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**COLLEGE OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING**

**BSc Electrical and Electronics Engineering**

**PROJECT TITLE:**

# AN AUTOMATED VEHICLE ACCESS MANAGEMENT AND BILLING SYSTEM FOR INSTITUTIONS

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*A Final Year Project submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the award of a Bachelor of Science Degree in Electrical and Electronics Engineering.*

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## DECLARATION

This project is our original work, except where due acknowledgement is made in the text, and to the best of my knowledge has not been previously submitted to Jomo Kenyatta University of Agriculture and Technology or any other institution for the Award of a degree or diploma.

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**SUPERVISOR CONFIRMATION:**

This project proposal has been submitted to the Department of Electrical and Electronic Engineering, Jomo Kenyatta University of Agriculture and Technology, with my approval as the University supervisor:

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**ABSTRACT**

In the modern world, security has become a major concern for institutions. The level of security needs might differ across the institutions but the main need common to all of them is effective security management. Carrying out a quick and effective visitor registration and access control management at their building site entrance is a daily challenge for most of these establishments. Most of them use a manually maintained paper-based visitor log book to manage their visitor traffic which is a highly inefficient and outdated method. Often visitors who are in a hurry to get to where they are going will fill the visitor log books with illegible handwriting scribbles and omissions. It also presents a huge and tedious administrative challenge when there is a need to rely on man power staff to search and trace back historical record of all information pertaining to a visitor's visit since all the records are written manually in paper form.

Thus, with this as a major area of concern, this project deals with the development of a complete automated visitor and vehicle security management system. Details of vehicle's number plate, entering the premises will be captured into the system using an IP camera. Visitor's identification number will be scanned using a mobile application. The captured information will then be synchronized to a common database and provide proof if the visitor owns the vehicle and a report will be generated. This will ensure a quick and efficient guest enrollment experience without compromising on the safety and security of the premises. Depending on the timestamp generated from the report, the visitor will be billed through the developed mobile application.

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## LIST OF FIGURES

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ANPR | Automatic Number Plate Recognition |
| OCR | Optical Character Recognition |
| API | Application Programming Interface |
| CPU | Central Processing Unit |
| HTML | Hypertext Markup Language |
| OpenCV | Open Source Computer Vision |
| SQL | Sequential Query Language |
| STK | Software Tool Kit |
| MRZ | Machine Readable Zone |

# 1 CHAPTER ONE: INTRODUCTION

## 1.1 1.1 Background Information

Access control is an essential part of security systems. With access control, premises can effectively be kept safe by controlling the movement of people in and out of the premises.

An access control system can be broken down into three main elements:

- **Identification;** in order to prevent unauthorized access of the premises it is important to determine the identity of any individual entering the building.
- **Authentication;** after identification it is imperative to authenticate the identity thus ensuring that only the right people are granted access.
- **Authorization;** after successful authentication, the individual is granted access to the premises.

Access control is very important since it prevents the entry of unauthorized individuals thus enhancing the security of a building.

In urban areas access control is usually carried out by a sentry who is posted at the various entrances and exits of a building or compound. The duties of the sentry involve identifying the vehicle, manually taking details of the visitor and recording them in an occurrence book. This is highly inefficient. In this project, a system is developed that aims to automate the process of vehicle identification. This is achieved through automatic number plate recognition (ANPR).

ANPR is a mass surveillance method developed by the Police Scientific Development Branch in the UK in the 1970s with the aim of combating crime. ANPR uses image processing techniques in order to extract the vehicle number plate from a digital image [1]. An ANPR system generally consists of a camera, processor, software capable of performing optical character recognition

(OCR) to transform the image of the license plate into alphanumeric characters and a database to store the license plate details.

An ANPR system generally consists of four main parts namely image acquisition, number plate recognition, character segmentation and finally character recognition [2].

The first stage which is image acquisition involves capturing the plate number using a camera. The next stage is number plate recognition which involves resizing of the image into a suitable aspect ratio and converting it into grey scale. Afterwards, character segmentation takes place which involves partitioning the lines or words into individual characters. The final stage which is character recognition detects and recognizes the characters from the input image and converts them into alphanumeric characters.

In addition to identifying the vehicle, there is also a need to identify the driver of the vehicle. This will be done by developing a computer vision model to automatically detect the machine-readable zone (MRZ) on the back of a national Identification (ID) card. The MRZ encodes identifying information of a given citizen, including the ID number, country, name, nationality and date of birth.

The details from the number plate and the ID card will then be sent to a secure database. The administrator of the system will be able to monitor the whole system.

## 1.2 Problem Statement

With the rising number of vehicles locally, it is getting difficult to effectively manage the vehicles. There is a need to identify all the vehicles entering and leaving residences and public premises effectively. In most places, the ongoing vehicle entry registration process for visitors entering an institution involves a security guard having to confirm membership by checking for a membership sticker on the windscreen of the vehicle or by checking the driver's identification card. The security guard then has to record the vehicle details as well as entry or exit time manually into a visitor log book which is highly unproductive and outdated. Often visitor log books are filled with illegible handwriting scribbles and omissions by visitors who are typically in a rush for their appointment. As the visitor records are all manually written in physical paper format, it also poses a huge and tedious administrative challenge when there is a need to rely on man power staff to search and trace back historical record of all information pertaining to visitor's visit.

This system hopes to solve this problem by having an automatic number plate recognition system that allows easy visitor identification as well as a convenient means of data collection and data storage.

## 1.2 Project Justification

The main motivation for developing this project is to make the check in and check out processes into various premises as quick and efficient as possible. Examples of this premises include institutions such as schools, hospitals, residential estates amongst others. This project will save the time spent during check in as the process is now automated. Vehicles can automatically be allowed access in and out if they match against the database of number plates, without anyone having to perform time consuming manual checks

In addition to the above reason, the following are also part of the motivation for the project

**a) Security**

It helps in keeping people and infrastructure safe. This is because only authorized people can access the premises. It also discourages people from targeting the premises for terrorism, theft or any antisocial behavior as there are records of everyone who accessed the premises.

**b) Parking control**

It prevents unwarranted access by people who only want to use an institution's parking facilities without being authorized to do so.

**c) Vehicle count is tracked**

The number of vehicles in and out of the premises can be tracked. This means that the time-in and time-out for each vehicle is on record. This information can be used for billing.

## 1.4 OBJECTIVES

### 1.4.1 MAIN OBJECTIVE

The main objective is to design, implement and test a vehicle parking security and billing system.

### 1.4.2 SPECIFIC OBJECTIVES

a) To capture the number plate of a vehicle and design a system for converting the captured image into variable digits.

b) To design a database for keeping school employees' vehicle details and report generation.

c) To provide a user interface for the system administrator to control and monitor overall system.

d) To design a mobile application system that prompts visitors to scan their National Identification, thereafter, vehicle details are updated and payment is done during check out.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Automatic identification

Automatic identification is a process where a system identifies an object automatically, collects the data about the object and feeds the data into the computer system without any need for human involvement. The data may be captured by analyzing images, sounds or videos. The data is captured by a transducer which converts the image or sound into a digital file which is stored and later analyzed by the computer.

Data is normally entered into a computer by using a keyboard. However, in certain cases this may not be the most efficient way of data input. Automatic identification may serve as an alternative means of data entry in many cases. Various techniques for automatic identification include Optical character recognition, speech recognition, radio frequency, vision systems, magnetic stripe, bar codes, magnetic ink and optical mark reading.

### 2.1.1 Speech recognition systems

In speech recognition systems, spoken input from a predefined library of words are recognized. Other applications of speech recognition systems can be used to recognize the speaker rather than words for identification.

### 2.1.2 Radio frequency identification

Most commonly used for identification of cars in toll booths. Special equipment on the car emits a radio signal with information about the car. A receiver on the toll booth reads the information.

### 2.1.3 Vision systems

A camera is used to identify objects by their appearance.

### 2.1.4 Magnetic stripes

Most commonly used in credit cards to store information which can only be read by specially designed equipment.

### 2.1.5 Bar code

It consists of several dark lines which represent a binary code for an eleven-digit number, ten of which identify the particular product. These lines are read optically by a laser beam being focused on the bars. The reflected light is measured and analyzed by a computer.

### 2.1.6 Magnetic ink

Characters are usually written in stylized fonts specifically designed for reading in ink that contains finely ground magnetic particles. These characters are read by interpreting the wave form obtained when scanning the characters horizontally.

## 2.2 Automatic Number Plate Recognition

Automatic number plate recognition (ANPR) is a mass surveillance method that was first developed in 1976 with the aim of combating crime. ANPR is a process where vehicles are identified using their number plate or license plate. ANPR uses image processing techniques in order to extract the vehicle number plate digital images.

ANPR systems generally compromises of an IP camera, processor and application capable of performing sophisticated optical character recognition (OCR), to transform the image of the plate into alphanumeric characters. Application software to compare the transformed license plate characters to databases of license plates of interest to institution; and a user interface to display the images captured, the results of the OCR transformation, and an alert capability to notify operators when a plate matching an employer in the institution or a visitor.

Successful implementations of ANPR systems have resulted in faster and easier vehicle identification. This has also resulted in faster and easier search and check in in institutions.

### 2.2.1 Image acquisition

The first step is the image acquisition stage. The image of the vehicle is captured using an IP camera. The constraint is that the image of the vehicle should be captured in such a way that the selected input image contains rear or front view of the vehicle with the number plate [1].

The image is usually captured in RGB (Red, Green and Blue) color model. The captured image is affected by many factors like: optical system, distortion, system noise, lack of exposure or excessive relative motion of the camera or vehicle thus resulting in a degradation of a captured vehicle image hence adversely affecting the results of the overall image processing [2]. As a correction mechanism, an image pre-processing stage is introduced to take care of any errors that may have occurred during the image acquisition stage. Image pre-processing mainly involves converting the RGB image into gray color, noise removal and border enhancement for brightness. Image pre-processing is usually done through image filtering.

### 2.2.2 Number plate detection

Number plate recognition phase follows that does several functions such as resizing of the image to a feasible aspect ratio. As well as converting the colored image into a grey scale.

Number plate detection searches an input image in order to identify specific features that contain the number plate [2]. The number plate can be found anywhere within an image, it is impractical to check all the pixels of the image in order to locate the number plate. Therefore, we only focus on those pixels that have the number plate.

### 2.2.3 Character segmentation

Character segmentation can be defined as a technique, which partitions images of lines or words into individual characters. It is operation that seeks to decompose an image of a sequence of

character into sub images of individual symbols. Character segmentation is an operation that seeks to decompose an image of a sequence of characters into sub-images of individual symbols [3].

Character segmentation is the process through which the text component within an image is isolated from the background. In order for proper text recognition to take place the line of text is first segmented, then from the segmented line the words are segmented and then from that the characters are segmented.

### 2.2.4 Character recognition

Optical character recognition (OCR) refers to the process of classification of optical patterns contained in a digital image corresponding to alphanumeric or other characters.

Optical character recognition is achieved through the following steps:

a) Segmentation

b) Feature extraction

c) Classification

OCR technology has enabled us to convert different types of documents such as scanned paper documents, pdf files or images captured by a digital camera into editable and searchable data.

Character recognition is process of detecting and recognizing characters from input image and converting it into meaningful text in ASCII (American Standard Code for Information Interchange) or other equivalent machine editable form. Character recognition is the process to classify the input character according to the predefined character class [4][2].

Template matching, or matrix matching, is one of the most common classification methods. In template matching, individual image pixel is used as features. Classification is performed by

comparing an input character image with a set of templates from each character class. A very basic description of a functional ANPR process is:

**Step 1:** Image acquisition-The camera takes a picture of the vehicle containing the number plate.

**Step 2:** Number plate detection and character segmentation- The camera isolates the plate, adjusts the brightness and contrast and segments it into characters.

**Step 3:** Character recognition - The pattern of each character is analyzed to convert the picture into text.

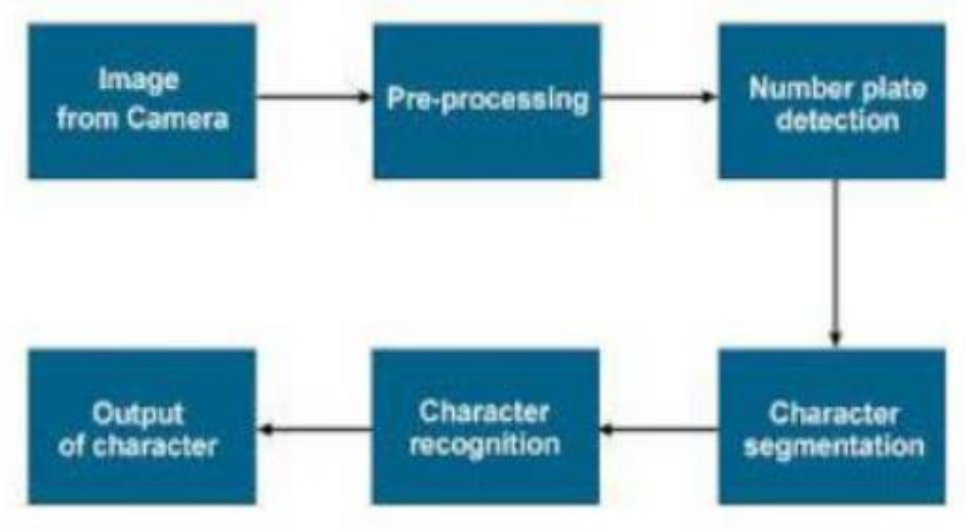


*Figure 1: Typical ANPR Process*

### 2.2.5 Tessaract OCR

Tesseract was developed between 1985 and 1994 at Hewlett Packard Laboratories Bristol and Hewlett Packard Co, Greeley Colorado. It appeared for the first time in 1995 at University of Nevada Las Vegas (UNLV) Annual Test of OCR Accuracy. It was a PhD research project conducted in HP Labs, Bristol, and it had the momentum as a possible software and hardware add-on for the HP's line of flatbed scanners. After ten years, due to lacking any further development, HP released the Tesseract as open source in late 2005. Currently, Tesseract library is available at

Github. Tesseract is suitable for use as the backend and can be utilized for more complicated OCR tasks.

#### *2.2.5.1 Applications of OCR*

There are widespread appearances of commercial OCR products over the last few years meeting different user requirements. there are two main application areas of OCR these include: Process automation and ata entry:

i. Process automation: This area controls a specific process. For example automation address reading for sorting mail thus the aim is to direct each mail into the appropriate folder by automatically reading off the mail address.
ii. Data entry: This process involves entering of large amout of text. It invoves the use of cameras or scanners to obtain the digital images of the original documents, then using Tesseract OCR software this will extracts the text from the images

## 2.3 Database

In this research, database is designed to support the ANPR system. It aims to record the data collection of vehicle number plate[5]. The database is required by ANPR system in order to record and retrieve some information related to the number plate such as owner information and vehicle information.

A database management system (DBMS) is a collection of interrelated data and a set of programs to access the data. The primary goal of a database is to provide a way to store and retrieve information that is both convenient and efficient.

### 2.3.1 Approaches to data base management

a) **File oriented approach**

This approach involves storing groups of records in separate files and were thus called file processing systems. In a typical file processing system, each department has its own files designed specifically for those applications.

b) **Database oriented approach**

Database oriented approach involves storing data in the form of interrelated tables and files.

**Advantages of database-oriented approach**

i) Data independence: the DBMS provides an abstract view of the data thus insulating the application code from such details.

ii) Efficient data access: data is usually stored and retrieved successfully by the DBMS.

iii) Data integrity and security: the DBMS can enforce integrity constraints on the data.

iv) Data administration: centralizing of the data administration where several users share information offers significant improvement. Redundancy is minimized and fine tuning of the storage of data ensures efficient retrieval.

**Disadvantages of a database-oriented approach**

**i)** **Complexity:** a DBMS creates additional complexity and requirements.

**ii)** **Requires qualified personnel:** the professional operation of a database requires appropriately trained staff.

**iii)** **Costs:** it is costly to create a database.

# CHAPTER 3: METHODOLOGY

## 3.1 Background

The access management and billing system is used to capture identity details of users checking in and out of an institution. There are various types of users who can access a premise. For this case, the following types of driver users were determined:

a) Visitors

b) Staff

c) Students

d) Others

The staff numbers and student registration numbers were used as reference to distinguish employees and students from visitors when accessing the institution. The car number plate is scanned, then the check is recorded.

If a visitor is identified, their details will be recorded in the database after which they will be billed during checkout depending on their time of stay.

For driving visitors, they present their ID cards which are scanned then their car number plate is scanned and the check in recorded.

## 3.2 Overall System Architecture

A system architecture or systems architecture is the conceptual model that defines the structure, behavior and views of a system. The figure below consists of an architectural design of the Capture and Registration Method for the Automated Number Plate. This architecture can be commonly defined as:

a. Client Side (Front-End)

b. Server side (Back-End)

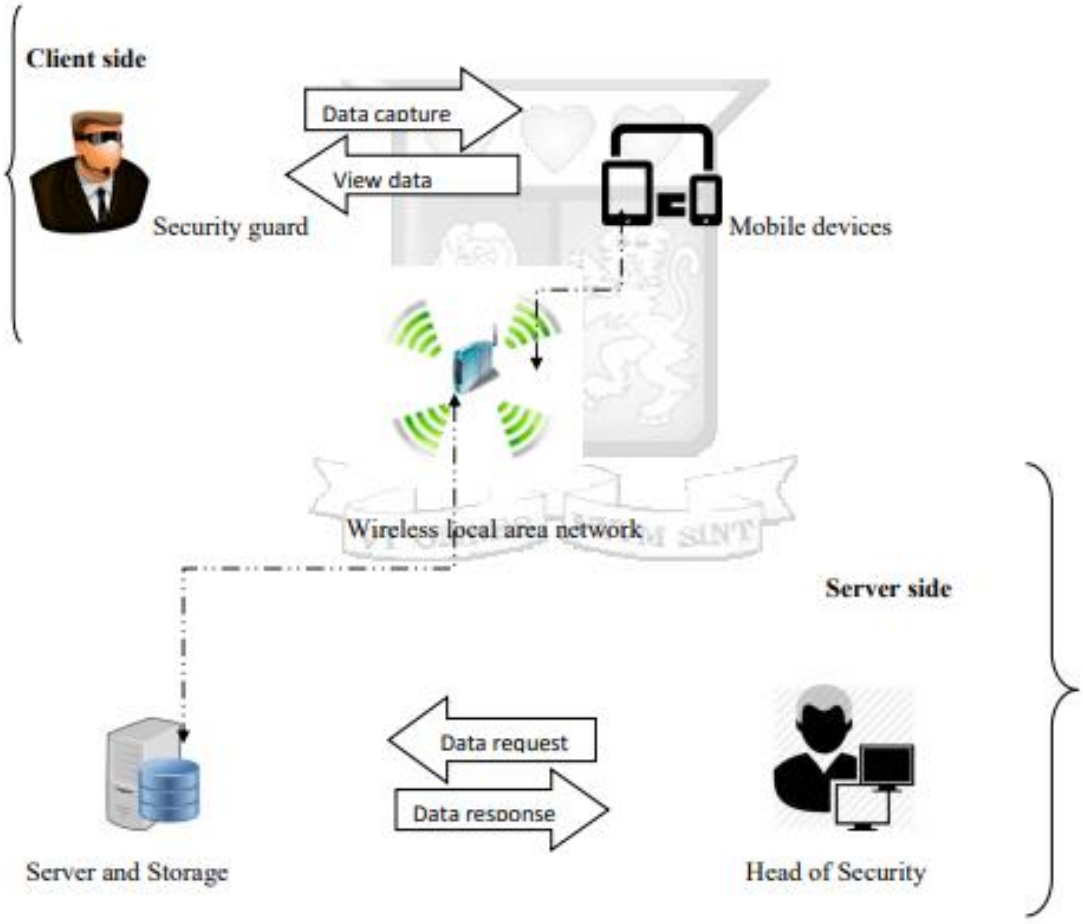


*Figure 2: Overall system architecture*

### 3.2.1 Client Side

This consists of the hardware components ie the Raspberry Pi and camera that have the functionality of the OCR used in scanning the number plate of the vehicle. The system also offers additional services, such as time capturing of the vehicle. The camera communicates with the server through the local network (WLAN) wireless.

### 3.2.2 Server Side

This consists of a server used to host scripts to send and receive information about the vehicle. A database is also used for the preservation of vehicle information as well as a platform for administrators to access records of vehicles.

With regard to the automatic plate capture and registration system architectural architecture. The security forces are the principal users of the mobile application while the institution's head of security is a secondary user, whereby he collects details from an online portal of the vehicles entering and leaving the premises of the institution.

## 3.3 HARDWARE STRUCTURE

The hardware structure comprises of a Raspberry Pi and a camera for vehicle capturing and number plate extraction.

### 3.3.1 The Raspberry Pi 3

The Raspberry Pi 3 is the central processing unit for systems. The Raspberry Pi 3 acts as the systems central processing unit. Its USB ports is present to allow connection to the camera, screen, keyboard and mouse. The Raspberry uses the output from the camera to obtain values of the number plates. The Raspberry Pi then passes the information of the number plate to the database via wireless connectivity.

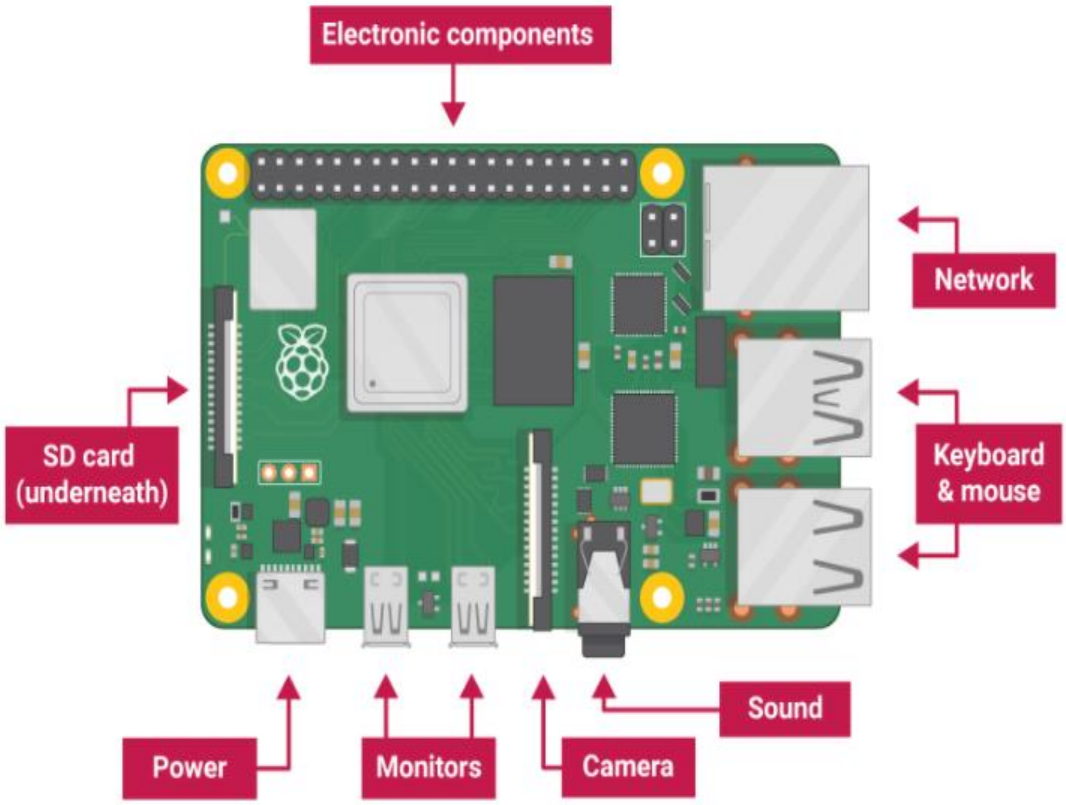


*Figure 3: Raspberry Pi*

### 3.3.2 Raspberry Pi Webcam

The photo capture was taken with the Raspberry Pi Webcam. The camera is linked to the Raspberry Pi by means of a USB cable. It is connected to a USB port on the Raspberry Pi. The picture sensor has a 8-megapixel native resolution and a fixed focusing lens.


*Figure 4: Raspberry Pi Webcam*

## 3.4 SOFTWARE STRUCTURE

### 3.4.1 Automatic Number Plate Recognition ANPR - OCR

The program to extract features from the image is developed using python programming language and OpenCV 2.3 library. The size of the input image is 1280 x 960 pixels. The image is converted from RGB to grayscale image. A 3x3 Gaussian kernel is used to minimize the noise in the grayscale image.

After that, binary thresholding is performed on the grayscale image to produce a binary image. Next, Hough Transform is performed on the binarized image to detect the plate region as the Region of Interest (ROI). Once the ROI is found, a bitwise operation is performed to mask the binarized image and the original image and the characters on the plate are recognized optically (Optical Characters Recognition, OCR) by the aid of the pytesseract library.

See the below process;

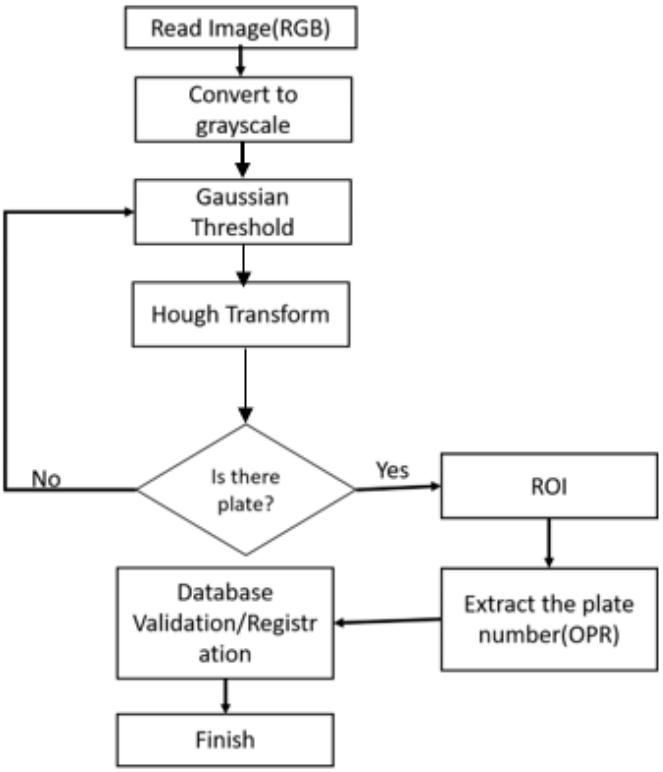


*Figure 5: OCR process*

**OpenCV**

OpenCV is an open source computer vision and machine learning software library designed to achieve computer vision, i.e. the ability of a computer to extract information from a digital image, or multiple images. It is designed for use with multiple programming language interfaces, with the ability to run on multiple operating systems including Windows and Linux. OpenCV will be used in this project to convert captured images to matrices, making it simpler and more effective for them to be sent and stored in a database.

**Tesseract**

The pytesseract software is used for OCR in this project. Tesseract is an open source OCR engine that supports several languages. It is highly acclaimed and is ideal for backend use. To use Tesseract, images need to be pre-processed for improved performance. It uses various image processing and support libraries for different image formats. Using the Tesseract generator, the captured image can be processed inside the Raspberry Pi and the text on the image can be identified to read the number plate of the vehicle. Reading text is then passed on for further processing inside the microprocessor.

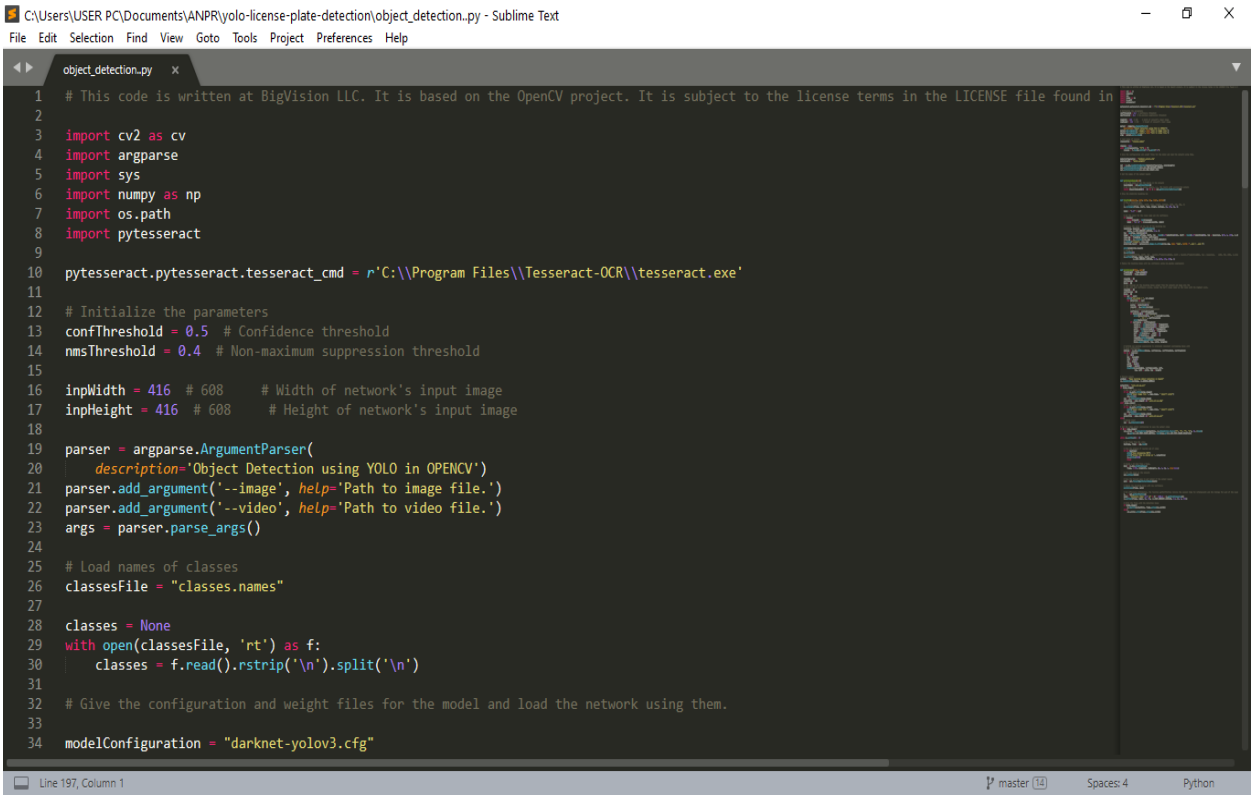


*Figure 6: section of the python code for OCR*

### 3.4.2 Database

This project uses MySQL as a database management framework that can be used on many systems platforms. A database is introduced in this project. The database stores the registered photos and the descriptions of the vehicle owner. It is a guide to collect information from the car owner and to store the data.

### 3.4.3 Web Portal

Python is used for this project as the backend development programming language. For server-side development, Python is suitable. It provides a wide range of frameworks and open source libraries to speed web application development. The front end languages like HTML and JavaScript can be quickly implemented. Python is used for the development of the Raspberry Pi database operational control and networking portal.

The website is implemented using the Flask framework. The portal is designed to connect to a MySQL database and to send emails to a site administrator via the contact page. A specific website token offers encryption features, and therefore a session key, to enhance the security of the website. Login parameters are set and without logging in the index, login and pages can only be accessed. The user is routed back to the Login Page if a page is accessed without authentication. The pages are templates for HTML pages.

During their relation to the database, most pages are dynamic and view data in formatted tables. You may also download these table data for further processing and reporting on Excel sheets. A contact page provides data input and e-mail for further response to the website administrator.

### 3.4.4 Android Application

An application is developed and installed in an android phone that the sentry at the gate is given. The application is connected to the phone's camera using the Android SDK (Software Development Kit) API. Android Studio was used as the IDE for developing the application.

The android application was developed by the Android Studio SDK. The application consists of four main parts:

1. Log in.

2. Visitor check in.
3. Visitor billing.
4. Visitor checkout

The following flowchart illustrates the general working of the android application.

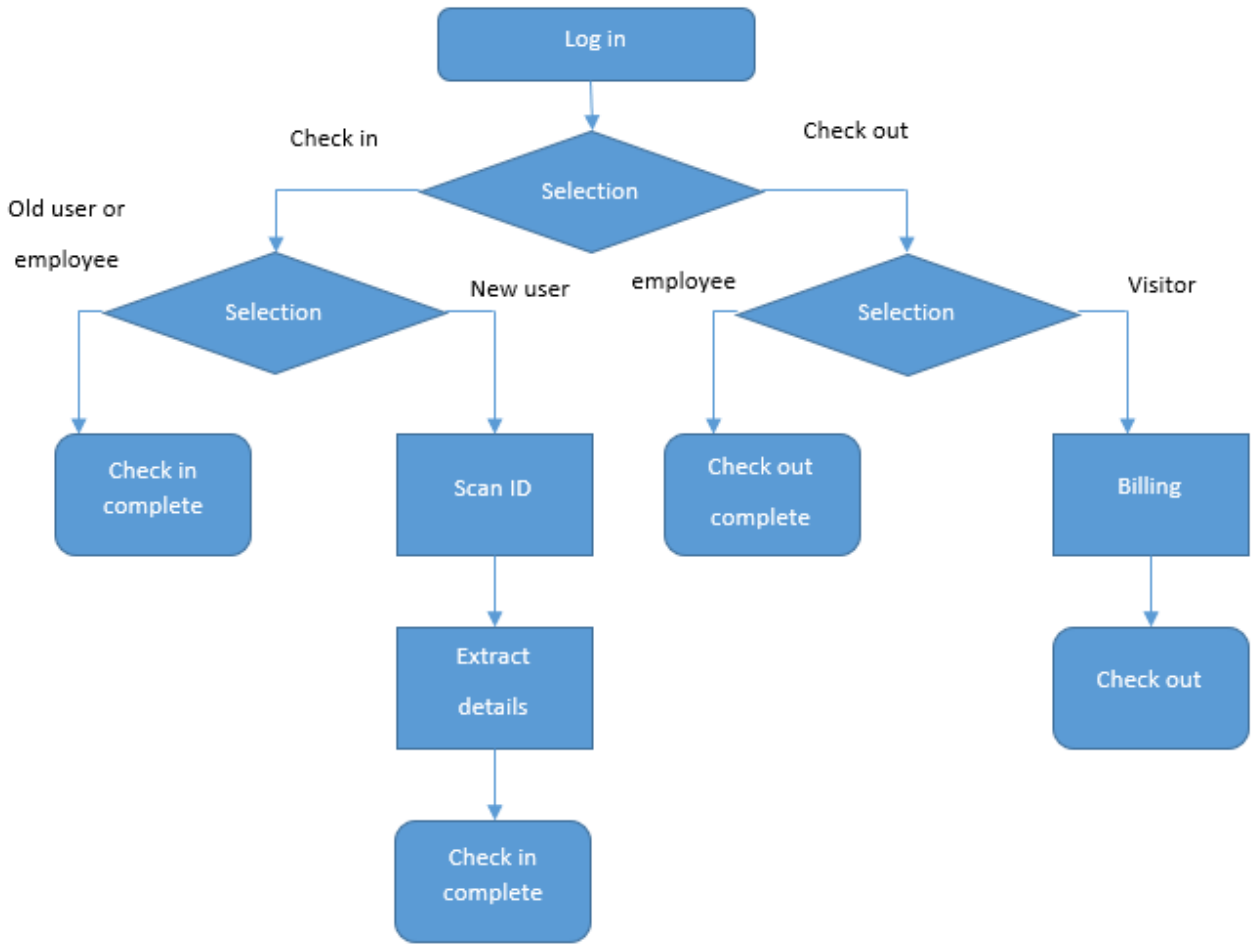


*Figure 7: Android application flow chart*

The security guard will first log in in to the android application. Whenever a vehicle reaches the gate, the soldier will check in the application to see the status of the approaching vehicle. If the

vehicle has been to the premises before the status will be cleared. If it is a new vehicle, then the soldier is prompted to scan the ID card of the driver. Once the image has been parsed and the details extracted, the vehicle will be checked in and a ticket number issued. During check out the ticket number will be fed into the android application and the visit details will be obtained. The time taken by the driver in the facilities will be calculated and this will be used to calculate the amount to be paid. Once the amount has been paid, the application will automatically check out the driver.

#### *3.4.4.1 Extraction of data from the MRZ of the ID card.*

This model will use OCR and text recognition to recognize the characters of the MRZ on the back of the photo of the identification card. The relevant information will be extracted from the image by the algorithm before being sent to the database.

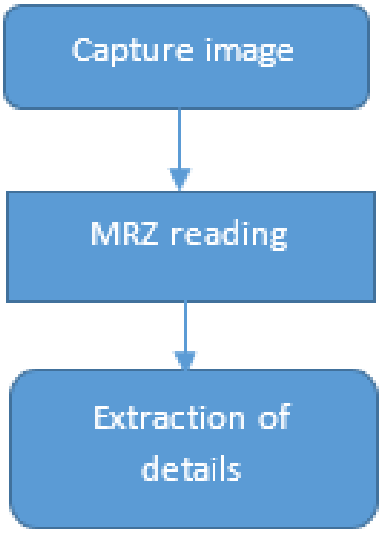


*Figure 8: MRZ process*

#### *3.4.4.2 Billing*

The billing module is implemented via an MPesa Express Push-STK API that begins the transaction automatically and only require an authorization to complete the transactions by way of an MPesa Pin. The billing module is used for testing on the Safaricom scrub.

The application takes some claims, and the transaction has begun. Arguments for input. It returns a set of parameters to show whether the transaction was successfully initialized.

# CHAPTER 4: RESULTS

## 3.1 Automatic Number Plate Recognition

The number plate identification system established is capable of:

• Number plate recognition

• Recognize number plate signs

Recognition of optical character on captured images is executed and the number plate marked.


*Figure 9: Sample vehicle image*


*Figure 10: Detected number plate*

The area with the number plate is marked and contoured.

Character recognition is then carried out on the contoured portion in order to achieve the desired number plate.

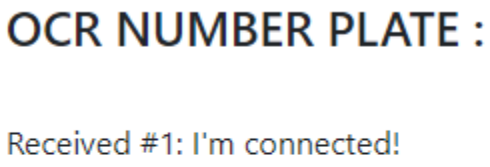


*Figure 11: Before extraction of number plate text*


*Figure 12: Number plate converted to text*

## 3.2 Web-Based Portal

The SQL database is maintained with a variety of tables depending on the type of data, hence the main database table containing the ID, number plate, name and time stamp of the vehicles.

Manager app.db app.db app.db app.db app.db app.db app.db app.db app.db

| id | name | national_id | timestamp | number_plate | phone_number |
|---|---|---|---|---|---|
| 1 | njeru | 2345 | 2020-11-17 20:00:38.184459 | 123 | 254708094707 |

*Figure 13: Section of the tables with numberplate data*

## 3.3 Billing

Billing of visitors includes:

- Paying parking depending on time spent in the institution, via M-Pesa using an STK-Push Prompt
- Database is updated on the status of the payment

# CHAPTER 5: CONCLUSION, CHALLENGES AND RECOMMENDATION

## 5.1 Conclusion

This project was based on action. It aimed to address the difficulties that security staff face with regard to the identification and registration of vehicles of all vehicles entering and exiting the premises of institutions. The result was the implementation, on a mobile device, of a software application, that makes vehicles easy to identify, register and billed.

A moving program allowing for the automated identification, recognition and display of car number plates has managed to successfully use OCRs (Optical Character Recognition). The OCR

mechanism forms the base of the entire framework proposed by the investigator in response to the security forces' challenges during vehicle registration.

The following advantages have been accomplished by the completion of the proposed system:

i. Delete the hard copy of the incident book and write it physically into the book, while all the car data are digitalized.
ii. Entering the registration procedure of the car, thereby reducing the amount of time it takes to record vehicle information when you reach the university.
iii. Precise registration of information on cars.
iv. Provides a simple way to share and store knowledge.
v. The Head of Security real-time information exchange for the entry and departure of vehicles to the organization.
vi. Fast and easier processing the information obtained from the car.

## 5.2 Challenges Faced

During the implementation of this project, many challenges were faced, among them:

1. The OCR module is configured in various situations, such as lighting, environments and image resolutions.

2. Interface with APIs from third parties such as M-Pesa STK Drive for production environments in particular There need to be a number of licenses and permits.

## 5.3 Recommendations

From the experience of the project implementation especially the challenges faced, and other contributing factor, we make several recommendations.

1. Implementing machine learning for a more robust OCR module.
2. Integrating multiple payment platforms like VISA and PayPal for billing offenders.

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