VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JNANASANGAMA”, BELAGAVI: 590018, KARNATAKA, INDIA

Final Year Project Report on

“IntelliSense Toll Management System: Automatic Vehicle Plate Recognition for Identity-Based Transactions”

Submitted in fulfilment for the award of degree Of

Bachelor of

Engineering In

ELECTRONICS AND COMMUNICATION ENGINEERING

By

ABIN CHACKO	**4NN20EC002**
KARAN S	**4NN20EC013**
MOHAMMED JUNAID	**4NN20EC022**
PHANEENDRA M V	**4NN20EC025**

Under the Guidance of

MS. PUSHPALATHA H P

Assistant professor

NIEIT, Mysuru-18

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NIE INSTITUTE OF TECHNOLOGY

MYSORE-570018- 2023-2024

NIE INSTITUTE OF TECHNOLOGY

#50(part), Hootagalli Industrial area, Koorgalli Village

Mysuru-18

ESTD-2008

Department of Electronics and Communication Engineering

CERTIFICATE

This is to certify that the project entitled **"INTELLISENSE TOLL MANAGEMENT SYSTEM: AUTOMATIC VEHICLE PLATE RECOGNITION FOR IDENTITY-BASED TRANSACTIONS."** is carried out by **ABIN CHACKO (4NN20EC002), KARAN S (4NN20EC013), MOHAMMED JUNAID (4NN20EC022), PHANEENDRA M V (4NN20EC025)**, bonafide students of 8th semester in partial fulfillment for the award of Bachelor of Engineering in Electronics and Communication Engineering of the Visvesvaraya Technological University,Belgaum during the year 2023-24. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library. The Project report has been approved as it satisfies the academic requirements in prescribed for the said Degree.

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Mrs. Pushpalatha H P	**Dr. Manjula A V**	**Dr. Rohini Nagapadma**
Assistant professor	Associate professor and HOD	Principal, NIEIT
Dept. of ECE, NIEIT	Dept. of ECE, NIEIT	Mysuru-18
Mysuru-18	Mysuru- 18	

External viva

Name of the examiners	Signature with date
1.	
2.	

DECLARATION

I, **PHANEENDRA M V (4NN20EC025),** the student of Bachelor of Engineering in Electronics and Communication Engineering, Department of NIE Institute of Technology hereby declare that the project entitled **"INTELLISENSE TOLL MANAGEMENT SYSTEM: AUTOMATIC VEHICLE PLATE RECOGNITION FOR IDENTITY-BASED TRANSACTIONS"** is carried out independently under the guidance of **Mrs. Pushpalatha H P**, **Asst. Professor,** Department of Electronics and Communication Engineering, NIE Institute of Technology, Mysuru, in partial fulfillment of the award of **Bachelor of Engineering in Electronics and Communication by the Visvesvaraya Technological University, Belagavi.** The project has been our original work and has not found the basis for the award of any degree, associate ship, fellowship, or any similar titles.

Date: 22/05/2024 **PHANEENDRA M V**

Place: Mysuru **(4NN20EC025)**

CERTIFICATE OF PUBLICATION

International Journal of Advanced Research in Electricals, Electronics and Instrumentation Engineering (IJAREEIE)

|www.ijareeie.com| ijareeie@gmail.com| ISSN: 2278-8875|

(A Monthly, Peer Reviewed, Refereed, Multidisciplinary, Scholarly Indexed, Open Access Journal since 2012)

Impact Factor 8.317

The Board of IJAREEIE is hereby Awarding this Certificate

PHANEENDRA M V

UG Student, Dept. of ECE, NIEIT, Mysuru, Karnataka, India

In Recognition of Publication of the Paper Entitled

"Intellisense Toll Management System:Automatic Vehicle Number Plate Recognition for Identity Based Transactions"

in IJAREEIE, Volume 13, Issue 4, April 2024

Editor-in-Chief

ACKNOWLEDGEMENT

We wish to express our sincere thanks to **Dr ROHINI NAGAPADMA**, Principal of the college, or providing us with all the necessary facilities.

We also place on record, our sincere gratitude to **Dr MANJULA A V**, HOD, Department of Electronics and Communication, for her constant encouragement.

We also place on record, our sincere gratitude to **Mr. RAGHAVENDRA M**, Project Coordinator, Asst. Professor, Dept. Of Electronics and Communication, for his constant encouragement.

We also place on record, our sincere gratitude to guide **Mrs. PUSHPALATHA H P**, Asst. professor **Dept. of Electronics and Communication**, NIEIT, Mysuru. We are extremely grateful and indebted to her, for an expert, sincere and valuable guidance extended to us.

We also place on record, our sense of gratitude to one and all who, directly or indirectly, have lent their helping in the venture. We would like to thank all the faculty members of the Department of Electronics and Communication, for their help and encouragement and for the support extended during the course of this project.

ABSTRACT

The Automatic Number Plate Recognition (ANPR) project, built around the versatile Node MCU microcontroller, represents a significant leap in the automation of vehicle identification systems. By seamlessly integrating the node mcu with ultrasonic sensors and the ESP32 camera module, the project establishes a robust foundation for real-time detection and capture of vehicle number plates. This integration addresses fundamental challenges in contemporary traffic management, security, and parking systems by introducing an intelligent and automated approach to vehicle identification. The core of the system lies in the Node MCU microcontroller, orchestrating the functionality of the ultrasonic sensor and camera module to ensure accurate and timely identification of approaching vehicles. The photo acquired is sent to a image processing server by using google drive API from which it downloads it to a server folder. This enables the establishment of a dynamic connection between the ESP32 and a server, creating a conduit for efficient image transfer and subsequent data processing. On the server side, a robust Python-based infrastructure, bolstered by OpenCV and Tesseract OCR, handles the intricate task of image processing. This ensures accurate extraction of alphanumeric characters from the captured number plates. The database management component, powered by python, facilitates the creation of a structured database associating vehicle owners with their respective number plates. This comprehensive server-side processing not only enhances the accuracy of the ANPR system but also lays the groundwork for a scalable and adaptable solution.

TABLE OF CONTENTS

List of Figures

CHAPTER 1
INTRODUCTION

In an era marked by technological advancements, the optimization of transportation systems has become a crucial endeavor. One key aspect of this optimization is the efficient collection of tolls on highways and expressways. Traditional toll collection methods often lead to traffic congestion and delays, which can result in decreased productivity and increased fuel consumption.

1.1 OVERVIEW

To address these challenges, this project "License Plate Recognition for Efficient Toll Collection: An Image Processing Solution " aims to introduce a solution that leverages image processing techniques to streamline the toll collection process.

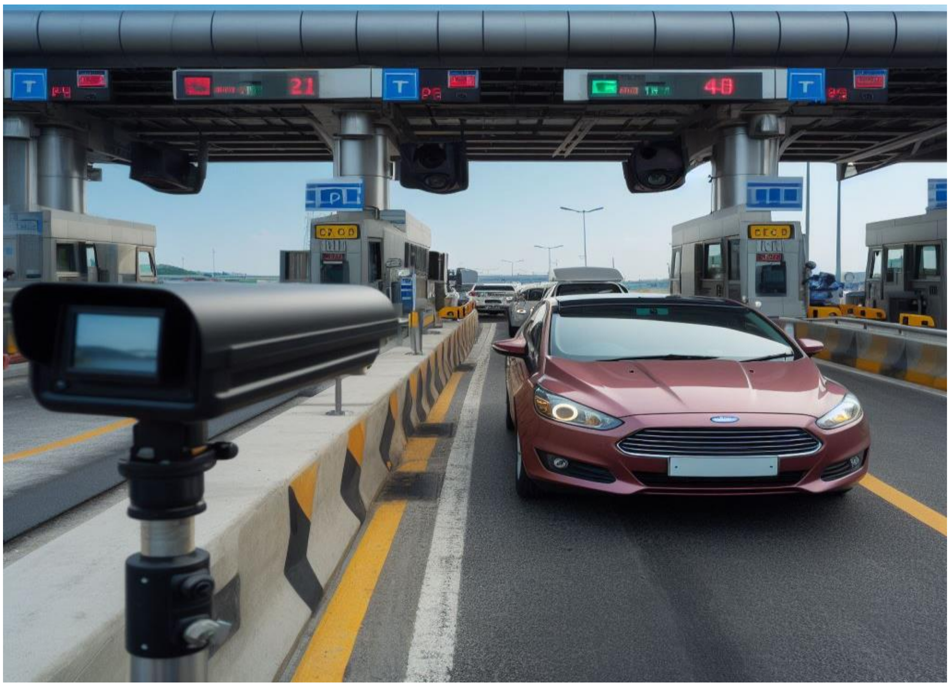

Fig 1.1 Intended Toll System

At its core, the IntelliSense Toll Management System leverages the capabilities of NodeMCU, a versatile microcontroller, to orchestrate the interaction between various hardware components and software modules. By utilizing NodeMCU as the central processing unit, we establish a robust communication network that enables real-time data acquisition, processing, and transmission. This approach not only enhances the agility and responsiveness of toll collection operations but also lays the foundation for future scalability and adaptability to evolving needs.

One of the key components of our system is the integration of ultrasonic sensors, which serve as the primary means of detecting approaching vehicles at toll booths. These sensors provide accurate and reliable data

1qaregarding the presence and proximity of vehicles, enabling timely actions to be initiated for toll collection and data capture. Coupled with the ESP32 camera module, the system captures high-resolution images of vehicles as they approach the toll booth, facilitating automated license plate recognition and data extraction.

The utilization of ESP32 camera modules represents a significant advancement in image capture technology, offering unparalleled clarity and precision in capturing vehicle details. This allows for accurate extraction of license plate information, which serves as the basis for toll calculation and billing processes. Furthermore, the integration of Google Script and Google API enables seamless uploading of captured images to cloud storage, ensuring secure and accessible data storage for subsequent processing.

On the server side, sophisticated image processing algorithms, including OpenCV and Tesseract OCR, are employed to extract license plate text from captured images. These algorithms leverage machine learning and pattern recognition techniques to accurately identify and interpret characters, even in challenging lighting and environmental conditions. The extracted license plate information serves as the basis for generating toll bills and facilitating communication with vehicle owners.

A key highlight of the IntelliSense Toll Management System is its focus on user convenience and transparency. By linking license plate information to registered email addresses, the system enables automated billing and notification processes, eliminating the need for manual intervention and paper-based transactions. Vehicle owners receive detailed toll bills via email, providing them with transparent insights into their toll usage and facilitating seamless payment options.

In addition to improving operational efficiency and user experience, the IntelliSense Toll Management System offers significant benefits in terms of traffic management and revenue optimization. By automating toll collection processes and reducing manual errors, the system contributes to smoother traffic flow and enhanced road safety. Moreover, the ability to track toll usage and analyze traffic patterns enables authorities to make informed decisions regarding infrastructure planning and revenue allocation.

As we embark on this journey to revolutionize toll management, we are mindful of the challenges and opportunities that lie ahead. Our project represents a collaborative effort to leverage technology for the greater good, with a focus on innovation, efficiency, and sustainability. By embracing emerging technologies and adopting a user-centric approach, we aim to transform toll collection processes and pave the way for smarter, more connected transportation systems in the digital age. Moreover, the project will employ smart toll collection methods, ensuring a seamless experience for commuters while enhancing the overall efficiency of the toll collection process. This project initiative not only promises to alleviate traffic congestion but reduces the fuel consumption too.

1.2 PROBLEM STATEMENTS

Develop an efficient Toll Management System that leverages image processing to identify the license number of the vehicle. The system should prioritize enhancing toll collection procedures to reduce traffic congestion common in traditional toll systems.

1.3 OBJECTIVES

- To develop a robust ANPR system that can accurately and efficiently recognize vehicle license plates using digital image processing techniques.
- Develop an efficient billing system capable of generating and delivering bills to the email addresses of vehicle owners.
- Implement a secure and efficient transaction system that facilitates seamless toll payment while concurrently mitigating traffic congestion.
- To develop a toll management system ensuring compatibility and integration with existing toll booth infrastructure, allowing for a smooth transition and adoption of the Intellisense Toll Management System without major disruptions.
- Implement security measures to protect user data and transaction information, ensuring the privacy and confidentiality of individuals utilizing the toll system while adhering to relevant data protection regulations.
- Develop a comprehensive error handling mechanism to address situations such as failed plate recognition or vehicles without license plate.

CHAPTER 2
LITERATURE SURVEY

- Prof. M.V. Sadaphule, Kshitij Patil, Aniruddha Patil, Kunal Waghmare, and Supriya Nikale present a noteworthy contribution in their paper titled "Automatic Number Plate Recognition System Using CNN," published in the JETIR (Journal of Emerging Technologies and Innovative Research) in May 2021. The paper addresses the primary goal of enhancing the accuracy and efficiency of vehicle number plate detection by employing Convolutional Neural Networks (CNN). In their innovative approach, the authors leverage the power of CNN to significantly improve the performance of automatic number plate recognition systems. By harnessing the capabilities of deep learning, the proposed system aims to achieve more robust and precise identification of number plates on various vehicles. This work holds promise in advancing the field of automatic number plate recognition, contributing to the development of more reliable and effective systems for real-world applications

- Emina E. Etomi and Donatus U. Onyishi present a comprehensive study in their paper titled "Automated Number Plate Recognition System," published in the Tropical Journal of Science and Technology in 2021. The primary objective of their research is to employ Automated Number Plate Recognition (ANPR) and Optical Character Recognition (OCR) technologies to identify and extract information from the number plates of vehicles. By integrating these advanced technologies, the authors aim to develop a robust and efficient system for automatic number plate recognition. The utilization of ANPR and OCR not only enhances the accuracy of identification but also contributes to the overall automation of the process. This work represents a significant step forward in the field of vehicle identification systems, offering potential applications in traffic management, law enforcement, and various other domains where accurate and rapid identification of number plates is essential.

- Mohamed Alkalai and Ahmed Lawgali contribute significantly to the field of vehicle-plate recognition in their paper titled "Image-Preprocessing and Segmentation Techniques for Vehicle-Plate Recognition," presented at the IEEE 4th International Conference on Image Processing, Applications, and Systems (IPAS) in 2020. The central focus of their work is to enhance the quality of vehicle plate images through a novel image preprocessing method. Subsequently, the authors employ a component segmentation technique to extract precise plate boundaries from the content of each image.

- K. Yogheedh, A. S. A. Nasir, H. Jaafar, and S. M. Mamduh contribute to the advancement of license plate recognition systems in their paper titled "Automatic Vehicle License Plate Recognition System based on Image Processing and Template Matching Approach," presented at the 2018 IEEE

Conference. The primary objective of their research is to propose an innovative automatic license plate recognition system leveraging image processing and a template matching approach. By combining these techniques, the authors aim to enhance the efficiency of license plate recognition systems, optimizing the accuracy and speed of identification. The proposed methodology involves the use of image processing to preprocess vehicle images and a template matching approach for recognizing license plates. This research is a valuable contribution to the field, offering a promising avenue for the development of more effective and reliable automatic vehicle license plate recognition systems with potential applications in traffic management, security, and law enforcement.

- In the paper titled "Intelligent Toll Collection System for Moving Vehicles in India," Rajeev Kumar Chauhan and Kalpana Chauhan present a novel approach to toll collection systems, published in the journal Intelligent Systems with Applications in 2022. The authors introduce an Automatic Toll Collection System (ATCS) designed specifically for toll plazas in India. The core innovation lies in the integration of an Optical Character Reader (OCR) to facilitate the automatic collection of tolls from moving vehicles. This system aims to streamline the toll collection process by automating it through OCR technology, enhancing efficiency, and reducing congestion at toll booths. The proposed intelligent toll collection system holds the potential to significantly improve the overall toll collection experience, contributing to the advancement of transportation systems in India.

CHAPTER 3
HARDWARE DESIGN METHODOLOGY

3.1 BLOCK DIAGRAM

- The following diagram represents the block diagram of the automatic number plate recognition system. It consists of NodeMCU microcontroller, Ultrasonic sensor, ESP32 camera module and a local server.

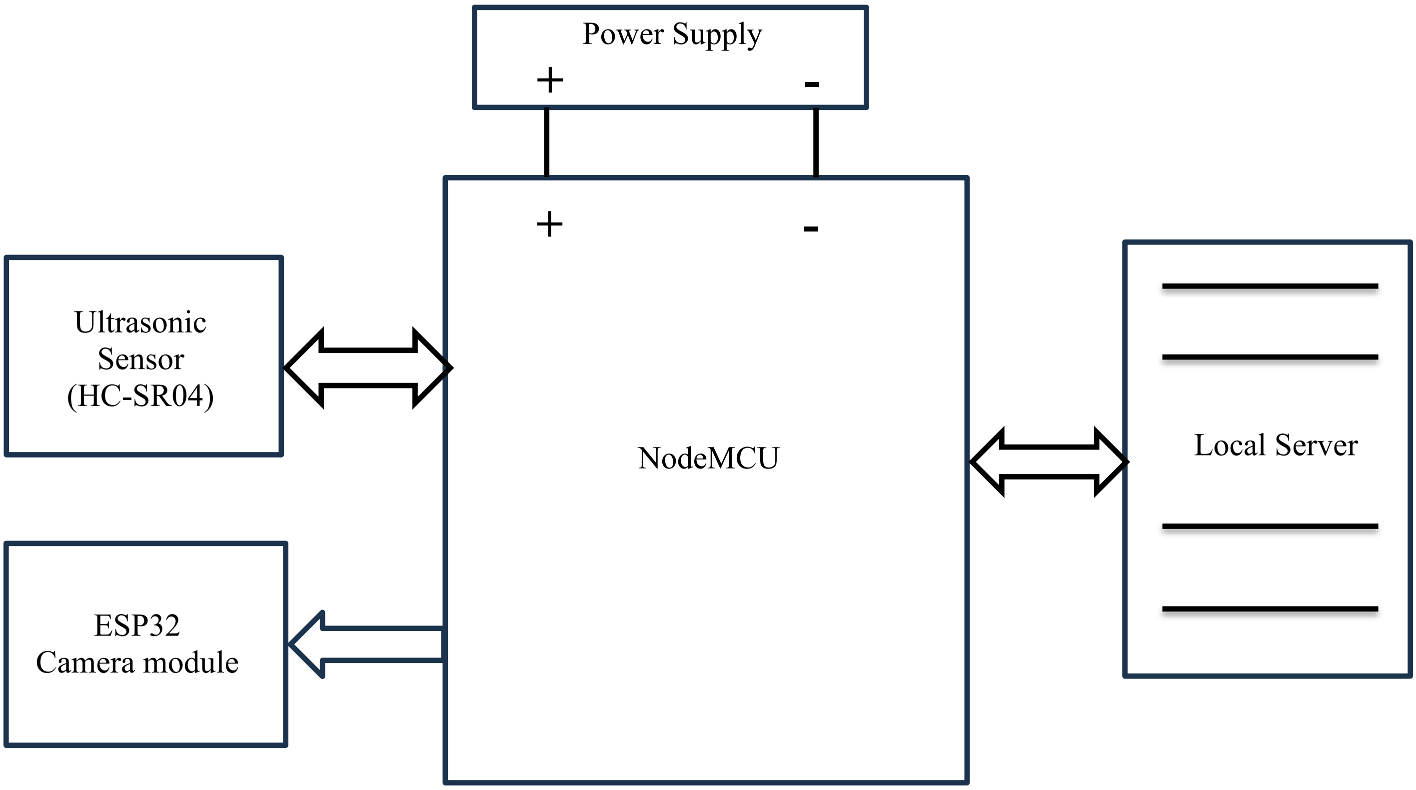

Fig-3.1 Block diagram of IntelliSense Toll Management System

NODE MCU:

The NodeMCU serves as a capable microcontroller unit in the Automatic Number Plate Recognition (ANPR) system, offering robust IoT capabilities. Powered by the ESP8266 Wi-Fi SoC, it facilitates wireless communication crucial for data transmission within the system. With its compact size and integrated Wi-Fi module, the NodeMCU is well-suited for IoT applications requiring remote connectivity. Equipped with GPIO pins, it effectively interfaces with peripherals such as the ultrasonic sensor (HC-SR04) and the ESP32 camera module, orchestrating the flow of data seamlessly. Despite its compact form factor, the NodeMCU provides ample processing power to manage sensor inputs and coordinate communication with the local server. Its compatibility with the Arduino IDE simplifies development, enabling rapid prototyping and deployment of ANPR system functionalities

HC-SR04 ULTRASONIC SENSOR:

At the forefront of vehicle detection, the ultrasonic sensor operates on the principle of emitting ultrasonic waves and measuring the time it takes for the echo to return. This sensor, with its configurable range and accuracy, plays a crucial role in initiating the image capture process. By detecting the presence of a vehicle within its range, it triggers the OV2640 camera module to capture images of the approaching vehicle, signaling the start of the ANPR system's workflow.

ESP32 CAMERA MODULE:

The ESP32 Camera Module plays a pivotal role in the Automatic Number Plate Recognition (ANPR) system, providing high-resolution image capture capabilities essential for accurate plate recognition. Featuring the OV2640 camera sensor, it offers flexibility in capturing images with resolutions up to 2 megapixels (1600x1200 pixels). Equipped with an SPI or I2C interface, the camera module seamlessly integrates with the ESP32 microcontroller, facilitating efficient communication and control. With built-in image processing capabilities and support for JPEG compression, the ESP32 camera module optimizes image capture and transmission for the ANPR system. Its compact form factor and low power consumption make it ideal for embedded applications, ensuring minimal footprint and energy efficiency in the overall system design.

LOCAL SERVER (Laptop):

Acting as the endpoint for data processing, the local server (laptop), fulfills a critical role in the ANPR system. Operating on a varied environment such as Windows, the laptop establishes a Wi-Fi connection to the ESP32 camera module for seamless data transmission. The protocol Equipped with software tools like OpenCV for image processing and Tesseract OCR for character recognition on the number plate. The local server conducts sophisticated analyses on the captured images extracts the text on the number plate and checks it against the stored database for owner of the car. After the owner is found out, the specified toll amount is deducted from his bank account, completing the ANPR system's processing pipeline.

3.2 CIRCUIT DIAGRAM

The circuit connection for the Automatic Number Plate Recognition (ANPR) project using the Node MCU involves the integration of various components to create a seamless and intelligent system. Node MCU is connected to an ultrasonic sensor, responsible for detecting the approach of a vehicle. The ultrasonic sensor, typically interfaced with GPIO pins on the Node MCU, provides real-time data on the distance of the vehicle, triggering the subsequent steps in the ANPR process.

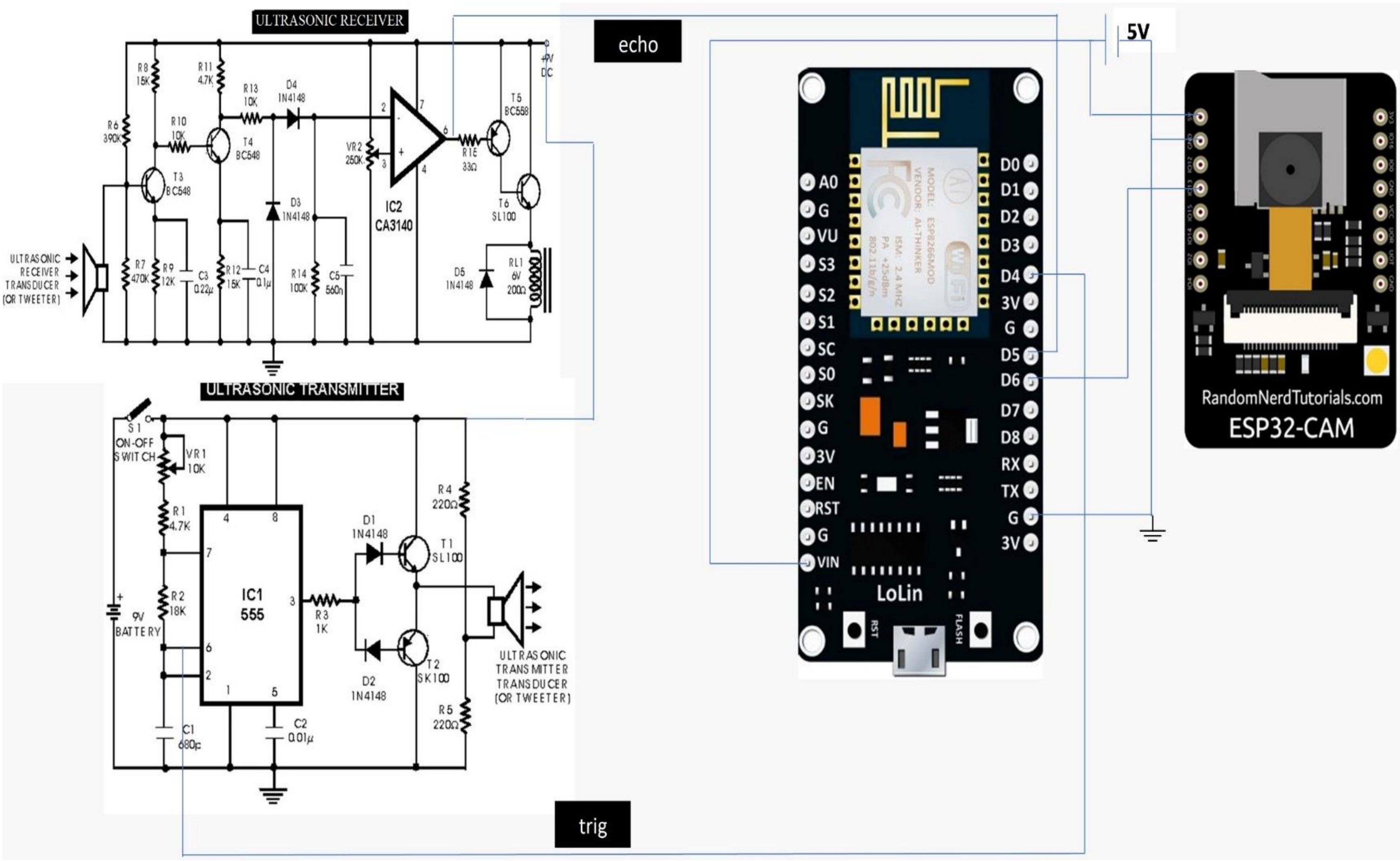

Fig 3.2 Circuit Diagram of ANPR System.

At the core of the circuit is the Node MCU microcontroller, serving as the brain of the project. The
In conjunction with the ultrasonic sensor, an ESP32 camera module is connected to the Node MCU to capture images of the vehicle's number plate upon detection. The camera module, communicating with the ESP32 ensures accurate image capture for subsequent processing. Optionally, an SD card module can be integrated into the circuit to store captured images for further analysis.

Node MCU Microcontroller:

The central component of the circuit is the Node MCU microcontroller, acting as the brain of the system. Connect the necessary power and ground pins, and establish communication with other modules and sensors.

HC-SR04 Ultrasonic Sensor:

Connect the ultrasonic sensor to the ESP32 to detect the presence of a vehicle. Typically, the sensor has separate pins for power (VCC), ground (GND), trigger, and echo. Connect the trigger and echo pins to specific GPIO pins on the ESP32 for control.

ESP32 camera module

Connect the ESP32 camera module to the Node MCU to capture images of vehicle number plates. The camera module usually has pins for power (VCC), ground (GND), and data transmission. Connect the SD card module to the SPI pins on the ESP32 for additional memory. The circuit is designed to be powered efficiently, with considerations for the power requirements of each component. Additionally, the ESP32 establishes a connection to the local network and server, typically through its built-in Wi-Fi capabilities, enabling communication with the server running on a laptop.

The laptop, acting as a local server, hosts the Python-based image processing

The overall circuit connection aims to create a robust ANPR system, seamlessly integrating hardware components and ensuring smooth communication between the ESP32 and the server for comprehensive vehicle identification and data processing.

3.3 DETAILED WORKING OF THE CIRCUIT

Vehicle Detection: When a vehicle approaches the toll booth, the ultrasonic sensor detects its presence by emitting ultrasonic waves and measuring the time it takes for the echo to return.

Image Capture: Upon detecting a vehicle, the NodeMCU triggers the ESP32 camera module to capture an image of the vehicle's license plate.

Image Transmission: The ESP32 camera module uses Google Script and Google API to upload the captured image to Google Drive for storage. This ensures secure and reliable storage of the images.

Server-Side Processing: On the local server, a program continuously monitors the designated folder in Google Drive for new image uploads. Once a new image is detected, it is downloaded for further processing.

License Plate Extraction: The downloaded image undergoes image processing using OpenCV and Tesseract OCR algorithms to extract the license plate text.

Toll Bill Generation: Using the extracted license plate text, the system retrieves the registered email address of the vehicle owner from the database. A toll bill is then generated in PDF format, including the date and time of toll passage.

Email Notification: The generated toll bill is sent to the vehicle owner's registered email address, providing them with a convenient and contactless payment option.

3.4 COMPONENTS USED

The **Hardware components** required for this system are.

- NodeMCU
- HC-SR04 Ultrasonic Sensor
- ESP32 camera module
- A local Server

NODE MCU MICROCONTROLLER

The NodeMCU serves as the backbone of the toll management system, boasting a robust architecture and versatile connectivity options to facilitate seamless communication and control within the system. As a central processing unit, the NodeMCU plays a pivotal role in orchestrating the interactions between various components, including the ultrasonic sensor and the ESP32 camera module. With its integrated microcontroller and built-in Wi-Fi capabilities, the NodeMCU enables real-time data transmission and processing, ensuring efficient operation of the ANPR system.

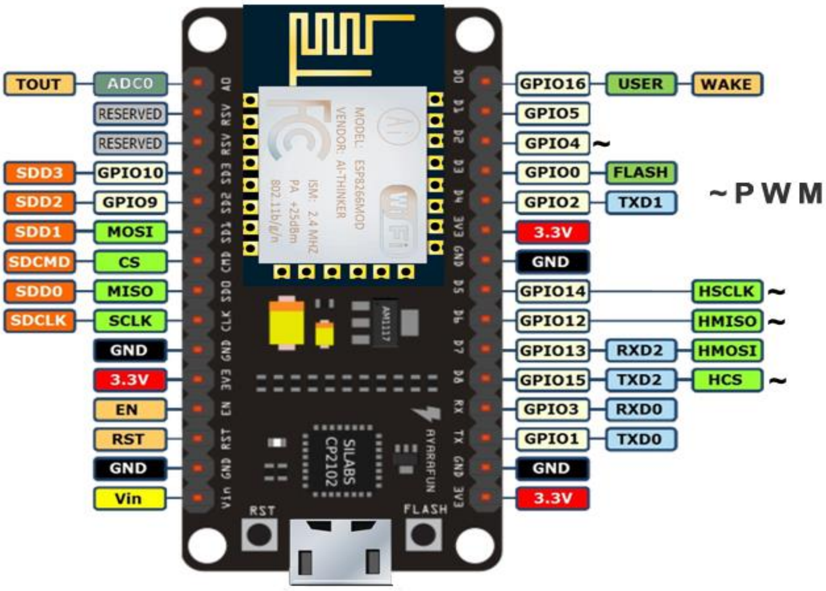

Fig 3.41 Node MCU microcontroller.

Features of NodeMCU:

- **Microcontroller:** Equipped with a powerful microcontroller for efficient data processing and control.
- **Wireless Connectivity**: Built-in Wi-Fi connectivity for seamless communication with other devices and the local server.
- **Operating Voltage:** Typically operates at 5 v, ensuring compatibility with various components in the system.

- **GPIO Pins:** Multiple GPIO pins for digital and analog input/output, enabling flexible interfacing with peripherals.
- **Memory:** SRAM and Flash memory for storing program code and data, facilitating smooth operation of the system.
- **Peripherals:** SPI, I2C, UART, ADC, DAC, etc., providing versatile connectivity options for interfacing with sensors and other devices.
- **Clock Frequency:** Adjustable clock frequency to meet the processing requirements of the system.
- **Operating Temperature:** Varies by NodeMCU module and manufacturer, ensuring reliable operation under diverse environmental conditions.

Pinout Details:

- **Power Pins:**
- **VIN:** External power supply voltage (5V recommended) for powering the NodeMCU.
- **3V3:** Regulated 3.3V output for external components.
- **GND:** Ground pins for ensuring proper electrical grounding.
- **Digital Pins:**
- **GPIO 0-15:** General-purpose digital input/output pins for interfacing with external devices.
- **TX, RX:** Serial communication pins (UART) for data transmission.
- **SCL, SDA:** I2C communication pins for connecting to I2C devices.
- **MISO, MOSI, SCK, SS:** SPI communication pins for interfacing with SPI devices.
- **Analog Pins:**
- **A0**: Analog input pin for reading analog sensor values.
- **PWM Pins:**
- **PWM 0-15**: Pulse Width Modulation pins for generating analog-like output signals.
- Special Function Pins:
- **EN**: Enable pin for the NodeMCU.
- **BOOT:** Boot mode selection pin for configuring the boot mode of the NodeMCU.
- **RST:** Reset pin for resetting the NodeMCU to its default state.
- **I2S Pins:** Pins for I2S communication for audio applications.
- **ADC Pins:** Additional pins for analog-to-digital conversion, enabling precise measurement of analog signals.

HC-SR04 ULTRASONIC SENSOR

The ultrasonic sensor is a vital component in the Automatic Number Plate Recognition (ANPR) project. Operating on the principle of emitting ultrasonic waves and measuring the time taken for the echo to return, the sensor detects the presence of a vehicle within its specified range. As a trigger mechanism, it initiates the image capture process by signaling the OV2640 camera module to capture images when a vehicle is detected. Its configurable range and accuracy make it well-suited for this role, serving as the first point of interaction in the ANPR system.

Fig 3.42 Ultrasonic Sensor

Features of Ultrasonic Sensor-

- **Detection Range:** Varies by model, typically between 5 and 300 centimeters.
- **Interface:** Provides digital or analog output for distance information.
- **Operating Voltage**: Typically operates within a range of 3.3V to 5V.
- **Maximum Current:** The maximum current draw of an ultrasonic sensor during operation is usually in the range of 10mA to 40mA.

Pinout Details:

- **VCC:** Power supply pin for connecting to the sensor's operating voltage source.
- **Trig (Trigger):** Trigger pin for initiating distance measurement by sending ultrasonic pulses.
- **Echo**: Echo pin for receiving and measuring the time taken for the ultrasonic pulses to return after being reflected by the target object.
- **GND:** Ground pin for ensuring proper electrical grounding and signal integrity.

LOCAL SERVER:

The laptop employed as the server, or local host, in the Automatic Number Plate Recognition (ANPR) project plays a pivotal role in processing and storing captured images. This server, typically running Python, OpenCV, Tesseract OCR. It serves as the backend infrastructure for image processing and database management. Python, with its extensive libraries, facilitates the extraction of relevant information from the captured images, such as alphanumeric characters from number plates, contributing to the creation of a comprehensive database of vehicle owners associated with their respective plates. The server is also associated with creating of Toll bill along with the time stamp of when the vehicle has passed the toll gate and a QR code facilitating easy transaction using UPI payment method.

Fig 3.43 Laptop as local server

To enable communication between the ESP32 camera module and the server, various protocols can be employed. One such protocol is HTTP (Hyper Text Transfer Protocol), which facilitates the seamless transfer of image files between the ESP32 camera module and the server. HTTP ensures reliable and secure file transmission, allowing the ESP32 camera module to upload captured images to the google drive using google script and google drive API. Alternatively, Base64 encoding and decoding techniques can be utilized to transmit image data as text over HTTP or other communication protocols. This method involves converting binary image data into a text-based format, making it easily transmittable. The server, upon receiving the Base64-encoded image data, decodes it back into binary form for subsequent image processing.

ESP32 CAMERA MODULE

Allows for flexible configurations of image resolutions (e.g., 160x120 to 1600x1200 pixels) based on project requirements Interfaces with the Node MCU microcontroller through D6 GPIO pin. After Image acquisition, the image is uploaded to google drive using google script and google drive by ESP32 camera module. Supports multiple output formats including JPEG, YUV422, and RGB565, catering to diverse needs in the ANPR system.

Fig 3.44 ESP32 Camera Module

Features of ESP32 CAMERA MODULE-

VIN: External power supply voltage for powering the ESP32 camera module: Regulated 3.3V output for external components and peripherals.

GND: Ground pins for ensuring proper electrical grounding and signal integrity.

Digital Pins: GPIO pins: General-purpose digital input/output pins for interfacing with the microcontroller unit and other devices.

ADC pins: Analog-to-digital conversion pins for capturing analog signals from external sensors and peripherals.

Special Function Pins:

EN: Enable pin for powering on or off the ESP32 camera module.

BOOT: Boot mode selection pin for configuring the module's boot behavior.

RST: Reset pin for resetting the module to its default state.

CHAPTER 4
SOFTWARE REQUIREMENTS

The software components required for this Automatic Number Plate Recognition (ANPR) project, are-

- **Arduino IDE for Node MCU** programming, involve a comprehensive stack that seamlessly integrates microcontroller programming, and ESP32 camera module.
- On the Node MCU side, the Arduino IDE serves as the development environment for writing and uploading firmware to the Node MCU microcontroller.
- Utilizing **HTTP protocols,** the ESP32 camera module establishes communication channels with the server. The ESP32 camera module uses google script and google drive API to upload the acquired image to google drive.
- On the server side**, Python** plays a pivotal role. It continuously checks for newly uploaded image in google drive. If any new image uploads is found, it downloads it and starts processing it. Using python, we can leverage popular libraries such as **OpenCV** for image processing and **Tesseract OCR** for optical character recognition.
- OpenCV facilitates tasks like image processing and feature extraction, while Tesseract OCR extracts alphanumeric characters from the identified number plate regions.
- Database of the registered License plate number matched against vehicle owner's Email id is stored in the server. Once the license plate is extracted, it is checked if an email-id is registered against it. If found, using python we generate a bill in PDF format consisting of time stamp and the amount to be paid.
- This integrated software ecosystem enables the NodeMCU to capture and transmit images seamlessly, while the server processes and extracts relevant information, contributing to the establishment of a comprehensive ANPR system with database management capabilities.

4.1 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) software serves as the programming tool for the microcontroller responsible for detecting vehicle approaching within a specific area. As an open-source platform, the Arduino IDE simplifies the programming of Arduino microcontrollers through its user-friendly interface. Utilizing the Arduino IDE, developers upload the necessary code to the microcontroller, which, in turn, manages the ultrasonic sensor and triggers an alert upon vehicle entry into the toll gate. The code, written in C++, is compiled and uploaded to the microcontroller using the Arduino IDE software. To establish a connection between the Arduino microcontroller and a computer for code upload, the FTDI Programmer Module comes into play. This compact device connects to the microcontroller, providing a USB interface for communication with the computer. Equipped with multiple pins, the module facilitates seamless integration with the microcontroller, and its built-in voltage regulator ensures stable voltage supply.

The combined use of the Arduino IDE software and the FTDI Programmer Module streamlines the microcontroller programming and code upload process. This streamlined workflow enables easy modifications and updates to the system, enhancing its flexibility and adaptability. Consequently, the system proves to be a versatile solution for monitoring and safeguarding agricultural fields, offering customizable features for crop and livestock protection.

4.2 OPENCV (OPEN-SOURCE COMPUTER VISION LIBRARY)

In this project, OpenCV (Open-Source Computer Vision Library) plays a pivotal role in image processing tasks essential for license plate extraction. OpenCV offers a comprehensive suite of functions and algorithms designed specifically for computer vision applications, making it an indispensable tool for tasks like object detection, image segmentation, and feature extraction. Leveraging the capabilities of OpenCV, the system can accurately locate and isolate the license plate region within the captured vehicle image, despite variations in lighting conditions, vehicle orientation, and environmental factors.

One of the primary functionalities of OpenCV utilized in this project is its ability to perform image preprocessing techniques. These techniques include operations like noise reduction, image enhancement, and edge detection, which are crucial for improving the quality of the captured images and isolating relevant features such as the license plate. By applying these preprocessing steps, the system enhances the clarity and readability of the license plate text, thereby improving the accuracy of subsequent OCR (Optical Character Recognition) operations.

Additionally, OpenCV provides powerful algorithms for image segmentation and contour detection, which enable the system to accurately identify and extract the region of interest containing the license plate. By delineating the contours of the license plate within the image, OpenCV facilitates precise localization of the plate, ensuring that only relevant information is extracted for further processing. Overall, the integration of OpenCV into the system's software architecture enhances its robustness, accuracy, and efficiency in license plate recognition, ultimately contributing to the seamless operation of the toll management system.

4.3 TESSARACT OCR

In this project, Tesseract OCR (Optical Character Recognition) serves as a critical component for extracting text from the captured vehicle images, particularly the license plate numbers. Tesseract
OCR is an open-source library renowned for its accuracy and versatility in converting images
containing text into editable and searchable text data. Leveraging the capabilities of Tesseract OCR, the system can precisely identify and extract alphanumeric characters comprising the license plate number from

the captured images, regardless of variations in font size, style, or orientation.

One of the key features of Tesseract OCR utilized in this project is its robustness in handling complex and degraded images. This includes images captured under varying lighting conditions, different weather conditions, and instances of occlusion or noise. Tesseract OCR employs advanced image processing algorithms to preprocess the input images, enhancing the clarity and readability of the text regions before performing character recognition. By mitigating the effects of image artifacts and distortions, Tesseract OCR ensures high accuracy and reliability in extracting license plate numbers from challenging image conditions.

4.4 FLOWCHART

The flowchart for the Automatic Number Plate Recognition (ANPR) project involves sequential steps to capture and process vehicle number plates. It begins with the activation of the ultrasonic sensor upon detecting a vehicle, triggering the ESP32 camera module to capture an image. The NodeMCU microcontroller then sends the image to a local host (laptop) via a local server. On the laptop, image processing using OpenCV and Tesseract OCR extracts text from the number plate .

The flowchart for the Automatic Number Plate Recognition (ANPR) system outlines a systematic sequence of steps, seamlessly integrating hardware and software components.

- It initiates with Step 1. Step1 and 2 combiningly represents a phase where the Node MCU is waitng for a iniating pulse from ultrasonics sensor. At this phase the sysytem just waits for the vehicle to approach near the toll gate.
- Step 2 is a decision making step. If ultrasonic sensor senses the approaching vehicle it triggers the capture of the image by the ESP32 camera module connected to the Node MCU microcontroller.
- Moving to Step 3, the captured image is uploaded to google drive using google script and google drive API.
- In step 4, the image is downloaded from google drive. It further undergoes intricate processing, including gray scaling, median/bilateral filters, thresholding, and binarization. Contour finding and number plate localization are performed, and characters are segmented using R-CNN.
- In Step 5, Optical Character Recognition (OCR) is employed to recognize and extract characters from the segmented regions.
- The flowchart progresses to Step 6, where the for the recognized license plate number obtained is checked if an Emil-id is registered against it. If the Email id is found the process flows to next step.
- If a emil is is not registered against the licence number, then a warning message “unauthorized vehicle” is displayed.

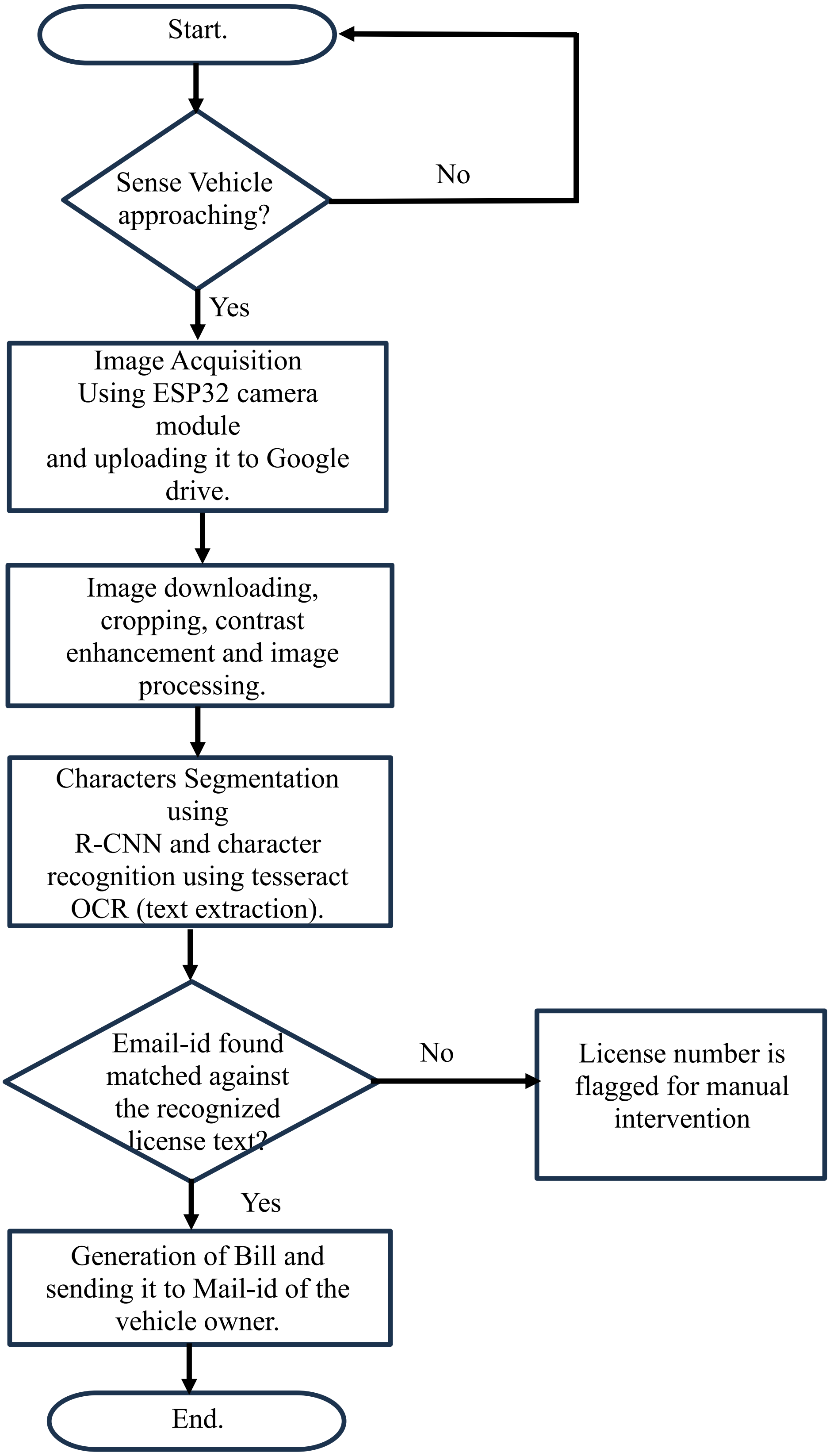

Fig 4.4 Flowchart for Toll Management System

- In the next step, bill is generated in pdf format and is mailed to users mail id. The pdf consists of toll amount, time stamp for when the car passed toll gate along with QR code
- The integration of image processing, OCR, and database checks demonstrates a comprehensive approach to automatic number plate recognition, offering real-time functionality and the ability to handle

exceptional cases through manual verification.

- Moreover, the flowchart encapsulates the end-to-end process of the ANPR system, showcasing its capability to seamlessly handle routine transactions, account for anomalies, and provide a mechanism for continuous improvement through human oversight. This holistic approach ensures the reliability, accuracy, and adaptability of the ANPR system in various scenarios, contributing to efficient traffic management and toll collection

CHAPTER 5
ADVANTAGES AND DISADVANTAGES

5.1 ADVANTAGES

- **Efficient and Automated Vehicle Identification:**
  ANPR provides an automated and efficient method for identifying vehicles through their number plates, reducing the need for manual intervention in various applications.
- **Enhanced Security:**
  The project enhances security by automating the process of identifying and tracking vehicles, enabling quick detection of suspicious or unauthorized vehicles entering restricted areas.
- **Reduced Manual Workload:**
  The automation of number plate recognition reduces the manual workload in tasks such as toll collection, parking management, and law enforcement, leading to increased operational efficiency.
- **Real-time Monitoring:**
  The system allows for real-time monitoring of vehicle movements, enabling prompt response to security threats, traffic incidents, or violations.
- **Accurate Data Collection:**
  ANPR systems provide accurate data on vehicle movements, contributing to reliable data collection for purposes such as traffic analysis and city planning.
- **Enhanced Public Safety:**
  The project enhances public safety by aiding law enforcement agencies in identifying stolen vehicles, monitoring traffic violations, and responding quickly to security concerns.

5.2 DISADVANTAGES

- **Image quality:** License plate recognition (LPR) accuracy depends heavily on image quality. Factors like lighting variations, weather conditions, and motion blur can affect recognition success.
- **Database accuracy:** The system relies on an accurate and up-to-date database of license plates and corresponding email addresses. Inaccurate data can lead to sending bills to wrong email addresses.
- **Unauthorized access:** The system should be protected against unauthorized access that could manipulate data or disrupt operations. Authentication mechanisms must be implemented for the server-side application.
- **Hardware malfunctions:** Component failures (NodeMCU, camera, or server) can disrupt operation. Consider redundancy measures for critical components.
- **Network connectivity:** The system relies on a stable Wi-Fi connection between the NodeMCU and the server. Interruptions can delay image transfer and bill generation.

CHAPTER 6
APPLICATIONS AND FUTURE ENHANCEMENTS

6.1 APPLICATIONS

- **Smart Cities:** ANPR technology contributes to the development of smart city initiatives by optimizing traffic flow, enhancing public safety, and supporting efficient urban planning.
- **Toll Collection:** ANPR is applied in toll collection systems to automate the tolling process, reducing delays, improving accuracy, and enhancing the overall efficiency of toll booths.
- **Access Control and Security:** The technology is used in access control systems for secure facility entry, enhancing security in restricted areas, and providing an audit trail of vehicle movements.
- **Traffic Monitoring and Optimization:** ANPR is employed in traffic monitoring systems to collect real-time data on traffic conditions, allowing for effective traffic management and optimization of transportation networks.
- **Border Control and Customs**: ANPR is utilized in border control and customs applications to automate the identification of vehicles entering or leaving a country, aiding in security and border management.
- **Logistics and Fleet Management:** ANPR supports logistics and fleet management by providing accurate vehicle tracking, improving inventory control, and ensuring efficient transportation operations.

6.2 FUTURE ENHANCEMENT

- **Enhanced Image Processing Algorithms:** Explore advanced image processing techniques to improve license plate recognition accuracy, especially in challenging conditions like low light or adverse weather, ensuring more reliable toll collection.
- **User Feedback Mechanisms:** Introduce mechanisms for collecting user feedback and satisfaction ratings to continuously improve the toll management system's usability and effectiveness. Analyzing user input can identify areas for enhancement and inform future
- **Integration with Cloud Services:** Investigate integrating cloud-based solutions for image processing and data storage, enabling scalability to handle increased traffic volume and facilitating real-time data analysis for traffic management insights.
- **Enhanced Security Measures:** Implement robust security protocols to safeguard sensitive data, including license plate information and user details, against potential cyber threats, ensuring compliance with data privacy regulations and enhancing system trustworthiness.

CHAPTER 7
RESULTS AND CONCLUSION

7.1 RESULTS

The Automatic Number Plate Recognition (ANPR) project utilizing the Node MCU microcontroller represents a significant advancement in intelligent transportation systems and security applications. The integration of NodeMCU, ultrasonic sensors, and the ESP32 camera module has resulted in a sophisticated yet accessible solution for automatic vehicle identification.

Fig 9.1 Image captured by ESP32 camera.

One of the key strengths of the ANPR system is the incorporation of additional components, such as LEDs for visual feedback and optional SD card modules for image storage, adds versatility and user-friendliness to the system, lies in its ability to seamlessly capture and process vehicle information. The NodeMCU microcontroller, serving as the project's central processing unit, efficiently coordinates the functions of the ultrasonic sensor and camera module, ensuring precise detection and image capture upon the approach of a vehicle.

The ANPR system's reliance on google script and google drive API extends its adaptability, enabling seamless integration with servers for image processing and database management.

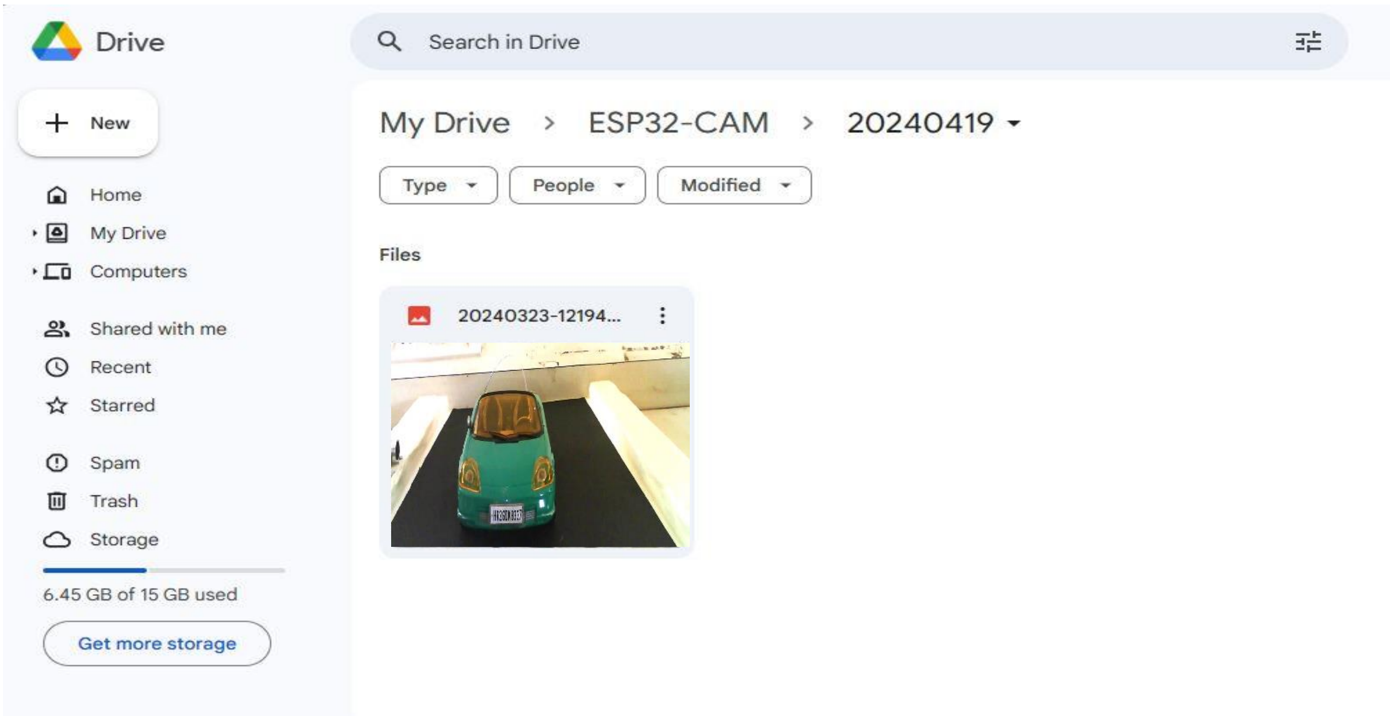

Fig 9.2 Captured Image Uploaded to google drive.

```
PS C:\Users\phane\OneDrive\Documents\Final Year Project> & C:/Users/phane/AppData/Local/Programs/Python/Python311/python.exe "c:/Users
/phane/OneDrive/Documents/Final Year Project/main.py"
Today's date without hyphens: 20240419
1 file downloaded: 20240323-121945.jpg
Current working directory: C:\Users\phane\OneDrive\Documents\Final Year Project
Image files found:
Extracted number plate number: HR26DK8337
PS C:\Users\phane\OneDrive\Documents\Final Year Project>
```

Fig 9.3 Image processed and License Text recognised.

The server, powered by Python, OpenCV, and Tesseract OCR, provides a robust foundation for extracting relevant information from captured images the ANPR project showcases the potential of smart technologies in revolutionizing traditional systems related to traffic management, security, and parking.

The successful integration of hardware and software components demonstrates the feasibility of creating intelligent systems that not only automate tedious tasks but also contribute to data-driven decision-making. The ANPR project, built on the foundation of the Node MCU microcontroller, sets the stage for future innovations in the realm of intelligent transportation systems and surveillance applications.

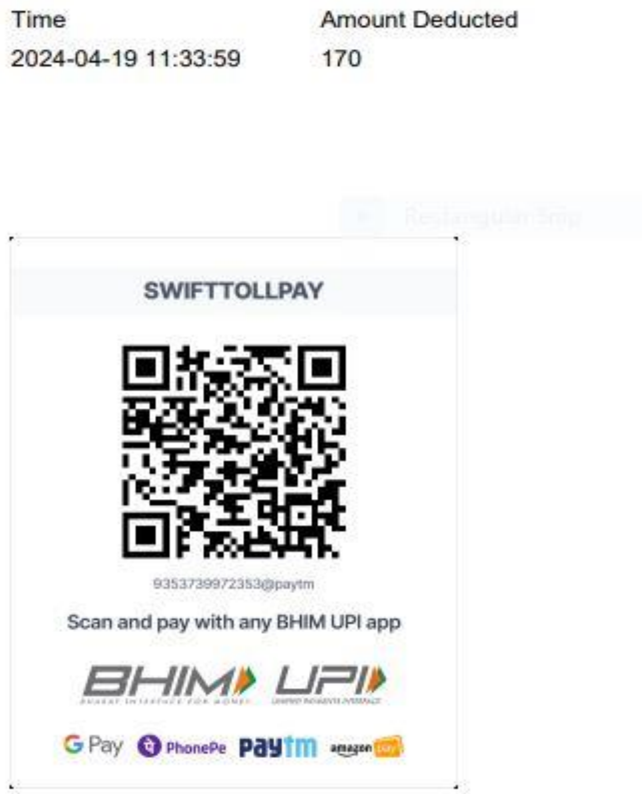

Fig 9.4 Bill genreated in PDF format.

PDF plays a crucial role in generating and delivering toll bills to vehicle owners. By converting billing information into PDF format, the system ensures that the bills are presented in a standardized and easily readable format. This enhances the user experience by providing clear and concise billing information, facilitating efficient payment processing. Additionally, PDFs offer versatility in terms of compatibility with various devices and operating systems, allowing vehicle owners to access their bills conveniently from smartphones, tablets, or computers. Furthermore, PDFs can be encrypted or password-protected to ensure the security and confidentiality of sensitive billing information during transmission and storage. Overall, the use of PDFs in the Toll Management System contributes to seamless billing operations, enhanced user satisfaction, and efficient management of toll collection processes.

Our overall project looks like in the picture below. It is a model of toll collecting station. It is made from Thermocol, KG sheets, cardboards and paper plasters.

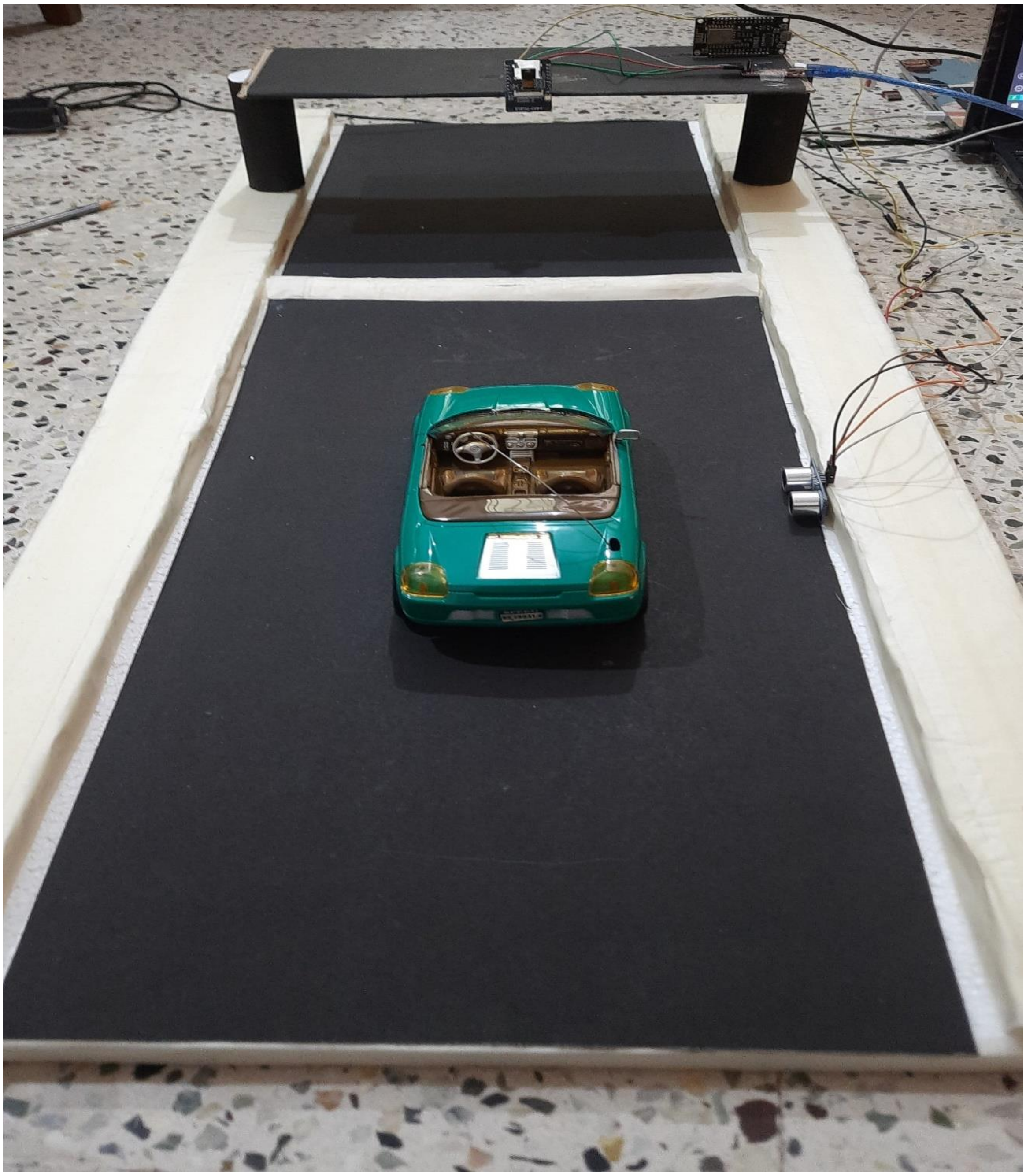

Fig 9.5 Model of Toll management system.

Ultrasonic sensor on the right senses the approaching vehicle, and alerts the node mcu placed at the top which in turn triggers the camera to capture the image. Finally, it is uploaded to server (laptop).

7.2 CODE

```
import openpyxl
import cv2
import pytesseract
import numpy as np
import re
import smtplib
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from datetime import datetime
from PIL import Image
from openpyxl import Workbook
from openpyxl.styles import NamedStyle
from reportlab.lib.pagesizes import letter
from reportlab.pdfgen import canvas
from reportlab.lib.units import inch
from email.mime.multipart import MIMEMultipart
from email.mime.text import MIMEText
from email.mime.base import MIMEBase
from email import encoders
HR26DK8337 = 'phancode23@gmail.com'
gauth = GoogleAuth()
drive = GoogleDrive(gauth)
folder = '13354mIilaGz8vJeSdlBNxQN5OdX92QaH'
download_directory = "C:/Users/phane/OneDrive/Documents/Inpr1/data base/Vehicle image"
# Get today's date
today_date = datetime.today().date()
# Format the date as "YYYY-MM-DD"
date = today_date.strftime("%Y-%m-%d")
# Remove hyphens from the formatted date
today = date.replace("-", "")
# Print the formatted date without hyphens
print("Today's date without hyphens:", today)
# Specify the name of the subfolder you want to download
  subfolder_name = today
```

```
# Find the subfolder in the main folder
subfolder_id = None
file_list = drive.ListFile({'q': f"'{folder}' in parents and trashed=false"}).GetList()
for file in file_list:
    if file['title'] == subfolder_name and file['mimeType'] == 'application/vnd.google-apps.folder':
        subfolder_id = file['id']
        break
# Download files from the subfolder
if subfolder_id:
    subfolder_file_list = drive.ListFile({'q': f"'{subfolder_id}' in parents and trashed=false"}).GetList()
    for index, file in enumerate(subfolder_file_list):
        print(index + 1, 'file downloaded:', file['title'])
        file.GetContentFile(os.path.join(download_directory, file['title']))
        # Delete files from the subfolder after downloading (optional)
        # file.Delete()
else:
    print(f"Subfolder '{subfolder_name}' not found in the main folder.")
# Set the path to the Tesseract executable (modify this according to your installation)
pytesseract.pytesseract.tesseract_cmd = r'C:\Program Files\Tesseract-OCR\tesseract.exe'

def crop_image(input_path, output_path):
    # Open the image
    img = Image.open(input_path)
    # Get the dimensions of the image
    width, height = img.size
    # Calculate cropping dimensions
    top_crop = int(0.15 * height)
    left_crop = int(0.2 * width)
    right_crop = width - left_crop
    lower_crop = height - top_crop
    # Crop the image
    cropped_img = img.crop((left_crop, top_crop, right_crop, lower_crop))
    # Save the cropped image
    cropped_img.save(output_path)
from PIL import Image, ImageFilter
```

```
def enlarge_image(input_path, output_path, scale_factor):
 # Open the image file
image = Image.open(input_path)
 # Get the original width and height
 original_width, original_height = image.size
 # Calculate the new width and height based on the scale factor
 new_width = int(original_width * scale_factor)
 new_height = int(original_height * scale_factor)
 # Resize the image using the BICUBIC resampling filter
 enlarged_image = image.resize((new_width, new_height), Image.BICUBIC)
 # Save the enlarged image
 enlarged_image.save(output_path)
 from PIL import Image, ImageEnhance
 def increase_contrast(input_path, output_path, factor):
 # Open the image file
 image = Image.open(input_path)
 # Create a contrast enhancer
 enhancer = ImageEnhance.Contrast(image)
 # Increase the contrast by the specified factor
 contrast_image = enhancer.enhance(factor)
 # Save the image with increased contrast
 contrast_image.save(output_path)
def image_operations(directory):
# Define the file extensions for images you want to include
image_extensions = ['.jpg', '.jpeg', '.png', '.gif', '.bmp']
# List all files in the specified directory
all_files = os.listdir(directory)
# Filter only the image files
image_files = [file for file in all_files if any(file.lower().endswith(ext) for ext in image_extensions)]
# Print the current working directory
print("Current working directory:", os.getcwd())
# Print the paths of the found image files
if not image_files:
   print(f"No images found in {directory}")
else:
```

```
    print("Image files found:")
    for image_path in image_files:
        directory1 = directory.replace("/","\\")
        path = os.path.join(directory1, image_path)
        path1 = path.replace("\\","/")
        crop_image(path1, path1)
        enlarge_image(path1, path1, 2.0)
        increase_contrast(path1,path1, 2.0)
  # Replace 'your_directory_path' with the path to the directory containing the images
vehicleimage_directory_path = 'C:/Users/phane/OneDrive/Documents/Inpr1/data base/Vehicle image'
image_operations(vehicleimage_directory_path)
def process_image(input_path, output_directory):
 # Load the image
 image = cv2.imread(input_path)
 # Preprocess the image for better text extraction
 gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
 gray = cv2.bilateralFilter(gray, 11, 17, 17)
 # Apply edge detection to find the contours of the number plate
 edges = cv2.Canny(gray, 30, 200)
 contours, _ = cv2.findContours(edges, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
 contours = sorted(contours, key=cv2.contourArea, reverse=True)[:10]
 # Find the number plate contour based on its shape and dimensions
 number_plate_contour = None
 for contour in contours:
 perimeter = cv2.arcLength(contour, True)
 approx = cv2.approxPolyDP(contour, 0.018 * perimeter, True)
 if len(approx) == 4:
        number_plate_contour = approx
        break
 if number_plate_contour is not None:
 # Extract the number plate region from the image
  mask = np.zeros(gray.shape, np.uint8)
    cv2.drawContours(mask, [number_plate_contour], 0, 255, -1)
    masked_image = cv2.bitwise_and(gray, gray, mask=mask)
    # Save the processed image in the output directory
```

```
 output_path = os.path.join(output_directory, f"processed_{os.path.basename(input_path)}")
 cv2.imwrite(output_path, masked_image)
 # Apply OCR (Optical Character Recognition) to recognize the text from the number plate region
 text = pytesseract.image_to_string(masked_image, config='--psm 11')
 def check_and_fix_string(input_string):
     while input_string and not input_string[0].isalpha():
         input_string = input_string[1:]
     while input_string and not input_string[-1].isdigit():
         input_string = input_string[:-1]
     return input_string
 result = check_and_fix_string(text)
 result1 = result.replace(" ", "")
 return result1
 else:
 print(f"No number plate contour found in {os.path.basename(input_path)}")
 # Input and output directories
input_directory = "C:/Users/phane/OneDrive/Documents/Inpr1/data base/Vehicle image/"
output_directory = "C:/Users/phane/OneDrive/Documents/Inpr1/data base/Number plate images/"
 # Iterate over all files in the input directory
 for filename in os.listdir(input_directory):
 if filename.endswith((".jpg", ".jpeg", ".png")):  # Adjust file extensions as needed
 image_path = os.path.join(input_directory, filename)
 process_image(image_path, output_directory)
result2 = process_image(image_path, output_directory)
def create_or_load_excel(filename):
try:
 workbook = openpyxl.load_workbook(filename)
except FileNotFoundError:
 workbook = Workbook()
return workbook
def add_row(sheet, time, amount):
next_row = sheet.max_row + 1
sheet.cell(row=next_row, column=1, value=time)
sheet.cell(row=next_row, column=2, value=amount)
def set_column_width(sheet, column, width):
```

```
sheet.column_dimensions[column].width = width
def save_to_excel(workbook, filename):
workbook.save(filename)
def convert_to_pdf(excel_filename, pdf_filename, image_filename):
workbook = openpyxl.load_workbook(excel_filename)
sheet = workbook.active
pdf_canvas = canvas.Canvas(pdf_filename, pagesize=letter)
# Set font and size
pdf_canvas.setFont("Helvetica", 12)
# Set the position for field names
pdf_canvas.drawString(100, 750, "Time")
pdf_canvas.drawString(250, 750, "Amount Deducted")  # Adjusted X-coordinate for "Amount
Deducted"
# Set the position for data rows
row_height = 20
y_coordinate = 730
for row in sheet.iter_rows(min_row=2, max_col=2, values_only=True):
    time, amount = row
    pdf_canvas.drawString(100, y_coordinate, str(time))
    pdf_canvas.drawString(250, y_coordinate, str(amount))  # Adjusted X-coordinate for data rows
    y_coordinate -= row_height
# Calculate the total height of text content
text_height = (sheet.max_row - 1) * row_height
# Set the position for the image below the text content
y_coordinate -= text_height + 50  # Place image below text content with additional spacing
# Get image dimensions
image_width = 3 * inch
image_height = 4 * inch  # Adjust image height as needed
# Draw image
pdf_canvas.drawImage(image_filename, 100, y_coordinate - image_height, width=image_width,
height=image_height)
pdf_canvas.save()
def upload_to_google_drive(pdf_filename, drive_folder_id):
gauth = GoogleAuth()
gauth.LocalWebserverAuth()
```

```
    drive = GoogleDrive(gauth)
    file_list = drive.ListFile({'q': f"'{drive_folder_id}' in parents and trashed=false"}).GetList()
    existing_file_id = None
    for file in file_list:
        if file['title'] == os.path.basename(pdf_filename):
            existing_file_id = file['id']
            break
    if existing_file_id:
        # If the file already exists, update its content and metadata
        existing_file = drive.CreateFile({'id': existing_file_id})
        existing_file.SetContentFile(pdf_filename)
        existing_file.Upload()
    else:
        # If the file doesn't exist, create a new one
        file = drive.CreateFile({'title': os.path.basename(pdf_filename), 'parents': [{'id': drive_folder_id}]})
        file.SetContentFile(pdf_filename)
        file.Upload()
    def delete_files_in_directory(directory):
    # List all files in the directory
    files = os.listdir(directory)
    # Iterate through each file and delete it
    for file in files:
        # Construct the full path to the file
        file_path = os.path.join(directory, file)
        # Check if it's a file (not a directory)
        if os.path.isfile(file_path):
            # Delete the file
            os.remove(file_path)
sheet_name = result2 + ".xlsx"
default_path = r'C:\Users\phane\OneDrive\Documents\Inpr1\data base\Bills'
image_filename = r"C:\Users\phane\OneDrive\Documents\Inpr1\data base\Bills\upi.png"  # Provide the
    path to your image file here
print (f"Extracted number plate number: {result2}")
workbook = create_or_load_excel(os.path.join(default_path, sheet_name))
sheet = workbook.active
```

```
    if sheet["A1"].value is None or sheet["B1"].value is None:
        sheet["A1"] = "Time"
        sheet["B1"] = "Amount Deducted"
    current_time = datetime.now().strftime("%Y-%m-%d %H:%M:%S")
    add_row(sheet, current_time, 170)
    set_column_width(sheet, 'A', len(current_time) + 2)
    excel_filename = os.path.join(default_path, sheet_name)
    pdf_filename = os.path.join(default_path, os.path.splitext(sheet_name)[0] + ".pdf")
    drive_folder_id = '1-iP3vmUwWUjJKz8vB88Uq7ox_yzmodtU'
    save_to_excel(workbook, excel_filename)
    convert_to_pdf(excel_filename, pdf_filename, image_filename)
    upload_to_google_drive(pdf_filename, drive_folder_id)
    directory_path = r"C:\Users\phane\OneDrive\Documents\Inpr1\data base\Vehicle image"
    delete_files_in_directory(directory_path)
    # Access the value of the variable using locals() or globals()
    accounts = locals().get(result2)
      def send_email(sender_email, sender_password, recipient_email, subject, body, attachment_path):
        # Set up SMTP server
        smtp_server = 'smtp.gmail.com'  # Update with your SMTP server
        smtp_port = 587  # Update with your SMTP port
        server = smtplib.SMTP(smtp_server, smtp_port)
        server.starttls()
        server.login(sender_email, sender_password)
        # Create a multipart message
        msg = MIMEMultipart()
        msg['From'] = sender_email
        msg['To'] = recipient_email
        msg['Subject'] = subject
        # Attach body
        msg.attach(MIMEText(body, 'plain'))
        # Attach file
        with open(attachment_path, 'rb') as attachment:
         part = MIMEBase('application', 'octet-stream')
         part.set_payload(attachment.read())
         encoders.encode_base64(part)
```

```
 part.add_header(
'Content-Disposition',
 f'attachment; filename= {attachment_path.split("/")[-1]}')
 msg.attach(part)
 # Send the email
 server.send_message(msg)
 del msg
 server.quit()
# Example usage
sender_email = 'phaneendra2k3@gmail.com'
sender_password = 'ejbk anhp rcvh gczd'
recipient_email = accounts
subject = 'Toll Bill'
body = 'This is the mail sent by National Toll Agency (NTA), please find the attached toll bill below.'
attachment_path = r"C:\Users\phane\OneDrive\Documents\Inpr1\data base\Bills\HR26DK8337.pdf"
send_email(sender_email, sender_password, recipient_email, subject, body, attachment_path)
```

algorithm

Step 1: Start.

Step 2: Sense the vehicle approaching using ultrasonic sensor.

Step 3: Capture the image using ESP32 camera module.

Step 4: Send the captured image to the server for image processing

Step 5: cropping and contrast enhancement.

Step 6: Contour finding and number plate localization, Characters Segmentation using R-CNN

Step 7: Character Recognition using OCR

Step 8: Passing Recognized License number to match with registered Email-id against that number plate for owner identification and toll deduction.

Step 9: If license plate number is not matched with existing database, then send the captured image and extracted for manual intervention.

Step 10: If the license number is matched with a mail-id, generate a bill consisting of time stamp and the amount to be paid along with QR code for UPI transaction

Step 11: End.

The algorithm for the Automatic Number Plate Recognition (ANPR) project unfolds in a systematic manner. In the initial step, the system senses the approaching vehicle using an ultrasonic sensor, triggering the capture of an image by the ESP32 camera module connected to the NodeMCU microcontroller. Subsequently, in Step 4, the captured image is transmitted to a server for further processing. The image undergoes a series of image processing steps in Step 5 and Step 6, involving gray scaling, filtering, thresholding, and contour finding to precisely localize the number plate and segment characters using R-CNN (Region-based Convolutional Neural Network). Step 7 employs OCR (Optical Character Recognition) for character recognition from the segmented regions.

Moving forward, Step 8 involves passing the recognized license plate number to a backend server, where owner identification and toll deduction take place. In cases where the recognized license plate is not found in the existing database, Step 9 initiates a process for manual intervention. The captured image along with the extracted information is sent for further examination, ensuring accuracy and reliability in the ANPR system's functionality. This algorithm seamlessly integrates hardware and software components to enable efficient and automated number plate recognition with provisions for manual verification when needed.

7.3 CONCLUSION

The Toll Management System presented herein represents a significant advancement in modernizing toll collection procedures and addressing traffic congestion issues. By leveraging image processing technology, the system streamlines the toll collection process, enhances accuracy in license plate recognition, and offers a seamless experience for both toll authorities and commuters. The successful implementation of this system demonstrates its potential to revolutionize toll management practices, paving the way for more efficient and sustainable transportation infrastructure. Moving forward, it is imperative to continue refining and optimizing the system to address existing limitations and meet evolving needs.

This includes further research into enhancing image processing algorithms for improved performance under diverse environmental conditions and exploring integration opportunities with emerging technologies such as artificial intelligence and blockchain for enhanced security and transparency.

Moreover, the future scope of the project extends beyond toll management to encompass broader initiatives aimed at enhancing urban mobility and transportation efficiency. This includes exploring partnerships with smart city initiatives, integrating real-time traffic management capabilities, and scaling the system to accommodate growing urban populations and technological advancements.

Overall, the Toll Management System represents a promising step towards modernizing transportation infrastructure and improving the overall commuting experience. By embracing innovation and collaboration, we can continue to drive progress in toll management practices and contribute to building smarter, more sustainable cities for the future.

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IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 13, Issue 4, April 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.317

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.1304050 |

Intellisense Toll Management System: Automatic Vehicle Number Plate Recognition for Identity Based Transactions

Abin Chacko, Karan S, Mohammed Junaid, Phaneendra M V, Pushpalatha H P

UG Students, Dept. of ECE, NIEIT, Mysuru, Karnataka, India

Assistant professor, Dept. of ECE, NIEIT, Mysuru, Karnataka, India

ABSTRACT: Toll collection booths represent some of the busiest spots across India, where vehicles consume significant amounts of fuel and travellers endure prolonged waiting times as they queue up behind others to pay tolls. This often results in traffic congestion and a notable loss of productivity. The proposed project Automatic Vehicle Number Plate Recognition for Identity Based Transactions, harnesses cutting-edge technologies like microcontrollers, sensors, and advanced image processing algorithms. This innovative system is designed to seamlessly recognize license plate numbers and streamline the toll collection process by recognizing the vehicle's owner and sending the Toll bill to his/her email id. By automating these tasks, the ANPR system effectively alleviates traffic congestion and enhances the efficiency of toll collection operations. With its capacity for scalability and expansion, this system holds immense potential for widespread adoption and further development.

KEYWORDS: ANPR, Toll collection, Google drive API, OpenCV, tesseract-OCR Node-mcu, esp32 cam, ultrasonic sensor.

I.INTRODUCTION

The length of national highways under toll across India amounted to nearly 30 thousand kilometres in financial year 2020. In an era marked by technological advancements, the optimization of transportation systems has become a crucial Endeavor. One key aspect of this optimization is the efficient collection of tolls on highways and expressways. Traditional toll collection methods often lead to traffic congestion and delays, which can result in decreased productivity and increased fuel consumption. FASTag has helped save 70,000 crore ($8.4 billion) in wasted fuel expenses in India, according to Road Transport and Highways Minister Nitin Gadkari. What if this system too can be optimized further by reducing the waiting time such that vehicles are allowed to move without stopping at the toll plazas. To address these challenges, this paper proposes a system that aims to introduce a solution that leverages image processing techniques to streamline the toll collection process. At the heart of this project is the implementation of License Plate Recognition (LPR) systems. These systems utilize sophisticated image processing algorithms to accurately detect and identify vehicle license plates as they approach toll booths. The project provides a reliable means to automate the collection of tolls, minimizing human intervention and reducing the potential for errors in the process. Moreover, the project will employ smart toll collection methods, ensuring a seamless experience for commuters. This project initiative not only promises to alleviate traffic congestion but reduces the fuel consumption too. The Automatic Number Plate Recognition (ANPR) system represents a pioneering solution in the realm of intelligent transportation systems, aiming to revolutionize the management of vehicular traffic and toll collection processes. In today's increasingly congested roadways, the need for efficient and accurate methods of identifying vehicles and processing their information has become paramount. The ANPR system, leveraging advanced technologies such as microcontrollers, sensors, and image processing algorithms, seeks to address this need by automating the identification and processing of license plate information with unparalleled efficiency and accuracy.

At the heart of the ANPR system lies the NodeMCU microcontroller, serving as the central processing unit orchestrating communication between various components. This includes an ultrasonic sensor tasked with detecting approaching vehicles and triggering image capture by the ESP32 camera module. The captured images of vehicle license plates are sent to a data processing server which is then subjected to rigorous image processing using OpenCV and Optical Character Recognition (OCR) algorithms from Tesseract OCR. Through this process, license plate numbers are accurately extracted from the captured images. The data collected by the ANPR system, comprising license plate

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| DOI:10.15662/IJAREEIE.2024.1304050 |

numbers and relevant vehicle information, is used to identify the vehicle owners email address to which the generated toll bill is sent. This centralized approach to data management facilitates efficient analysis and utilization of the captured information, empowering authorities with valuable insights for traffic management, toll collection, and vehicle tracking purposes.

II. SYSTEM MODEL AND ASSUMPTIONS

This paper presents an innovative approach to automate toll collection processes utilizing advanced technologies including ESP32-CAM, Ultrasonic sensor, NodeMCU, OpenCV, Pytesseract, and Google Drive API. The proposed system aims to enhance efficiency, accuracy, and transparency in toll gate operations by automating vehicle detection, number plate recognition, and billing processes. The system integrates real-time image acquisition, cloud storage, server-side image processing, and OCR techniques to achieve seamless toll collection. Experimental results demonstrate the effectiveness of the proposed solution in improving toll gate operations, reducing manual. Toll collection at transportation facilities is a critical aspect of modern infrastructure management. Traditional toll collection methods often involve manual processes, leading to inefficiencies, errors, and delays. To address these challenges, this paper proposes an automated toll collection system leveraging cutting-edge technologies to streamline toll gate operations.
System Architecture:
The proposed system comprises several key components:
ESP32-CAM: Responsible for capturing real-time images of approaching vehicles.
Ultrasonic sensor and NodeMCU: Detects vehicle presence and triggers image capture.
Google Drive API: Facilitates seamless upload of captured images to a designated Google Drive folder for centralized storage.
Server environment equipped with OpenCV and Pytesseract: Performs image processing and optical character recognition (OCR) for number plate recognition.
Billing system: Generates toll bills based on extracted number plate information and predefined criteria.
Implementation:
Vehicle Detection & Imaging: The Ultrasonic sensor integrated with NodeMCU detects approaching vehicles and signals the ESP32-CAM to capture images in real-time.
Cloud Integration: Captured images are uploaded to a designated Google Drive folder using the Google Drive API, ensuring centralized storage and easy access to data.
Server-Side Operations: The server environment equipped with OpenCV and Pytesseract processes captured images, performs contour detection algorithms to isolate number plates, and utilizes Pytesseract OCR for accurate extraction of number plate information.
Billing System: Integrated functionalities for generating toll bills with date timestamps and calculated amounts based on predefined criteria ensure accurate toll collection.

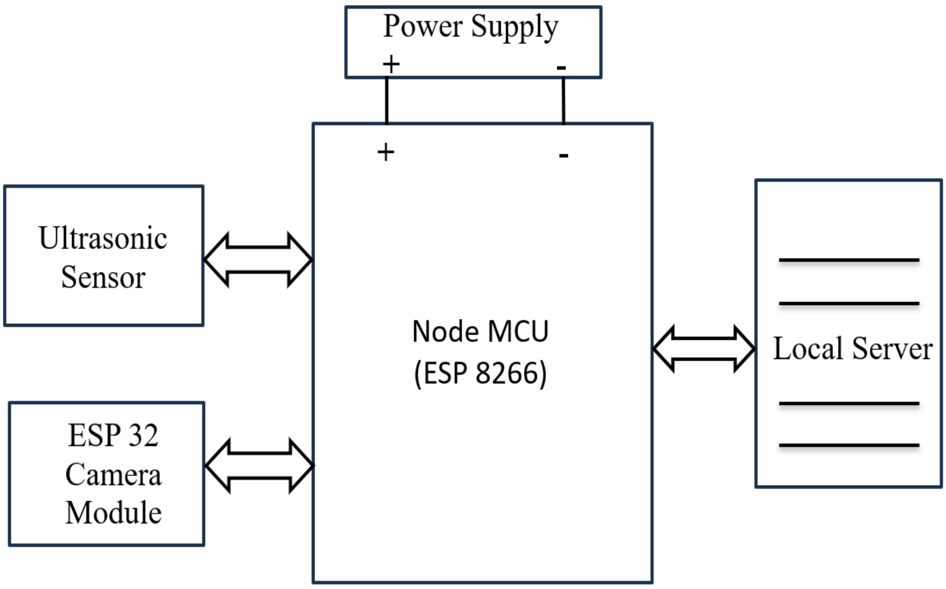

Fig. 1 System Model

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.1304050 |

III.METHODOLOGY

The suggested approach for recognizing number plate using automatic number plate recognition and toll collection includes the following components:

System Components and Technologies: The ANPR project utilizes a combination of hardware and software components to achieve its objectives. The hardware components include the NodeMCU microcontroller, ultrasonic sensor (HC-SR04), and ESP32 camera module. Software tools such as Arduino IDE for programming the microcontroller, OpenCV for image processing, and Tesseract OCR for optical character recognition are employed. These components and technologies are carefully selected to ensure compatibility, functionality, and performance in the ANPR system.

ANPR System Architecture: The ANPR system is designed to automate the process of identifying and processing license plate information from vehicles. The system architecture encompasses the flow of data and interactions between the hardware components, image processing algorithms, and data transmission mechanisms. This architecture is conceptualized to optimize efficiency, accuracy, and reliability in license plate recognition and data processing.

Data Collection and Preprocessing: The first step in the methodology involves collecting a dataset of images containing vehicle license plates. These images are captured by the ESP32 camera module upon detection of approaching vehicles by the ultrasonic sensor. The captured images are sent to a server in which the image undergoes preprocessing techniques, including noise reduction, image enhancement, and resolution adjustment, to prepare them for further analysis.

Image Processing and License Plate Recognition: The preprocessed images are subjected to image processing algorithms implemented using OpenCV. These algorithms extract license plate regions from the images and enhance the clarity of the text characters. Subsequently, optical character recognition (OCR) techniques from Tesseract OCR are applied to accurately identify and extract the license plate numbers from the images.

Data storage: Once the license plat numbers are extracted. The server stores the captured license text in a database.

Toll Bill generation: The extracted text from the number plate is used to identify the owner and their email address to which the bill amount of the toll along with UPI QR code (to which the payment is to be made) is sent

The user can view and download the bill pdf and pay the bill at his comfort within the specified period of time. The users can make use of QR code to pay the bill seamlessly through UPI.

Integration with External Systems: In the final phase of the methodology, the ANPR system is integrated with external systems or platforms to enhance its functionality and interoperability. This integration may involve connecting the ANPR system with existing traffic management infrastructure, law enforcement databases, or smart city initiatives to leverage additional data sources and enhance overall system capabilities.

IV.SURVEY DESCRIPTION

Jin Yeong Tan, Pin Jern Ker, Dineis Mani, and Puvanesan Arumugam's "GPS-based highway toll collection system: Novel design and operation" developed a GPS-based highway toll collection system using Raspberry Pi 2 as the microcontroller. The system utilized GPS coordinates to track vehicles and incurring toll fees at specific points. Additional electronic modules included a GPS module, LCD module, speaker, wireless Wi-Fi router modem, and wireless Wi-Fi adapter. The system aimed to provide motorists with a smooth travel experience and eliminate the need for expensive toll booths. The authors also implemented an automatic delay time adjustment system to reduce power consumption without compromising accuracy. Furthermore, the system featured internet and GPS connection availability detection to enhance reliability. SQL databases were established to store toll destination information and user travel history , . The authors highlighted the importance of a structured approach to developing a GPS-based toll collection system, emphasizing the ease of commercialization with a microcontroller featuring 3G and GPS connectivity .In terms of system configuration, Raspberry Pi 2 was chosen as the microcontroller due to its processing speed and communication capabilities. The system ran on Raspbian OS, which was optimized for Raspberry Pi hardware. The authors flashed the Raspbian image into a 32 GB micro-SD card for system operation. Overall, the developed GPS-based highway toll collection system aimed to streamline toll fee payment processes, enhance travel efficiency, and reduce congestion on highways.

Shridevi Soma's "an intelligent toll-gate system for toll collection based on distance and pollution control using internet of things" presents an innovative Intelligent Toll-Gate System designed to revolutionize toll collection processes by incorporating advanced technologies such as RFID and Internet of Things (IoT). This system aims to tackle two major

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challenges faced at toll highways: congestion and pollution. By automating toll collection through RFID tags and prepaid accounts linked to vehicles, the system streamlines the payment process and reduces waiting times at toll booths. Furthermore, the integration of GPS technology enables the calculation of toll fees based on the distance traveled by each vehicle, ensuring a fair and accurate billing system. In addition to toll collection, the system also focuses on pollution control by implementing wireless sensor networks for monitoring vehicle emissions. A smoke sensor installed in vehicles detects harmful emissions, and the data is transmitted to a central monitoring station at the toll booth. If emission levels exceed predefined thresholds, alerts are sent to vehicle owners via GSM technology, prompting them to take necessary actions to reduce emissions. This proactive approach not only promotes environmental sustainability but also holds vehicle owners accountable for their emissions, thereby encouraging compliance with emission regulations.

Dr. Rajeev Kumar Chauhan and Dr. Kalpana Chauhan’s "Intelligent Toll Collection System for Moving Vehicles in India" discusses the development of an Intelligent Toll Collection System for Moving Vehicles in India by Dr. Rajeev Kumar Chauhan and Dr. Kalpana Chauhan. The system aims to automate toll collection processes at toll plazas by utilizing automatic license plate recognition (ALPR) technology. This approach involves capturing images of moving vehicles, extracting license plate information, and recognizing the license plates. The use of LABVIEW software, along with morphological filters and optical character readers, enables efficient processing of captured images for accurate license plate identification. The proposed system architecture includes components such as a vehicle detector, camera, MyRIO hardware module, computer, and vehicle barrier system. By integrating ALPR technology with LABVIEW and MyRIO, the system can automatically identify vehicles, process transactions, and enforce toll collection regulations. The implementation of morphological filters and optical character readers enhances the system's ability to extract license plate information in real-time, contributing to faster and more accurate toll collection processes. Furthermore, the system incorporates a database created using Microsoft SQL Server Management Studio to store and manage information related to vehicle owners, their unique identification numbers, mobile numbers, and linked bank account balances. This database integration allows for testing the performance of the toll collection system with a comprehensive dataset of vehicles. The results demonstrate a significant reduction in vehicle waiting times, queue lengths, fuel wastage, and pollution emissions at toll plazas, highlighting the system's effectiveness in improving overall operational efficiency.

Sheenam Naaz, Suraiya Parveen, and Jawed Ahmed’s "An Artificial Intelligence Based Toll Collection System" presents a comprehensive overview of an innovative toll collection system that leverages artificial intelligence (AI) technology to enhance efficiency and reduce congestion at toll gates. The system incorporates radio frequency identification (RFID) technology to automate the toll collection process, addressing the challenges faced by traditional manual ticketing systems. By utilizing RFID tags that store vehicle and account details electronically, the system enables seamless transmission of data to the main office in real-time, eliminating the need for vehicles to stop at toll gates and significantly reducing manpower requirements. Furthermore, the paper highlights the advantages of RFID tags over traditional paper-based ticketing systems, emphasizing their reusability and convenience. The implementation of an AI-based toll collection system not only streamlines the toll payment process for users but also contributes to a more efficient and organized toll management system. The integration of an infrared scanner at toll stations ensures accurate validation of incoming and outgoing vehicles, while the RFID scanner facilitates data retrieval from vehicle tags for toll processing. This approach creates a rapid and reliable ecosystem for automated toll collection, enhancing the overall user experience and operational efficiency. Additionally, the authors emphasize the role of AI in revolutionizing toll collection systems and enhancing transportation infrastructure. The paper underscores the significance of adopting innovative technologies like RFID and AI to modernize toll operations, reduce manual interventions, and optimize resource utilization. By presenting a detailed analysis of the proposed RFID-based toll collection system and its benefits, the authors advocate for the adoption of AI-driven solutions to address the evolving needs of toll management and urban mobility. Overall, the PDF provides valuable insights into the potential of AI technology in transforming toll collection processes and improving the overall efficiency of transportation systems.

V. FUTURE SCOPE AND DISCUSSION

1. Advanced Image Processing Techniques: The future potential of the ANPR system lies in the exploration of advanced image processing techniques to enhance its accuracy and efficiency. Research and development efforts could focus on incorporating deep learning algorithms and convolutional neural networks (CNNs) to improve license plate recognition capabilities, particularly in challenging lighting and weather conditions.

2. Cloud-Based Solutions: The scalability and flexibility of the ANPR system could be further enhanced through the adoption of cloud-based solutions. By leveraging cloud computing resources, the system can handle large volumes of data processing and storage, enabling seamless integration with existing traffic management infrastructure and facilitating real-time decision-making.
3. Enhanced Security Measures: As the ANPR system plays a critical role in traffic management and law enforcement, future developments should prioritize enhancing security measures to prevent unauthorized access and tampering of data. Implementation of robust encryption protocols, secure data transmission mechanisms, and intrusion detection systems can fortify the system's defences against cyber threats and ensure data integrity.
4. Integration with Smart Cities Initiatives: The ANPR system holds significant potential for integration with smart cities initiatives aimed at improving urban mobility and sustainability. By partnering with municipal authorities and urban planners, the system can contribute to the development of smarter, more efficient transportation networks, reducing traffic congestion and emissions while enhancing overall quality of life for residents.
5. Continuous Improvement through Feedback Mechanisms: To ensure the effectiveness and relevance of the ANPR system in real-world scenarios, it is essential to establish feedback mechanisms for gathering user feedback and performance metrics. By soliciting input from stakeholders, including traffic management authorities, law enforcement agencies, and transportation providers, the system can undergo iterative improvements to address evolving needs and challenges.
6. Integration with IoT Platforms: Future iterations of the ANPR system could explore integration with Internet of Things (IoT) to enhance real-time monitoring and management capabilities. By integrating with IoT devices such as traffic cameras and sensors, this system can gather contextual data and improve its accuracy in identifying and processing license plate information

VI. RESULT AND DISCUSSION

The result of the project is a fully functional automated toll collection system that significantly enhances the efficiency, accuracy, and transparency of toll gate operations. By automating vehicle detection, image capture, number plate recognition, and billing processes, the system improves throughput at toll gates, reduces errors in toll collection, and enhances the overall user experience for drivers. Leveraging advanced technologies such as OpenCV and Pytesseract ensures accurate number plate recognition, while the integration of Google Drive API facilitates centralized storage and transparent record-keeping of toll transactions. With reduced manual intervention and streamlined procedures, the system offers cost savings for transportation authorities and scalability to accommodate future growth in traffic volumes and toll gate expansions, ultimately modernizing and optimizing toll collection operations.

VII.CONCLUSION

The IntelliSense Toll Management System proposes a novel and intelligent approach to automate toll collection, leveraging image recognition and wireless communication technologies. This project demonstrates the feasibility of a system that utilizes an ESP32 Cam module triggered by an ultrasonic sensor to capture vehicle license plates. Subsequent image processing on a server, employing OpenCV and Tesseract OCR, extracts the license plate text. By referencing a database linking license plates to owner email addresses, the system can generate and send toll bills with UPI QR codes, enabling contactless payment. The proposed system offers several advantages over traditional toll collection methods. Automation of license plate recognition and toll bill generation significantly improves efficiency by reducing manual intervention and processing time. Additionally, image recognition minimizes human error associated with manual license plate reading, leading to enhanced accuracy. This system also offers convenience for users by allowing remote toll payment within a specified timeframe, increasing flexibility. Finally, faster processing has the potential to reduce congestion at toll booths, improving overall traffic flow.

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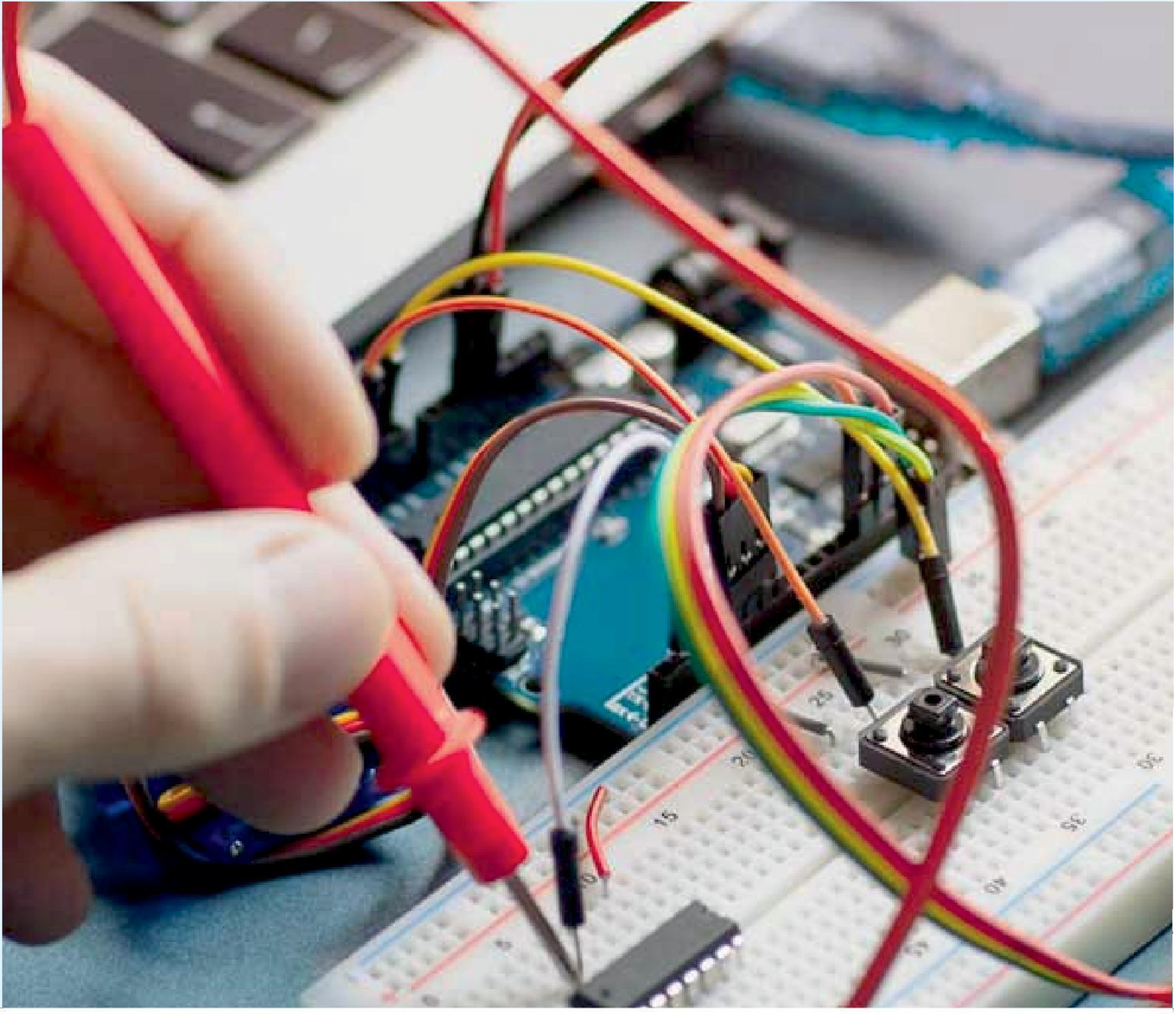

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