing image is passed for plate localization to extract the number plate details. This system just speaks about the image processing technology, it is not integrated with other systems [5]. Moreover, the process is too long and complex making it unadaptable for effective utilization of monitoring the vehicles. The paper [6] focuses on a system which consists of micro-controller, RFID reader, GSM module, motor driver, motor and toll gate. Once the RFID tag is detected by the RFID reader. The activation of control signal takes place in the micro-controller [7],[8]. The vehicle number linked to the RFID tag is obtained and using the cloud database the online payment is proceeded. Therefore, the toll gate is opened. The system cannot be used for various purposes except the automatic toll payment. Thus, the system is less adaptable for using it in real-time [9],[10].

4. Design and Implementation
The automatic toll collection system can be used for two other purpose such as signal breaking avoidance, stolen vehicle detection system. The components used in this system are PIC micro-controller which is PIC16F887 and other components which are used are LCD display of specification 16*2, IR sensor of model number RKI-3141, RFID reader, buzzer, toll gate module, light system and power supply module are shown in Figure 2- Figure 7. The power supply module has a rectifier circuit and the tollgate module has a DC motor which opens and closes the gate by rotations. The following are,

**PIC16F887A microcontroller**

The PIC16F887 is an 8-bit micro-controller from microchip. The 40-pin IC has 14 channel 10-bit ADC making it perfect for applications which include more ADC inputs. The IC also consists of 2 comparators, 2 timers and it support SPI, I2C and UART communication protocols. The micro-controller has an external oscillator with the operating speed up to 20MHz and precision internal oscillator with the tunable range from 8MHz to 32MHz. It supports nano watt technology, so consume very low power and operate in power sleeping mode. The PIC micro-controller is preferred due to its high standard in industrial applications. The PIC microcontroller is programmed using MPLABX v3.35 IDE software. For dumping the code into the microcontroller, the PIC kit 3 device is needed. It is a simple, low cost circuit debugger which is controlled by the software MPLABX.

**RFID**

The RFID is defined as Radio Frequency Identification which belongs to the group of technologies referred as the Automatic Identification and Data Capture (AIDC). The AIDC methods identify objects automatically, then collect their respective data and send those data directly to a personal computer system with little or no interference of humans. It consists of three parts namely, RFID reader, RFID tag and an antenna. The RFID tag has an integrated circuit with an antenna which transmit data to the RFID reader. The RFID tag is positioned in the windshield of every vehicles. The unique identification number on tag is linked to the vehicle’s registration number and the user account of the vehicle owner once the owner buys the vehicle. The RFID reader is present in the toll system which gets the radio waves from the tag once the vehicle reaches the toll and it converts these radio waves into more usable form as data. The payment is done by interfacing
the toll system with the cloud database where the user account will be linked to the bank.

**Buzzer**

The buzzer is made of piezo electric crystal. It works on the principle of Hall effect. If the electric supply is provided to the terminals of the buzzer it will be subjected to orthogonal vibration which creates a sound. The buzzer here is activated through the control signals when the alert message is received from the transmitter system [10-12].

**LCD display**

The LCD display is used for displaying the instructions as text message as the vehicle enters, while debiting the amount from the bank, after the completion of payment and finally instruct the vehicle to surpass the gate once the payment is finished. The LCD screen can be replaced with 16*2 or may be 20*4 which has 5*7 pixels each providing the best output results. The 16*2 LCD is preferred in our system.

**LCD display**

The ULN2003 is a monolithic high voltage and high current transistor arrays. It contains seven NPN Darlington pairs that renders high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair transistor is 500mA. The Darlington pairs can be made in parallel for higher current capability. ULN2003 is used in relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers. The ULN2003 has a 2.7kW series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices. This driver is used to rotate the DC motor which is present in the toll gate module. Once the payment is done the ULN2003 is activated by the control signal and the DC motor is made to rotate. After the completion of payment the IR sensor ensures whether the vehicle is surpassed or not and closes the gate by rotating the motor in reverse direction if the vehicle is surpassed.

**DC Motor**

The DC motor is a commonly used machine which is driven by the ULN2003 if interfaced with the micro-controller. The motor rotates as soon as the supply is given to it. The normal DC motor has high accuracy and can be controlled easily with the driving circuit. The DC motor here is integrated with the gate mechanism. It rotates in both the direction ensure the closure and open condition of the toll gate.

**IR sensor**

The IR sensor module consists of the Infra-red transmitter and the receiver. The transmitter projects the infra-red waves and the receiver receives it once if any object hinders the path of the transmitter’s projection. The output of the module can be achieved as both analog and digital.

5. **Prototype and It's Output**

Fig. 2: The toll gate is automated using the DC motor which is interfaced with the PIC micro-controller.

Fig. 3: Shows the output of the buzzer control which is turned on if vehicle doesn’t surpass.

Fig. 4: Shows the output of the DC motor used for toll gate module which would turn on and off for closing and opening of toll gate automatically.

Fig. 5: Shows the output of IR sensor which will sense the arrival of vehicle at the toll booth and once it is detected, the RFID tag is read by the RFID reader.
6. Future Enhancement
The automated toll collection system is used for other two purposes namely stolen vehicle detection and signal breaking avoidance. The automated toll collection system can be enhanced by making the transaction few Kilometers away from the toll booth. For implementing this, the Google maps API must be created for individual vehicle. The vehicle must locate its destination before departure. Once it does, the IoT module such as ESP-32 or ESP8266 can be used to link the vehicle with all the toll databases along its route. Once the acknowledgement is received from all the toll databases and the vehicle owner the transaction is proceeded prior crossing the toll gate. Once the transaction is finished the RFID chip is validated to surpass the toll gate. If such vehicles pass through the tolls the RFID readers in the toll system automatically recognizes them as validated and opens the gate. Therefore, this enhancement in the present system can make the toll transaction process prior and the system will be more efficient than any other existing system. The quick surpassing of tolls can be achieved by this and the system would be more reliable.

7. Conclusion
The proposed model contains the merits that overcomes the time-consuming process of toll collection. Moreover, the system is advantageous as it can also be used for stolen vehicle detection and signal breaking avoidance. The use of RFID merited the entire system due to its quicker sensing capability. It can be concluded from this, that the system is more reliable, quicker and efficient than other existing system.

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