ISSN 2278-3091
Volume 9, No.5, September - October 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse318952020.pdf
https://doi.org/10.30534/ijatcse/2020/318952020

Automated Parking Management and Monitoring System through Plate Number Detection using Image Processing

Sandra Jeysa Mae R. Schulz[1], Virgilio A. Montalbo III[1], Artesio C. Dua Jr.[1], Rodrigo S. Pangantihon Jr.[2]
[1,2]Computer Engineering Program, College of Engineering Education
University of Mindanao , Matina, Davao City, Philippines
[1]sandraschulz411@gmail.com
[1]virgilio.montalbo3@gmail.com
[1]artdua18@gmail.com
[2]rodrigo_pangantihon@umindanao.edu.ph

ABSTRACT

This paper has delved on developing a system that provides security, access control, and identification of vehicles entering a specific premise deemed necessary, especially in this time of COVID-19 pandemic. Upon automobiles' entry, plate numbers will be captured and compared to the existing information gathered during the registration of accounts. Visual Basic.Net and microcontrollers are used in the process of plate number extraction, communication of the system to the database and display of real-time data. To provide accurate performance of the license plate number recognition, the application made use of image manipulation, namely: image acquisition, image enhancement, thresholding, image segmentation, and character recognition. With the various tests conducted through the aid of multiple data sets, the system yielded an accuracy rate of 94.18%. The system is proposed to be implemented at the University of Mindanao, Matina Campus, Davao City, Philippines, with the target of automating the process of vehicle identification of the institution.

Key words : Image processing, Parking Management, Barrier System, RFID Technology, Plate Number Detection

1. INTRODUCTION

As Davao City pushes its way to economic growth, the rate of car ownership, specifically, at the University of Mindanao is also growing. This growth is also affecting the available spaces in the University, which causes congestion and time wastage for managing parking spaces and manually checking the identification of each vehicle entering the institution's premises.

The studies in [1-4] focused on Automatic Number-Plate Recognition (ANPR). They may have used similar components but have different approaches and methods on how they constructed the study. Automatic Number-Plate Recognition (ANPR) is a type of image processing technology used to recognize and identify the number plate of a vehicle. A camera is used in ANPR systems to capture vehicle number plates and a software system that extracts the number plates from the images captured using a character recognition tool that allows pixels to convert into numerical readable characters [5]. Vehicle plate number helps to identify the vehicle uniquely [6]. Many works proposed over the last years aimed at improving parking management [7]. Image processing is said to be more convenient and faster to acquire data [8]. The Automatic Number Plate Recognition (ANPR) is an internationally recognized approach used to identify vehicles [9]. Each phase has its significance in identifying a car. When license plate images are tilted, and characters are not noticeable or broken, each character and identification segmentation may be unverified [10]. There are many advanced license plate detection algorithms. Although license plate detection has been studied for many years, detecting license plaques from different angles, partial occlusion, or multiple instances is still challenging. Detection of license plates uses an input picture to classify such local patches containing license plates [11]. The paper [12] reviews various methods and methodologies of Automatic Number Plate Recognition. Radio Frequency Identification (RFID) is a wireless communication system that can recognize marked items or individuals uniquely. RFID devices have been commonly used in many applications such as inventory control, product monitoring through production and assembly, access and control of parking lots, tracking of containers or pallets, identification (ID) badges, and access control, equipment, or staff [13]. RFID Technology has been integrated into a system but with different platforms such as Linux and Windows [14-16].

This study focuses on the automation of managing vehicles entering the University of Mindanao using plate number detection and real-time user registration system. It is also designed with various types of equipment and hardware design to make this study possible. It is intended only to detect registered students, faculty members, and visitors of the University.

This study aims to develop a system that will manage and automate the University of Mindanao's parking system. A prototype system for detecting plate numbers using image analysis using Visual Basic and a real-time user registration system designed to designate the parking slots for the students, faculty, and visitors of the University of Mindanao.

Improving the security in the premises of the institution and the automation of parking management of the University of Mindanao are the primary importance of the study. Technology is essential today because it serves a variety of functions in many of modern society's most critical aspects. Thus, this study's success allows the institution to secure the premises much more efficiently with less man force.

The scope of this study is only to detect plate numbers and identifying the owners through their plate numbers. Plate number detection is known for many purposes, such as reviewing vehicle violations outside the University, Motor tolling, and Border control, but these applications are not applicable in this study. This system aims not to detect a vehicle's speed and how they park their car inside the University. The plate numbers used in this study have plain backgrounds and not the old Philippine plate numbers for the plate number detection accuracy. The implementation of this study is applied to the University of Mindanao, Matina campus only.

2. MATERIALS AND METHODS

The Conceptual Framework of the study is shown in Figure 1. Captured plate numbers and RFID cards are the primary input for both the software and hardware development processes. The system processes all the information and compares the data with the information saved in the database. Once the data are processed, the system displays the output in the graphical user interface and the barrier system's movement. Trade-off analysis was performed and the Pugh Matrix technique was used to identify which design will be implemented [17].

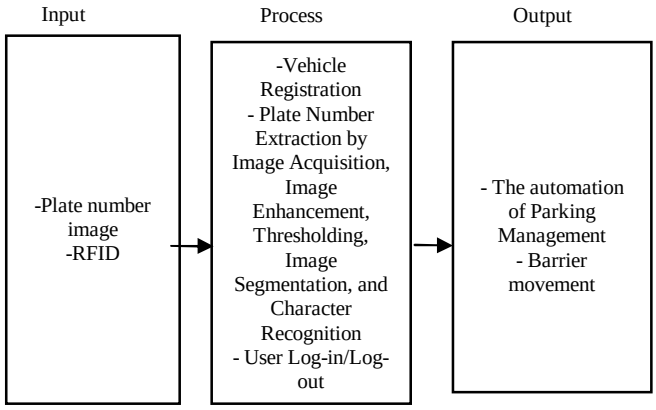


Figure1: Conceptual Framework

2.1 Software Development

A. Vehicle Registration

The Student Affairs Office (SAO) requires the car owners to provide the following requirements: Official Receipt and Certificate of Registration of the vehicle, Form 1, and Student I.D./Faculty I.D. These requirements will verify if the car is registered currently and if the registrant is allowed to enter the University premises in the present semester. Figure 2 illustrates this process.

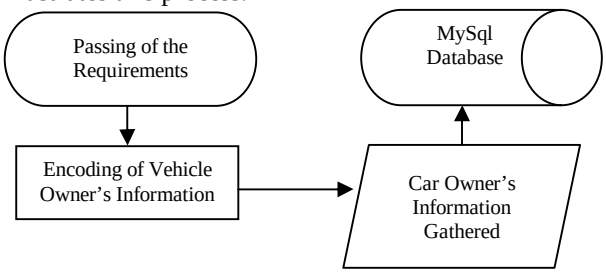


Figure 2: Vehicle Registration Flow

B. Plate Number Recognition

The central part of this system is the plate number recognition. This part uses a series of image processing techniques implemented in Windows PC using the license plate extraction method. This License plate extraction method is divided into five parts shown in Figure 3.

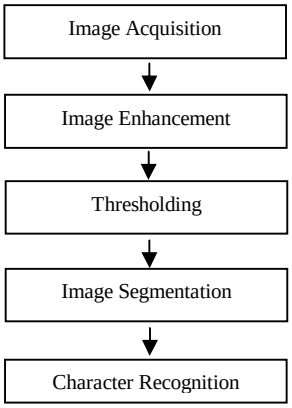


Figure 3: Method of Extraction

C. Image Acquisition

The initial phase of recognizing the plate number is acquiring the car's images entering the premises presented in Figure 4. A Web Camera is used as a tool for capturing the images. The images will be cropped and stored in JPEG color format, whereby it removes the smallest rectangle that detects the edge of the license plate.

Figure 4: Capturing the Image of the Plate Number

D. Image Enhancement

The purpose of this process is to enhance the clarity of the image. This step should help develop and render the images visible displayed in Figure 5.

Figure 5: Enhancing an Image

E. Thresholding

The most uncomplicated thresholding strategy is to convert the image to grayscale and remove the image pixel according to its strength of the signal. If the image intensity of the captured image is less than the threshold value, black pixels replaced the pixels. If the image intensity is higher than the threshold value, white pixels replaced the pixels, as illustrated in Fig. 6.

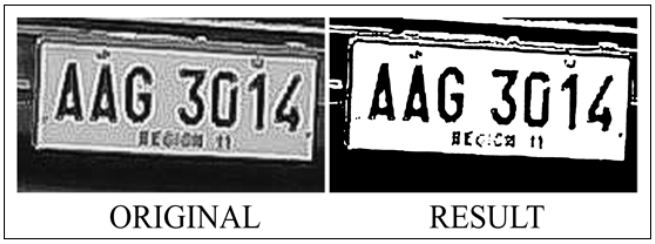


Figure 6: Result of Thresholding an Image

F. Image Segmentation

The image should be partitioned into separate sections to evaluate and extract the data from the picture. The system compares the extracted data to the alphanumeric character database. Character shapes evaluate the image, the number of lines, vertical or diagonal edges, etc. Fig. 7 shows the conversion of the image from bit map data to machine segmented image for analysis.

Figure 7: Image Segmentation of plate number

G. Character Recognition

In this process, the extracted characters will be converted to binary image size and then reshaped to a regular dimension shown in Fig. 8. These normalized characters will be added to the database of characters to improve each process's pattern recognition. The system improves by increasing the database size, accuracy, and reliability.

Figure 8: Character Recognized by the System

H. System Integration

This system is implemented through image processing and RFID Technology in VB.net to provide monitoring and car park management system for both teaching/non-teaching

personnel and students of the University of Mindanao, Matina Campus, and also to maximize security to those who will enter the campus. The system will detect the plate number of the entering cars/vehicles. The RFID technology integrated into the Arduino microcontroller played an important role in recognizing if the vehicle entering the campus is registered or not as shown in Figure 9.

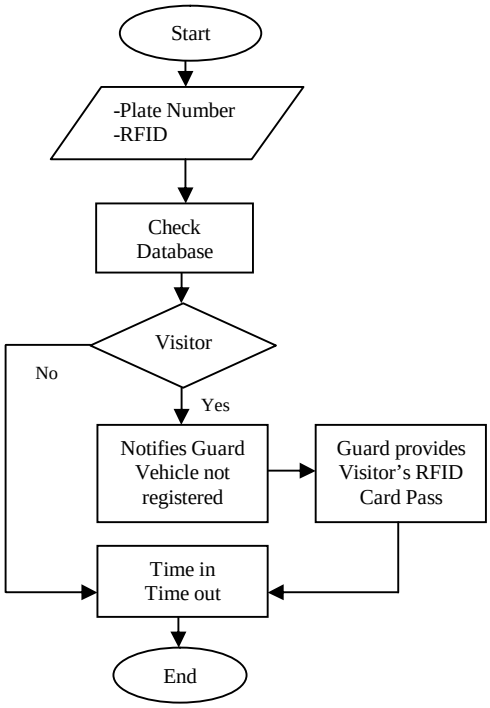


Figure 9: System Flowchart

2.2 Hardware Development

A. Hardware Design

Fig. 10 illustrates the overall function and connection of the hardware to the software model. Visual Basic implemented in Visual Studio is the brain of the system. It stores all the information gathered. The data collected will be processed and are used to evaluate the collected data and compare it with the data stored in the database. The database stores the vehicle owners' information gathered upon registration. These details will be used as evidence by the vehicle owners if a vehicle that enters the premises is registered or not. For the accuracy and reliability of the image processing, the system uses alphanumeric characters. The Web Camera is the one that captures images and sends them to the system. The photos collected are improved, segmented, and normalized by the machine algorithm. The barrier system for Students, Faculty, and Visitors of the University of Mindanao features RFID Technology. Tapping the RFID card is required for a specific area; the barrier will open according to its ID type. If the ID is specifically for the student, faculty, or visitor, the barrier will open, but tapping the RFID card to the wrong place won't open the barrier. This system will sort and arrange the classification of owners inside the University.

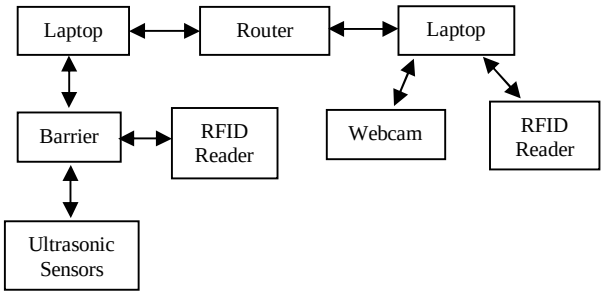


Figure 10: Hardware Design Block Diagram

B. Hardware Development Flow

Fig. 11 indicates the system flow of the barrier system. The barrier system uses AC/DC stepper motor connected to the Arduino embedded with RFID readers and Ultrasonic Sensors. The Arduino gathers the information from the RFID Cards and determines the authorization of the owner. Parking Area for students, faculty, and visitors are designated with barrier system. Once the system detects that the car entered the wrong parking slot, the barrier will not open.

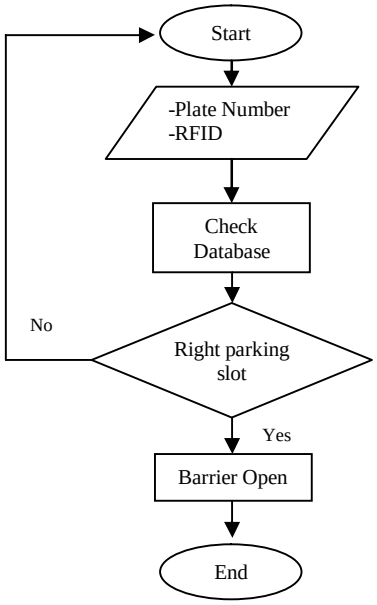


Figure 11: Hardware Development Flow

C. Testing Procedures

Fig. 12 explains the overall testing of the study. Requirements of the definition imply what the following aspects of the study need to be strengthened and considered. This phase is essential to proceed to another level of prototype testing. System and Software Design is the implementation of the ideas discussed in the previous step. This phase is the creation of the Software and the graphical user interface. It includes

the image processing of the plate numbers, registration of the vehicle owners, and the installation of the RFID technology. Implementation and Unit testing combine Hardware and Software Models. This phase will test the accuracy and capability of the prototype system. This phase shows the system's errors and bugs and requires the things needed to proceed to the next phase of testing. After improving and upgrading the system, the actual testing happens, and testing yields results. Using these results leads to improvement and enhancement of the system for final presentation. Full operation and maintenance of the system will be the final phase of the system—the completion of the system results of the implementation in the University.

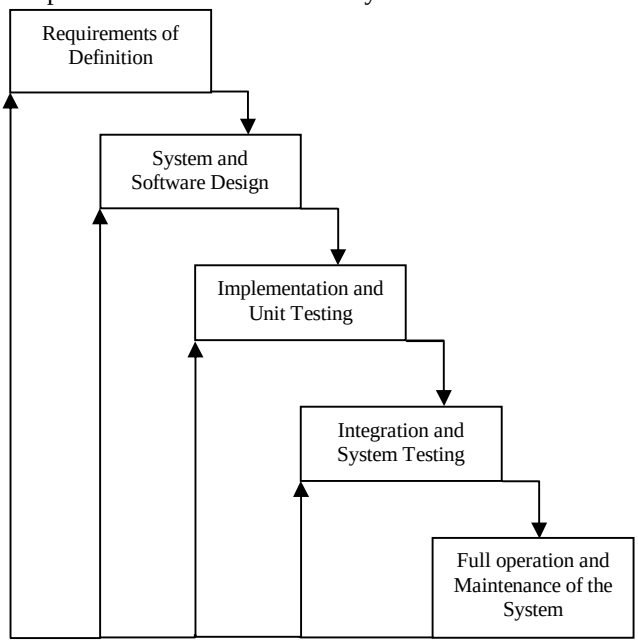


Figure 12: Testing Procedure Cycle

2.3 Network Set-Up

Fig. 13 illustrates the network set up of the system. The barrier system uses a long-range router to communicate to the central server of the system. The barrier system is dependent on the main server because it classifies and compares the vehicle's data entering a parking space to the main database.

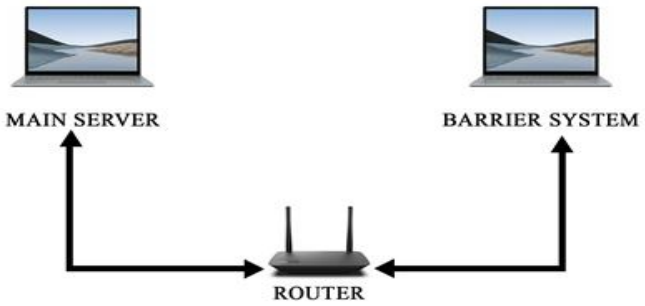


Figure 13: Network Set-up

3. RESULTS AND DISCUSSUIONS

3.1 Device Set-Up

A. Software Platform

Fig. 14 shows the actual set-up for software development. The system runs in a laptop with the use of VB.net. Connected to the system are the C922 Pro Logitech Web camera and the Arduino embedded with RFID readers to register the vehicle owners. The Web Camera has a 16-megapixel sensor that is capable of 1080p video streaming and capturing high-definition images. The camera is placed on a tripod for better stability while capturing images and installed at the main entrance of the University, the Maa gate.

Figure 14: Software Development Set-Up

B. Hardware Platform

Fig. 15 presents the actual set up for hardware development. A UTP cable connects the RFID reader box to the barrier. RFID Reader installed inside the barrier sends and receives data between the system and RFID Reader. After sending a confirmation to the Arduino, the movement depends on the authorization of the ID Type. Unauthorized entry of users would mean closed barrier. Once the barrier opens, the ultrasonic sensor will detect an obstacle in front of the barrier. The sensors can detect up to 3 meters in range, and after the vehicle passes, the barrier will automatically close.

Figure 15: Barrier System Set-Up

3.2 Graphical User Interface

Fig. 16 displays the Registration page of the students and faculty of the University of Mindanao with their complete information.

Figure 16: Registration Page

Fig. 17 shows the Log-in Page wherein Security Guards can see the vehicle's information that is entering the campus, and the system records the time they entered. If the vehicle is not registered, the system will display it to the guards. They will also be able to see the parking space left on each parking slot inside the University.

Figure 17: Log-in Page

Fig. 18 represents the Log-out page wherein the information of the entire vehicle that will be leaving the campus will be saved, including their name, plate number, and the date and time they left the University through RFID cards.

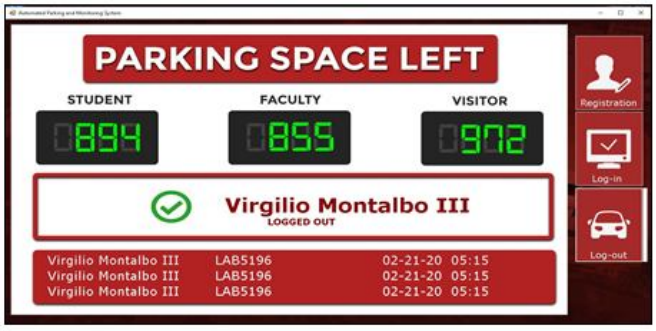
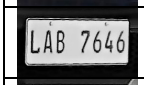
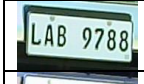
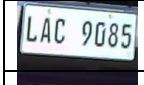


Figure 18: Log-out Page

3.3 Functionality Test Accuracy

Table 1 shows the captured images from the actual testing at Maa gate of the University of Mindanao. This table determines the system's actual output and verifies where it is registered, not registered, or unknown. The database stores the information of the registered vehicles displays the data upon entering. The system will show if the vehicles are not registered and if the captured images are unknown, the output will be "000000" as programmed in the system.

Table 1: Actual Plate Numbers Captured

Plate Number	Expected Output	Actual Output	Registered	Unregistered	Unknown
	ABF5214	ABF5214	✓		
	LAB7646	LAB7646	✓		
	UIO978	UO98	✓		
	AAG8549	AAG8549		✓	
	MAI1384	MAI1384		✓	
	130107	13017		✓	
	MAE2481	MAE2481		✓	
	LXD254	000000		✓	
	MAH4266	000000			✓
	LAB9788	LAB9788	✓		
	LAC9085	LAC9085		✓	
	NBH1487	NBH1487		✓	
	LAC6868	LAC6868	✓		

Damaged, scratched, and unrecognizable plate numbers are classified as Unknown. Most of the plate numbers recognized by the system have a plain white background and bold characters, improving the system's accuracy. The gathered data were enough to improve the system's efficiency through continual actual testing of the system at the Maa gate of the University. The system datasets comprise of gathered actual plate numbers images and plate number fonts. With the use of the confusion matrix, Table 2 shows that the accuracy rating of the system is 94.18%.

Table 2: Accuracy Rate of the System Software

		Actual		
		Registered	Unregistered	Unknown
Predicted	Registered	25	0	0
	Unregistered	0	143	1
	Unknown	2	5	14
TOTAL		27	148	15
ACCURACY		92.59%	96.62%	93.33%
NO. OF SAMPLES		190		
OVERALL ACCURACY		94.18%		

The best position of the RFID cards is 10 cm above the MFRC522 RFID Module from the series of tests. The system recognizes the RFID cards by comparing the unique value to the existing database. If the owner tapped their ID to a specific parking slot according to their ID type, the barrier opens and closes within a particular time. The system only recognizes registered RFID Cards. The overall testing of the hardware development system is successful and calculated with the use of the Confusion Matrix, which has an accuracy rating of 100%.

Table 3: Accuracy Rate of the System Hardware

		Actual		
		Student	Faculty	Visitor
Predicted	Student	12	0	0
	Faculty	0	8	0
	Visitor	0	0	5
TOTAL		12	8	5
ACCURACY		100%	100%	100%
NO. OF SAMPLES		25		
OVERALL ACCURACY		100%		

4. CONCLUSIONS AND FUTURE WORKS

The development and implementation of an automated parking and monitoring system succeeded. The prototype system detected the plate number using image analysis with the use of Visual Basic. The real-time user registration software program designates the parking slots for students, faculty, and visitors of the University of Mindanao. The system was working in a proper camera placement with a certain distance and angle to capture the plate number in front of the vehicle accurately. These factors affected the accuracy of extracting the characters from the plate number. The registration system worked perfectly fine with the RFID technology using Arduino connected to the system. The gate barrier system used RFID technology to determine the vehicle owners that will enter the parking slots.

The system was in good working condition despite all the factors that may affect the plate numbers' detection. For this system's future works, using a High Definition surveillance camera produces and receives reliable images. At least a minimum of 16-megapixel camera should be used in capturing plate number images. For the barrier system, using a high voltage dc motor balances the barrier's weight and provide better security for the parking slots. This project is to automate the registration process of vehicles at the University of Mindanao and to check incoming and outgoing cars. Still, it is also to provide better security for the campus. The positive and reliable feedback of the system that was tested and implemented at the University of Mindanao prepares the system to be implemented in the future by other institutions.

REFERENCES

1. Balamurugan G., S. Punniakodi, Rajeswari K. and Arulalan V., "Automatic number plate recognition system using super-resolution technique," 2015 International Conference on Computing and Communications Technologies (ICCCT), Chennai, 2015, pp. 273-277
2. A. Kashyap, B. Suresh, A. Patil, S. Sharma and A. Jaiswal, "Automatic Number Plate Recognition,"2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida (UP), India, 2018, pp. 838-843
3. B. Pechiammal and J. A. Renjith, "An efficient approach for automatic license plate recognition system," 2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM), Chennai, 2017, pp. 121-129
4. R. Islam, K. F. Sharif and S. Biswas, "Automatic vehicle number plate recognition using structured elements," 2015 IEEE Conference on Systems, Process and Control (ICSPC), Bandar Sunway, 2015, pp. 44-48
5. Mutua, S. M (2016). An Automatic Number Plate Recognition system for Car Park Management. Strathmore University, Nairobi. Retrieved from https://suplus.strathmore.edu/handle/11071/4893
6. Kiran Kumar, K., Sailaja, V., Khadheer, Sk., Viswajith, K. 2017/01/24/ Automatic Number Plate Recognition System. Indian Journal of Science and Technology; Volume 10, Issue 4, January 2017
7. Simon, Mutua & Mutua, Kaibiru & Kasamani, Bernard. (2017). An Automatic Number Plate Recognition System for Car Park Management. International Journal of Computer Applications. 175. 10.5120/ijca2017915608
8. Alagao, Stephen & Alolino, Jazhiel & Ybanez, Michael & Rubio, Edjie & Caya, Meo Vincent. (2018). Wireless Electric Consumption Acquisition Using Image Processing. 1-6. 10.1109/HNICEM.2018.8666324.

9. Sircar, Siddharth & Alok, Shivam & Sarkar, Pratima. (2018). Vehicle Number Plate Detection and Recognition of Characters by Image Processing. International Journal of Computer Applications. 179. 7-11. 10.5120/ijca2018916846
10. Aishwarya Agarwal, “Automatic License Plate Recognition using Raspberry Pi,” IEEE International Interdisciplinary Conference on Science Technology Engineering Management Singapore, 22nd, 23rd April 2017
11. Gowthaman, Naveen Balaji. (2017). Smart Vehicle Number Plate Detection System for Different Countries Using an Improved Segmentation Method. "Imperial Journal of Interdisciplinary Research (IJIR). 03. 263-268
12. M. Khinchi and C. Agarwal, "A Review on Automatic Number Plate Recognition Technology and Methods," 2019 International Conference on Intelligent Sustainable Systems (ICISS), Palladam, Tamilnadu, India, 2019, pp. 363-366
13. Syamil Mazlan, Muhammad & A Hamid, isredza rahmi & Kamaludin, Hazalila. (2018). Radio Frequency Identification (RFID) Based Car Parking System. JOIV : International Journal on Informatics Visualization. 2. 10.30630/joiv.2.4-2.173
14. Abu Shehab, Wael & Al Shabaan, Ghadeer & Al-sawalmeh, Wael. (2015). RFID-Based Inventory and Security System. Innovative Systems Design and Engineering. 6. 53-58
15. Thariq, Muhammad & Chai Wen, Chuah. (2017). Staff Attendance System using RFID. JOIV : International Journal on Informatics Visualization. 1. 250. 10.30630/joiv.1.4-2.73
16. Abdulsada, Hayder. (2017). Design and Implementation of Smart Attendance System Based On Raspberry pi. Journal of Babylon University/Engineering Sciences. 25. 1610-1618
17. P.P Soroño, K.V.F. Eran, K.J.R. Medina and R.S. Pangantihon Jr. (2020). Development of Mobile Application for Geotagged Fault Lines in Southern Mindanao, Philippines using ArcGIS and Google Earth. International Journal of Advanced Trends in Computer Science and Engineering, 9(4), 6805-6811. doi: 10.30534/ijatcse/2020/380942020