Automated Toll Collection System Using ML-Based VNR For Smart Cities

Mahbub Mokaddes Akash | Abrar Ur Alam | Md. Fazle Rabby Foysal | Nafis Fuad

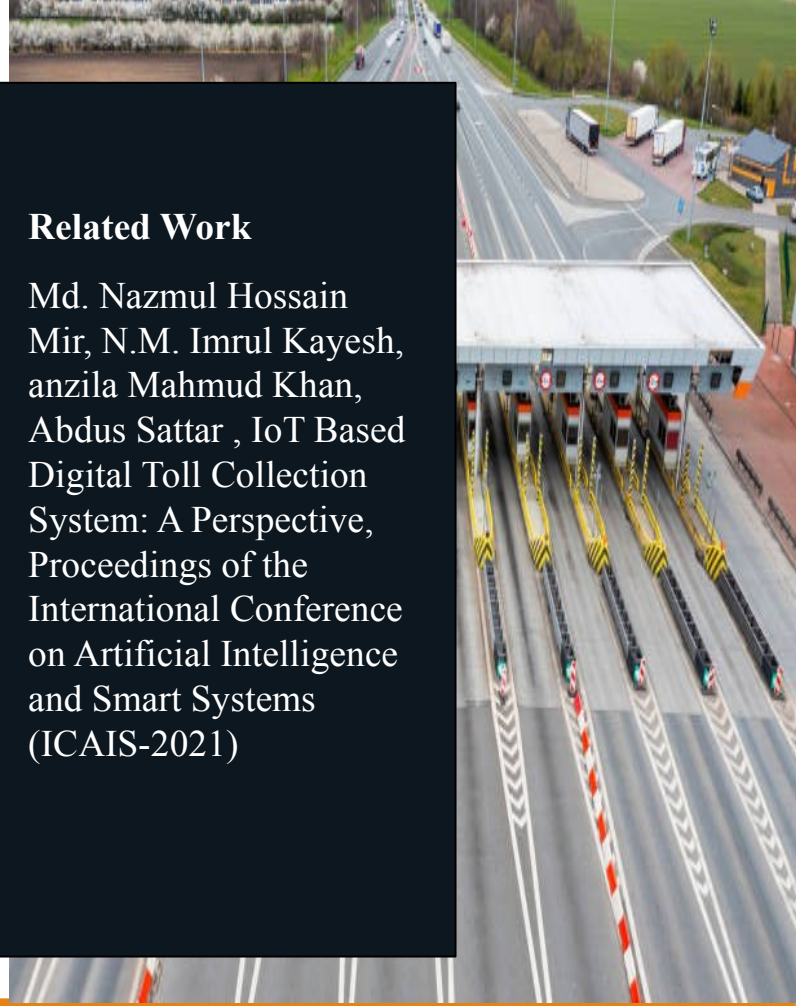
Motivation:

We need to modernize toll collection systems and overcome the shortcomings of traditional methods. By leveraging cutting-edge image processing technology, the project aims to streamline toll collection processes, enhance accuracy, and reduce congestion at toll checkpoints.

The implementation of automated systems promises cost-effectiveness and efficient enforcement measures to minimize revenue loss from toll evasion. This project seeks to embrace technological advancements to create a seamless and reliable toll collection experience for motorists while ensuring the integrity of toll revenue management.

Brief about the topic

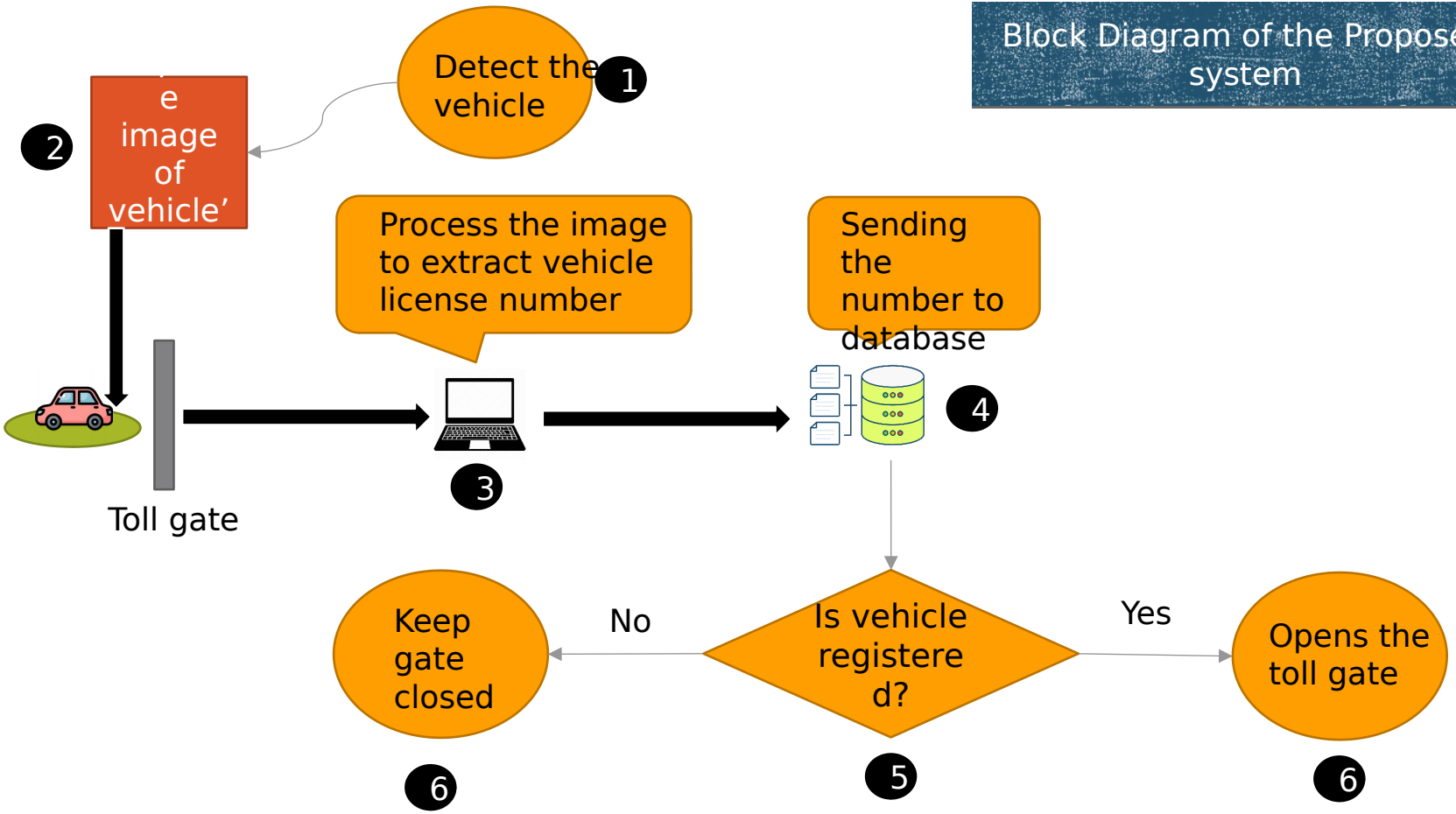
Our **Automatic Toll Collection System** streamlines toll payments in metropolitan cities, alleviating congestion and **enhancing traffic flow**. Leveraging cutting-edge technology, the system **automatically detects vehicles**, **captures number plate images**, and employs **Optical Character Recognition (OCR)** for seamless toll processing. With hassle-free **e-wallet payments**, this system not only accelerates toll collection but also **provides comprehensive traffic monitoring** and database record-keeping for **user convenience**.



Related Work

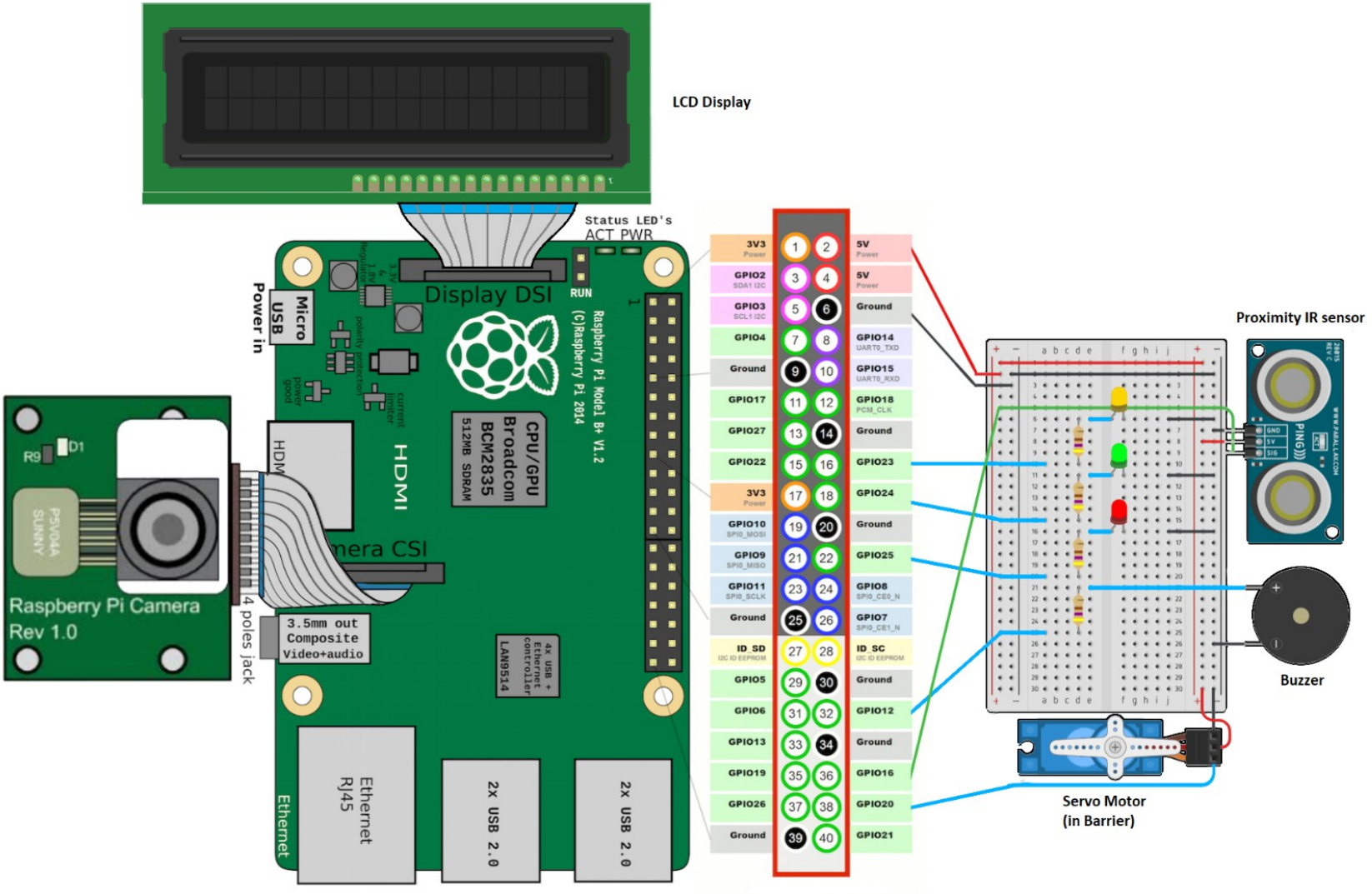
Md. Nazmul Hossain Mir, N.M. Imrul Kayesh, anzila Mahmud Khan, Abdus Sattar , IoT Based Digital Toll Collection System: A Perspective, Proceedings of the International Conference on Artificial Intelligence and Smart Systems (ICAIS-2021)

Block Diagram of the Proposed system

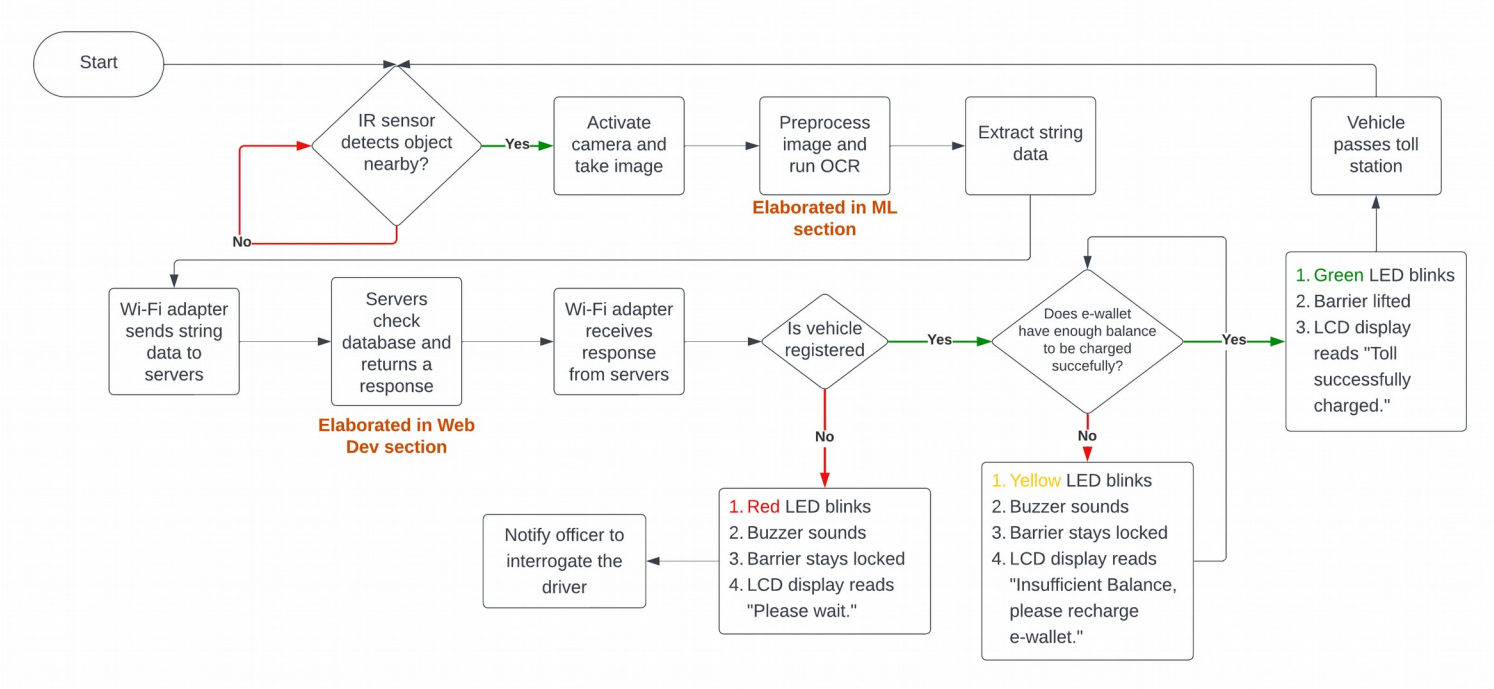


Microcomputer

METHODOLOGY


LCD Display
Status LED's
ACT PWR
RUN
Display DSI
Micro USB
Power in
HDMI
CPU/GPU
Broadcom
BCM2835
512MB SDRAM
Raspberry Pi Model B+ V1.2
(C)Raspberry Pi 2014
Raspberry Pi Camera
Rev 1.0
R9
D1
4 poles jack
3.5mm out
Composite
Video+audio
4x USB +
Ethernet
controller
LAN9514
Ethernet
RJ45
2x USB 2.0
2x USB 2.0
3V3 Power
5V Power
GPIO2 SDA1 I2C
5V Power
GPIO3 SCL1 I2C
Ground
GPIO4
GPIO14 UART0_TXD
Ground
GPIO15 UART0_RXD
GPIO17
GPIO18 PCM_CLK
GPIO27
Ground
GPIO22
GPIO23
3V3 Power
GPIO24
GPIO10 SPI0_MOSI
Ground
GPIO9 SPI0_MISO
GPIO25
GPIO11 SPI0_SCLK
GPIO8 SPI0_CE0_N
Ground
GPIO7 SPI0_CE1_N
ID_SD I2C ID EEPROM
ID_SC I2C ID EEPROM
GPIO5
Ground
GPIO6
GPIO12
GPIO13
Ground
GPIO19
GPIO16
GPIO26
GPIO20
Ground
GPIO21
Proximity IR sensor
Buzzer
Servo Motor
(in Barrier)

Flowchart | Microcomputer



Raspberry Pi 4 model B

The microcomputer we have chosen to use is the **Raspberry Pi 4 model B**

- 2GB RAM
- 1.5GHz 64-bit quad-core CPU
- Sale price ৳5185
- Sufficient for running image processor and OCR quickly

RP 4 uses Python, so we'll have to code the image preprocessor and OCR model in Python language

- For the image processor we'll use the **OpenCV** library
- For OCR training we'll use **Tensorflow** library

How RPi 4 handles I/O

For input and output to the microcomputer, we use a few of the 40 **GPIO** pins that RPi 4 comes built-in with

- GPIO stands for "**G**eneral **P**urpose **I**nput **O**utput"
- This means that these pins can be used for **both** input or output
- we can change their modes to input or output using Python code.

To clarify the concept, let's look at an examples of:

- receiving input signals from the IR proximity sensor
- sending output signals to the green LED

```
import RPi.GPIO as IO  # Import Raspberry Pi's library for GPIO pins

IO.setwarnings(False)  # Ignores unwanted GPIO pin warnings
IO.setmode(IO.BCM)     # Sets the pin numbering mode to BCM (Broadcom SOC channel numbering).

IO.setup(16,IO.IN)     # GPIO 16 set to input mode (-> IR sensor as input)


while 1:


    if(IO.input(16)==True):

        print("No object detected near IR sensor. The vehicle has left the station.")
        # Insert code that activates servo motor
        # Which will put the barrier down, so next vehicle can't pass


    else:

        print("An object is nearby. The next vehicle has arrived at the station")
        # Insert code that activates camera module
        # Which will take a picture of the vehicle's backside, for OCR process
```

```
import RPi.GPIO as IO  # Import Raspberry Pi's library for GPIO pins

IO.setwarnings(False)  # Ignores unwanted GPIO pin warnings
IO.setmode(IO.BCM)     # Sets the pin numbering mode to BCM (Broadcom SOC channel numbering).

IO.setup(24,IO.OUT)    # GPIO 24 set to output mode (-> Green LED as output)

hasPayed = fetchValidation();            # user-defined function which returns bool value based
                  # on database server's validation / invalidation

    if(hasPayed):

        print("Toll successfully charged. Notifying with green LED.")
        IO.output(24,True)          # Sets GPIO 24 to digital high signal(3.3V)
                        # 3.3V turns on green LED

        # Insert code that activates servo motor
        # Which will pull barrier up, so vehicle can pass station
        # Insert code that will display "Toll Successfully Charged" message on LCD Display
```

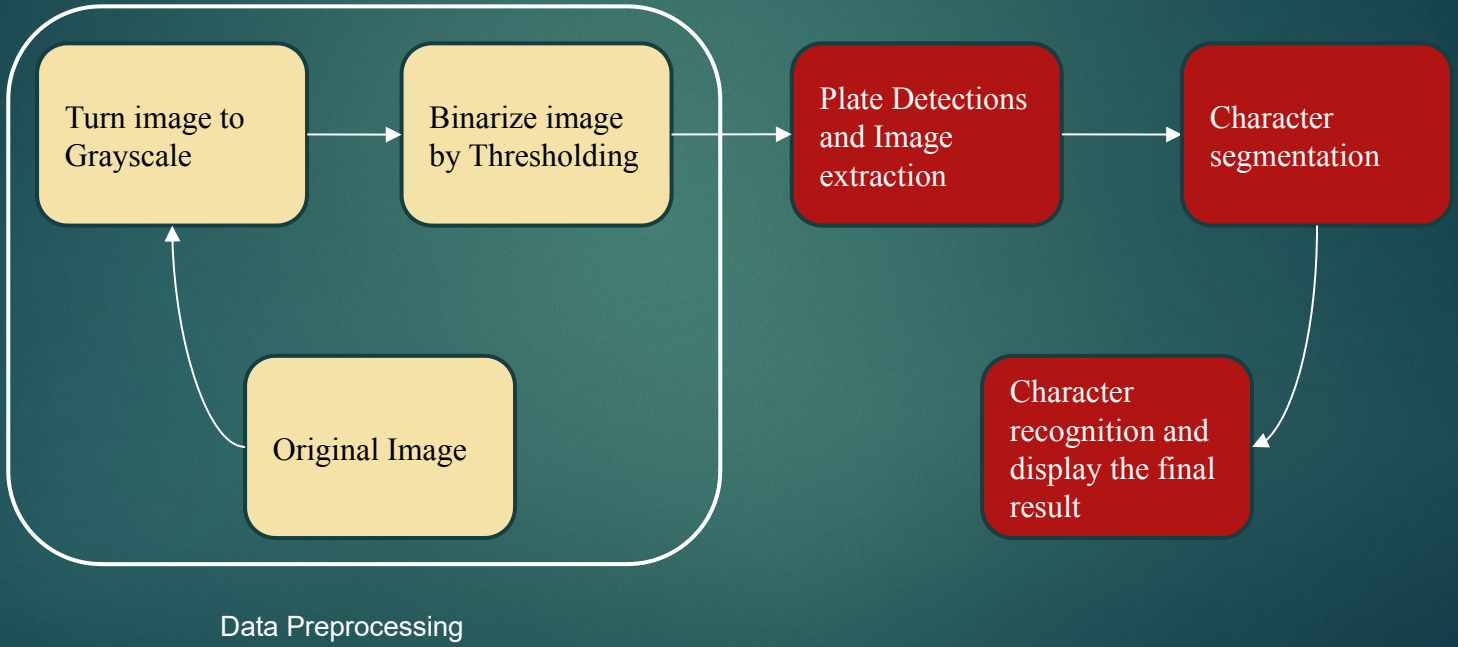
OCR

Machine Learning Model

Steps

1. Image Preprocessing
2. Plate Detections and Image extraction
3. Character segmentation
4. Character recognition and string output

Flow Diagram of Image Processing



Brief Description :

Initially, we have the picture that was captured by the camera module. Images are then **preprocessed** to grayscale and binaralized via thresholding. This is typically done in order to separate "object" or foreground pixels from background pixels to aid in the next steps. To find the number plate location we will use **edge detection technique**. Then we proceed to optical character recognition / **OCR** and also we will be using some library to maintain the work flow and ensure getting the high accuracy score detecting the number plate.

This starts with **character segmentation** which is an operation that seeks to decompose an image of a sequence of characters into sub images of individual symbols. It is one of the decision processes in a system for OCR. Then each character is recognized one by one. The characters are then concatenated into a string.

Dataset **Collection** Features

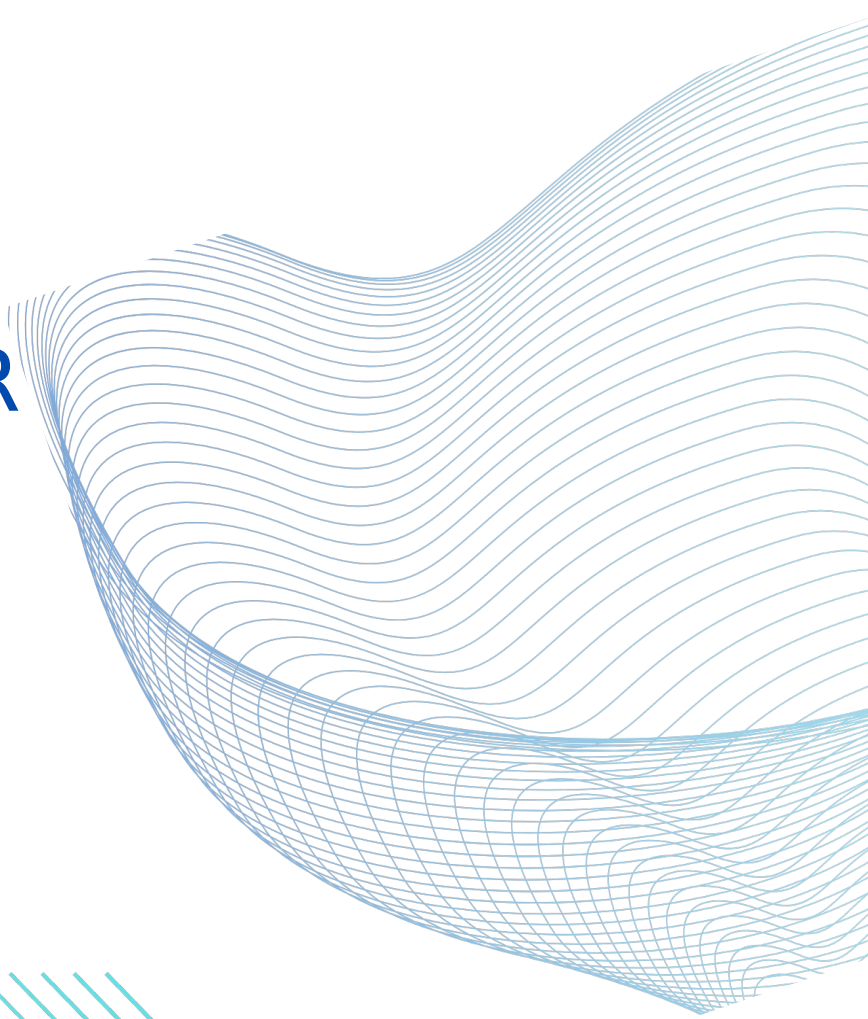
Logo	Number plate Edges	Character Segments	Characters		
			Alphabets	Numbers	Symbols
...	...	...	...	...	...

Dataset **Sample**

Logo	Number plate edges	Character Segments
		
“TOYOTA”		

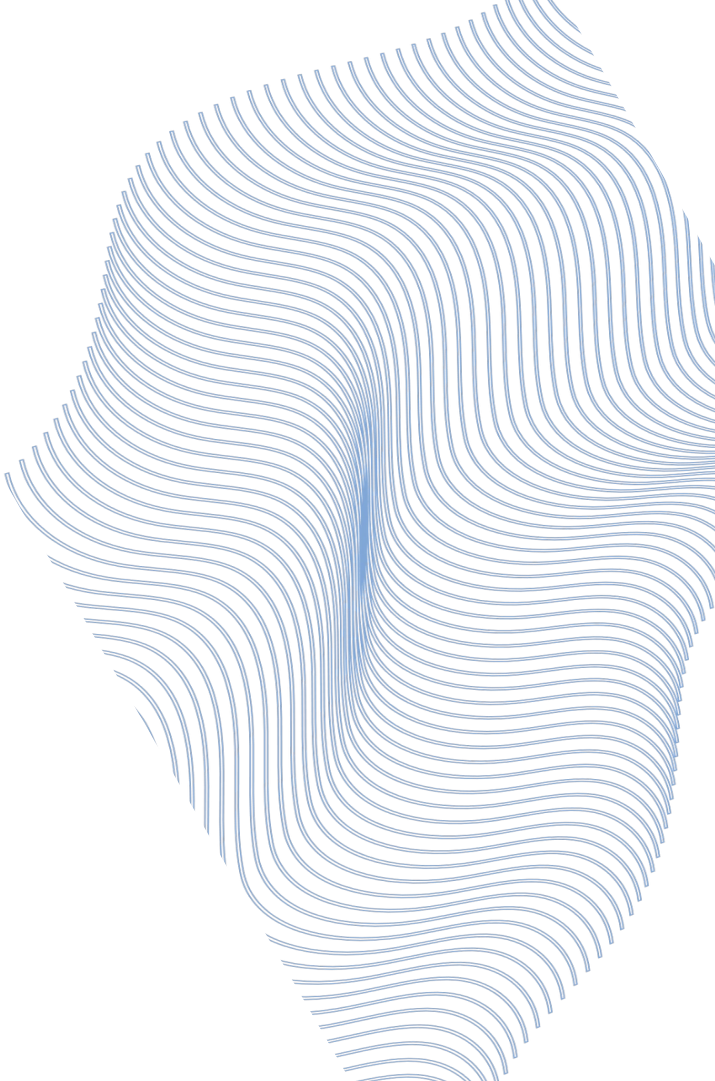
Alphabets	Numbers	Symbols
		None in example
‘G’	‘3’	None in example

WEBSITE AND SERVER INTERFACING

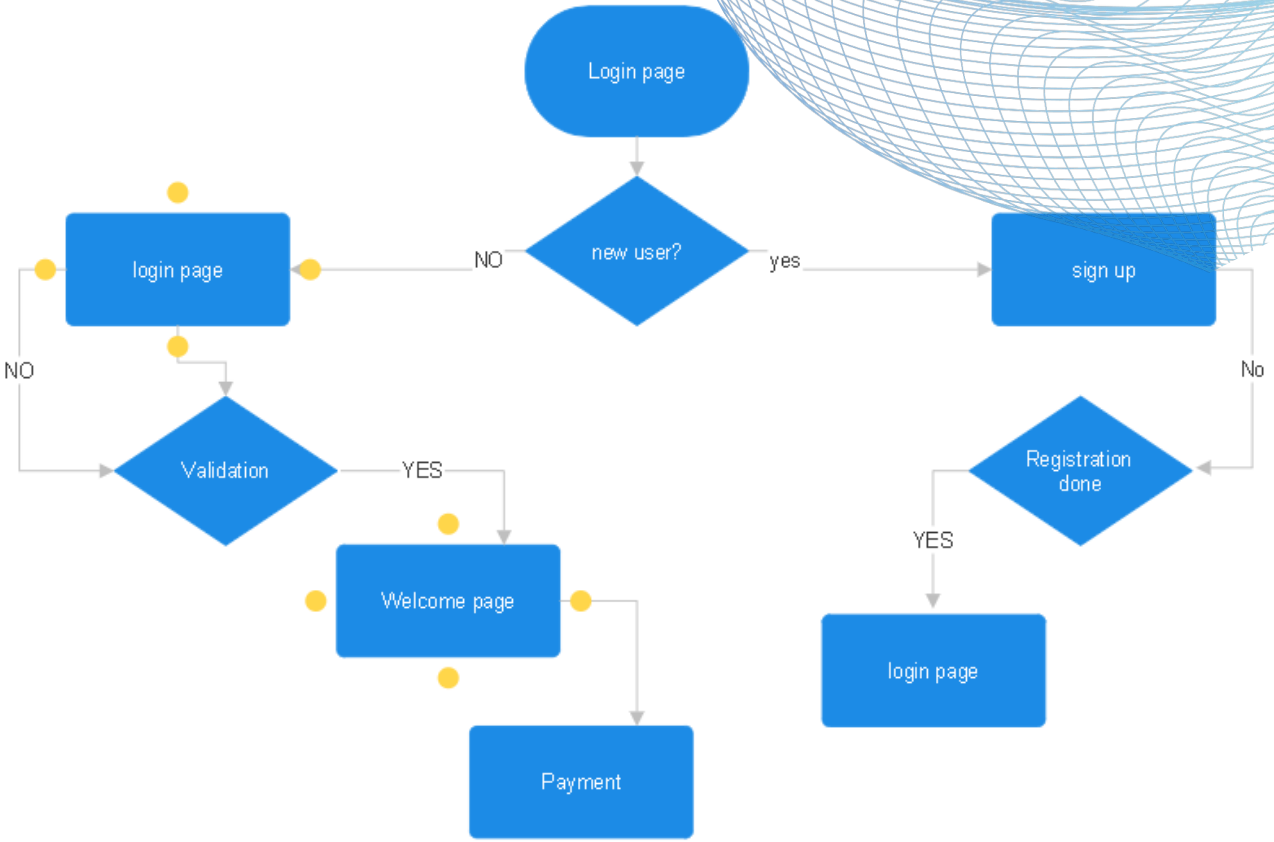


PURPOSE

- New users or numberplates can sign up using this website. Details such as username, email id, and password are stored in the main database. Users can log in with their password and username and enter their information as first name, last name, address, mobile no, plate number, and vehicle type. All of this information are stored in the central database and can be monitored by the admin



FLOWCHART


Login page
new user?
NO
yes
login page
sign up
NO
No
Validation
YES
Registration done
YES
Welcome page
login page
Payment

TOOLS AND TECHNOLOGIES

Frontend:

HTML: To create the basic structure of the frontend.

CSS: For styling the appearance of the web pages (fonts, colors, etc.).

JavaScript: Handles interactivity to the website (form validation, dynamic elements).

Back-end:

Server-side language (Python/Java, Node.js): Processes user interactions and communicates with the database.

Web framework (Django): Provides a foundation for building the website efficiently.

Database (MySQL): Stores user data and information.

Additional tools:

Web server (Apache): Delivers web pages and resources to users.

Version control system (Git): Tracks code changes and enables collaboration.

THE PROCESS

1

Process 01

If the vehicle is registered then the user has to login to a page

2

Process 02

The captured vehicle number is checked in the main database and the information is than extracted and the amount of toll is sent to the user phone

3

Process 03

If the numberplate is recognized then the output will be shown and if not recognized then the system will display as numberplate not registered

GANTT CHART


TASK / PROCESS
MARCH Week1
MARCH Week2
MARCH Week3
APRIL Week4
APRIL Week5
APRIL Week6
APRIL Week7
MAY Week8
MAY Week9
MAY Week10
Model processing
Model testing
Hardware setup
Hardware testing
Building frontend
Building Backend
integrating model with the website
Deployment
Finetunning
Writing paper

Contribution:

Mahbub Mokaddes Akash- 2031338642:

- Training OCR-related machine learning models
- Implementing Vehicle Number Recognition using OCR

Md. Fazle Rabby Foysal- 2211582042:

- Front-end, Backend and API (design + implementation)
- Integrating database, hardware and OCR technology

Abrar Ur Alam- 2211447042:

- Microcomputer programming
- Peripheral devices setup

Nafis Raihan – 2011809642:

- MySQL database development
- model deployment and refinement.

All members will help each other upon facing difficulties.

Novelty:

- ***1.Corruption in money collection at toll booths: -*** The existing manual toll collection system is susceptible to corruption due to the potential for cashiers to pocket collected fees. Our automated system eliminates this risk by facilitating secure and transparent cashless transactions.

- ***2.Increasing rate of stolen vehicle: -*** The current tollbooth system lacks the ability to identify stolen vehicles, contributing to their proliferation. Our system leverages information from databases to effectively detect stolen vehicles, enabling prompt notification of authorities and appropriate action.

- ***3. Vehicle congestion at toll booths: -*** The current manual system at tollbooths, involving receipt issuance and cash transactions, leads to lengthy queues and traffic congestion. Our IoT-based system automates the process, significantly reducing waiting times and alleviating congestion.

- ***4. Toll deduction is time consuming: -*** While the existing system relies on a time-consuming manual cash payment process, our fully automated digital system streamlines toll collection for increased efficiency.

- ***5. Manual system and Wastage of paper: -*** The current manual tolling system, reliant on cash and paper receipts, creates inefficiencies and unnecessary paper waste. Our automated system eliminates this waste and streamlines the process with a cashless, e-wallet-based system, significantly improving collection speed and efficiency.

- ***6. Handling cash and carrying credit cards: -*** The existing toll system requires manual cash or credit card payments, inconveniencing users by requiring them to carry physical means of payment. Our fully digital, automated system eliminates this inconvenience by offering cashless payment options.

- ***7. Fuel consumption: -*** The current tollbooth system often results in vehicle congestion and idling engines, leading to significant fuel waste. Our IoT-based system's swift toll collection process minimizes wait times and queuing, significantly reducing fuel consumption and its associated environmental impact.

References:

- IOT-and-Machine-Learning-based-Automatic-Toll-Collection-System.pdf (researchgate.net)
- IoT Based Digital Toll Collection System: A Perspective | IEEE Conference Publication | IEEE Xplore
- Automated Toll Tax Collection System using Cloud Database | IEEE Conference Publication | IEEE Xplore
- IOT-BASED-TOLL-COLLECTION-SYSTEM-USING-IMAGE-PROCESSING.pdf (researchgate.net)
- NUMBER_PLATE_RECOGNITION_USING_OCR_TECHNIQUE-libre.pdf (d1wqtxts1xzle7.cloudfront.net)
- Automated Text Extraction from Images using OCR System | IEEE Conference Publication | IEEE Xplore
- AN-EFFICIENT-METHOD-OF-VEHICLE-NUMBER-PLATE-DETECTION-AND-RECOGNITION.pdf (researchgate.net)
- document (psu.edu)

Additional References

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Etqad Khan, Dipesh Garg2, Rajeev Tiwari and Shuchi Upadhyay , Automated Toll Tax Collection System using Cloud Database, 978-1-5090-6785-5/18/$31.00 © 2018 by IEEE

THANK YOU EVERYONE

ANY QUESTION?