DE LA SALLE LIPA

College of Information Technology and Engineering

Computer Science Department

Automatic Plate Number Detection System for DLSL ISSESO

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BACKGROUND OF THE STUDY

Introduction

After nearly two years of online classes due to the COVID-19 pandemic, learning institutions, including De La Salle Lipa, are now transitioning back to full face-to-face classes. As a result, the campus is experiencing the usual surge of traffic both inside and outside its premises. To ensure the safety and security of

students, faculty, and staff, the institution's security department (ISESO) has resumed its practice of monitoring vehicles entering and exiting the campus.

Traditionally, the ISESO office relied on manual methods to record license plate data, using a logbook and pen. However, with the return to regular operations this brought back the increasing amount of vehicles entering the campus making the current practice being done deemed inefficient and labor intensive. This is where the proposed system comes in, an automated license plate recognition system, leveraging IoT technology, OCR (Optical Character Recognition), and YOLO (You Only Look Once) algorithms. This system enables a camera to capture license plate images, which are then processed by an IoT device using OCR and YOLO algorithms. The extracted text, along with a timestamp, is displayed in a desktop application.

The YOLO algorithm plays a crucial role in identifying the location of the license plate within the captured image, facilitating accurate extraction of license plate numbers in real-time using OCR technology. This combination of technologies is essential for automated text data collection in various applications.

Additionally, the system includes a data analysis component, which generates reports on peak hours, dead hours and others with regard to the local

file which will contain all the plate numbers gathered through the system. This analysis would help the ISESO Employees in mitigating and preparing strategies based on the analysis and visualizations provided by this function of the system.

It is important to note that the utilization of a license plate extraction and saving system, when employed responsibly, can contribute to achieving several United Nations Sustainable Development Goals (SDGs). By enhancing vehicle monitoring and public safety, it supports the development of sustainable campuses, fosters economic growth, and promotes peace, justice, and strong institutions. However, ethical considerations surrounding privacy and civil liberties must be taken into account when implementing such systems.

Statement of the Problem

With the current approach of using record books to manually register plate numbers for any vehicles coming in or out of De La Salle Lipa campus, it's no surprise that human errors occur far too often when trying to record the plate numbers through log books and pens, there is also the factor of high amount of vehicles entering which slows down this process and would lead to traffic congestion inside and outside the campus. Additionally, traffic flow and parking management are also raising concerns because of the rising numbers of

students making use of cars to enter the campus. The proposed system attempts to address the following questions:

1. How can YOLO and OCR be utilized to read and record plate numbers entering the campus?
2. How can data analytics be incorporated effectively to record traffic patterns, vehicle identification, anomaly detection and enforcement?
3. How can YOLO-based plate detection systems, aiming to optimize the algorithm for real-time performance without compromising accuracy?

Objectives of the Study

The current practice being done is through manual paper and pen recording of the plate numbers of vehicles entering the campus.

a. The proposed system aims to use YOLO and OCR algorithms together with the device in order to automatically read and extract the plate numbers for recording.

b. The proposed system aims to incorporate data analytics on the data gathered and presented effectively through a website interface with various graphs and percentages.

c. The proposed system aims to incorporate a YOLO-based detection system that is optimized through training and testing to provide reliable accuracy.

Purpose and Description

In order to reduce the manual labor involved in recording plate numbers of the security management and also to provide reports on vehicle and sticker type amount, the goal of this research project is to create a plate number detection system with data analytics for De La Salle Lipa utilizing YOLO and OCR algorithms. Due to the lack of an automated mechanism to identify and recognize the license plate numbers of vehicles entering the campus, De la Salle lipa is experiencing difficulties in these areas.

Our research intends to address the issues of human error in manual data entry through logbooks and pens, increasing parking spaces and enhancing campus traffic flow efficiency. To do this, we're creating technology that automatically detects and recognizes the license plate numbers on moving vehicles using OCR (optical character recognition) and analyzes the data that will be gathered. Our efforts to manage parking and traffic flow within the campus will be even more optimized due to this creative approach, which allows us to record the vehicle plate number information and generate percentages and the amount of vehicles in a daily and weekly basis which can be used by the traffic management department for adjustment in their traffic and parking flow and protocols, while also automating the process of plate number recording.

The proposed IOT based recording and analyzing system will enhance the efficiency of the process in recording vehicle plate numbers, and provide a

reliable basis in controlling the traffic and parking protocol within the campus. There will be two key parts/functions:

1. Function to automate the recording process of license plate numbers of vehicles entering the campus by providing an automatic license plate recognition system at the entrance.
    a. To automatically record the plate number using optical character recognition and automatically send it to the users folder.
    b. To benefit the supposed person tasked to record the plate numbers with an autonomous process.
2. Function to provide a data analytics portion in the web-app dashboard that generates percentages and graphs on the number of vehicles that:
    a. Enter the campus within the day and data matched to present the owner information together with other vehicle informations
    b. To present reliable information for traffic and parking management adjustments

The project aims to promote the Sustainable Development Goals which are the; SDG 9 Industry Innovation and Infrastructure and SDG 11 - Sustainable Cities and Communities. There will be promotion of the industry innovation and

infrastructure as there will be the improvement of the current system being used by De La Salle Lipa, there is an existing license plate recognition system being used and this will be the basis for improvements on this project by incorporating it with better features and enhancing its accuracy when detecting. This project will also seek to promote the 11th SDg of sustainable cities and communities as this concept will greatly improve and enhance the quality of life of the students, teachers and stakeholders within the school. While also preventing overcrowding of not only cars but also people within the campus by limiting or giving access to certain amounts of vehicles in a day.

For the students/teachers/parents who drive

The students and teachers will be one of the main beneficiaries of this project as it would relatively help them to have a better experience when it comes to coming in and out of the campus, as well as being provided with enough parking space for all the visitors.

For the school traffic and parking management

The traffic and parking management of the school will be the other main beneficiary of this project as they will be provided with better ways and procedures in doing their tasks such as replacing their manual encoding of plate numbers. They will also be provided data and analytics of how many vehicles entered the campus for them to adjust their management system.

For the future researchers

The future researchers would gain information from this project for them to further improve with their future research.

Scope and Limitation

The proposed system aims to automate plate number recording and data analytics website interface for efficient record management within the premises of De La Salle Lipa campus. Using object detection and character recognition techniques, it captures and stores the plate numbers of vehicles, allowing for seamless record keeping. The system also includes data analytics capabilities, enabling the generation of reports and insights based on the collected data. It is important to note that the system is designed exclusively for the campus and its unique requirements.

However, the system has certain limitations. The accuracy and reliability of the camera used for capturing plate numbers play a significant role in its performance. Factors such as poor lighting conditions, low-resolution cameras, or malfunctions can impact data capture. External factors like adverse weather conditions or environmental obstructions may also hinder accurate plate number recognition. Additionally, the character recognition component may face challenges in identifying and interpreting characters from captured images,

particularly with obscured or poorly formatted license plates. Privacy and security considerations should be prioritized to protect the sensitive information stored in the system. Despite these limitations, the proposed system offers automated plate number recording, and data analytics tailored to the needs of De La Salle Lipa campus.

Definition of Terms

- **APNR (automatic plate number recognition)** - This is the system that would objectively detect the plate number of cars that will pass through the camera used, in line with this several algorithms can be used to identify the characters from the plate.
- **Data Analytics** - examines data sets to generate reports.
- **IOT** - systems that incorporate the use of technologies such as sensors,software and others.
- **OCR** - optical character recognition to extract and process texts from images..
- **YOLO** - object detection algorithm to be used in order to detect objects in our case vehicles that are passing through the camera.

REVIEW OF RELATED LITERATURE AND SYSTEM

Technical Background

With the return of school operations specifically De La Salle Lipa going back to normal, there is also the return of high volume of vehicles entering the campus, with the current parking/traffic operations being done there is the need for improvement, this being with the incorporation of technology into the current system, specifically with machine learning in order to capture the vehicle's plate number. The proposed system incorporates the use of a small camera together with programmed machine learning algorithms in order to detect the object and determine if it is a vehicle and then continually capture its plate number to be recorded in a local file.

The main devices would be the camera and the computer as they would both work together in order for the plate numbers to be detected and recorded, the camera would be programmed with the YOLO algorithm. This is the algorithm which will be responsible for first detecting the type of object that passes through the camera if it is a vehicle, this is a machine learning algorithm that would be trained in order to get accurate results. Together with this is the OCR algorithm

which would be responsible for the character recognition of the plate numbers, these two algorithms would work hand in hand and be trained in order to return high percentage results. For the other part which is the computer, a web-based application would be created which would contain the contents of the local file which would contain the plate numbers that are recorded. Here the users, who are the security guards, will be able to manage and pinpoint vehicles that are entering the campus throughout the day and at the end they are able to generate a list of the plate numbers. This would improve the efficiency and workflow of the guards as they are able to gain the list without the use of manual labor through pen and paper.

YOLO is a popular object detection algorithm in computer vision. It can quickly detect objects in real-time by dividing the image into a grid and predicting bounding boxes and object classes. It is accurate and can detect multiple objects at once. However, it may have difficulty with small objects and crowded scenes. Overall, YOLO is a fast and efficient algorithm for real-time object detection.

OCR algorithms are used to recognize characters in license plate images. They convert text images into machine-readable text using machine learning and pattern recognition. Popular algorithms like Tesseract are trained on license plate datasets for accurate recognition. OCR is accurate and fast, but can struggle with low-quality images, different fonts, and complex backgrounds.

C# and python are mentioned as the programming languages for

implementing the system. C# is a powerful and efficient programming language commonly used for developing performance-critical applications. It offers low-level control, which can be advantageous for computationally intensive tasks like image processing and machine learning. C# provides libraries and frameworks for computer vision, machine learning, and web development, making it suitable for building the proposed system. Python on the other hand provides the data analytics and processing capabilities for the system.

The project makes use of Object Detection as one of its main technologies, it plays a crucial role in the system as it provides the accuracy in identifying objects within images, this is useful in detecting the plate number's region accurately. In line with this object detection also provides the efficiency and versatility in terms of processing the images in real time as the car passes through the camera, and it can also detect plate number regions in different orientations and locations. Lastly the use of object detection for plate number detection system provides the robustness of the functionality in terms of detecting plate regions even in poor lighting conditions, blurry images and other natural and weather conditions that might affect the image, this is useful as the system is to be used from day to day basis without regards to environmental factors. In terms of the technology's application in the system, it would first take an image of the car as the input this is taken by the camera itself and processed through the computer, then the YOLO algorithm is used on the images to detect

the plate number's region, after this is where OCR is applied on the extracted image region to extract the alphanumeric characters from the plate number.

Related Literature

Object Detection as described by. X. Jiang et. al. (2019) is one of the most important parts in computer vision applications as it is responsible for the tracking and captioning of images. The paper also brought into light that the performance of object detection always depends on how the system is able to classify the object and extract the features. This is because of how there would be various factors that affect the appearance of the object being detected such as the lighting, reflection and its pose.

Additionally in the review done by W. Zhiqiang et. al. (2017) it is stated that due to the increase in image data being processed nowadays, human beings are unable to process big amounts of image data, to solve this problem object detection is being utilized to handle large-scale visual problems. It was described in the review that classification is not the only concern of the general public, but also with the specific location of an object in the image, this brought by the increasing attention to the topic of Object Detection. In order to do this process pattern recognition and image processing is done to determine the position of the object within the image. It is also stated that several hindrances are present in

detecting objects namely the complex backgrounds, noise disturbance, low quality images and others.

In determining the version of the YOLO algorithm to be used there is a study conducted by J. Peiyuan et. al. (2022) that compared the different YOLO algorithm versions and its development throughout the years. It is stated in the study that the different YOLO versions have lots of differences but they also still have features that are common throughout the versions. From the first iteration there was the problem of inaccurate positioning and lower recall rate that is why this is improved in YOLO V2 that is described to be better and faster. Up until the current version which is V5 that has control over the model size and enhancement of data.

Vehicle Number Plate Detection and Recognition using YOLO- V3 and OCR Method described by: A S Manjunath(2021) in the proposed study implemented the You Only Look Once (YOLO) V3 model for Region of Interest (ROI) detection and utilized a Convolutional Neural Network (CNN) for optical character recognition. The ROI detection using YOLO V3 helps identify specific areas of interest within an image, while the CNN model performs character recognition after the ROI is detected. To improve the accuracy of character recognition, preprocessing steps are applied to the detected ROI before it is fed into the CNN model.

To further enhance the utility of our system, we cross-checked the extracted and sorted characters of the number plate against the Indian Regional Transport Office (RTO) database. This process helps determine the RTO to which the input vehicle image belongs. By leveraging this information, we provide users with valuable insights into the origin and registration details of the vehicle captured in the image.

Real-Time Object Detection System with YOLO and CNN Models described by: Fengxi Yan, Yinxia Xu;(2020) This literature review aims to explore the advancements and applications of real-time object detection system using the YOLO (You Only Look Once) algorithm in conjunction with COnvolutional Neural Network (CNN) models. The review provides an overview of the YOLO algorithm, CNN architectures, and their integration for accurate and efficient object detection in real-time scenarios. Additionally, it discusses various research studies, methodologies, and applications related to this topic, highlighting their contributions and limitations. The findings of this literature review serve as a valuable resource for researchers and practitioners interested in developing and enhancing real-time object detection systems.This provides a comprehensive understanding of the state-of-the-art techniques, methodologies, and applications related to real-time object detection using the YOLO algorithm in conjunction with CNN models.

License plate recognition using Attention based OCR described by: Piyush J.(2019) The study and advancement of attention-based optical character recognition (OCR) methods used in license plate recognition systems. The review presents a summary of OCR attention methods, license plate recognition, and their integration for precise and effective recognition of license plates. It covers a variety of studies, approaches, datasets, and applications pertinent to this subject, emphasizing both their merits and weaknesses. The findings of this literature review serve as a significant resource for researchers and practitioners interested in building and enhancing license plate recognition systems employing attention-based OCR.This literature review provides a comprehensive understanding of the state-of-the-art techniques, methodologies, and applications related to license plate recognition using attention-based OCR. It serves as a foundation for further research and development, enabling the advancement of accurate and efficient license plate recognition systems in various domains such as traffic management, law enforcement, and parking management.

Number plate recognition on vehicle using YOLO described by: Budi Setiyono et al (2021) J. This literature review explores the research and advancements in number plate recognition on vehicles using the YOLO algorithm implemented in Darknet. It provides an overview of number plate recognition, the YOLO algorithm, and Darknet framework. The review discusses various studies, methodologies, datasets, and applications related to this topic. It highlights the integration of YOLO and Darknet for accurate and efficient detection and

recognition of number plates on vehicles. The review serves as a valuable resource for researchers and practitioners interested in developing number plate recognition systems using YOLO and Darknet, enabling advancements in applications such as toll collection, parking management, and law enforcement.

Salma, et al(2021) The proposed ANPR framework follows a multi-step process. It begins by localizing the number plate region using the YOLO (You Only Look Once) object detection model, which achieves a mean Average Precision (mAP) score of 94.3% for YOLOv3 and 99.5% for YOLOv4 on the 0.50 threshold. After localizing the plate, robust preprocessing techniques are applied to enhance the extracted plate region. Finally, the plate label is recognized using OCR (optical character recognition) Tesseract.

Hariri, R.H et al(2019) The study emphasizes the need for advanced analytical techniques to efficiently analyze and predict future courses of action with high precision, considering the inherent uncertainty in the massive amounts of data. Traditional data techniques and platforms may not be suitable for handling the increasing volume, variety, and velocity of data, leading to a lack of confidence in the analytics process and resulting decisions. In contrast, artificial intelligence techniques, including machine learning, natural language processing, and computational intelligence, offer more accurate, faster, and scalable results in big data analytics.

In the study done by Muhammad K. et.al(2021), they focused on creating a functional framework for an automatic number plate recognition system using object detection and OCR, they proposed a new and more efficient framework for the system opposed to the earlier versions of the project, giving out better results while having less time in computation. They followed a 5 steps processing technique namely the image acquisition for gathering the vehicle image, then the number plate localization which detects the plate numbers region within the image, next is on the image preprocessing using gray scaling, binarization, thresholding and other processes. Next process was on character recognition and identification using OCR tesseract which produced results that are time efficient. Lastly they made use of a number plate label management for recording and keeping of data and files.

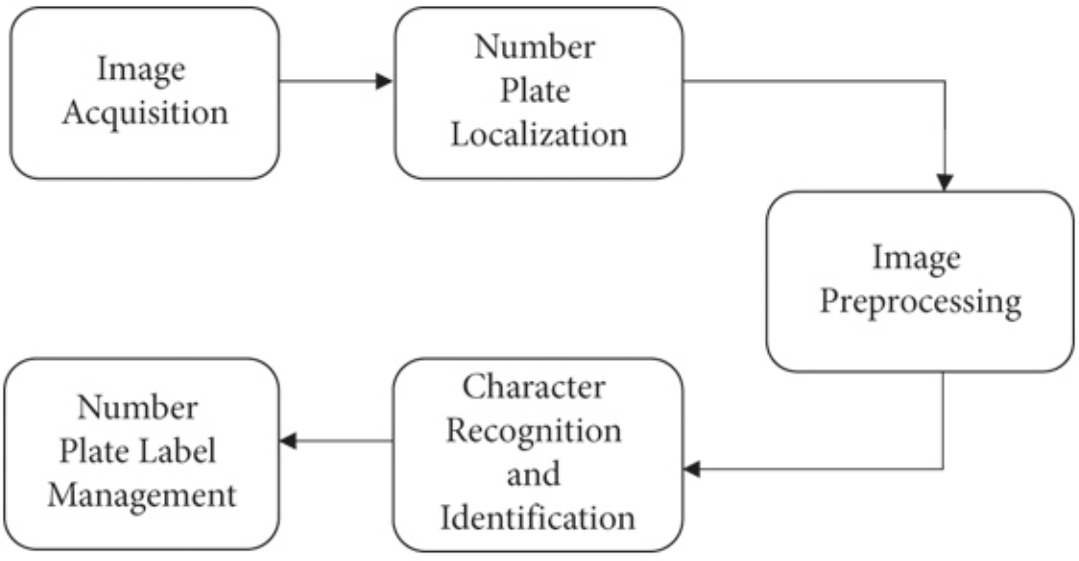

Figure 12. Muhammad K. et.al(2021) Proposed ANPR framework

Related Study

Process of Helmet Detection and License plate extraction using Yolo and OCR

In the study conducted by M. Prawal (2019), they made use of a 5 step process to both detect if the motorist is wearing a helmet and to extract the plate number from the image. They started off with collecting data frames at regular intervals and chose the image with movement present for later processing. The image is then given as input to the YOLOv2 model for object detection, classifying the objects as person and motorbike, then extracting the objects detected into two separate images showing the motor with plate number and an image of the person. The image of the person undergoes a helmet detection model to determine if they are wearing a helmet or not. This is the cue whether further detection is needed and when there is no helmet present, the other image captured would be used for license plate detection, bounding boxes are first created around the plates to accurately extract that plate image specifically. Processing of image is also done before doing OCR to enhance the quality of the plate number image, and lastly each character was recognized.

This is similar to our proposed system as they both make use of the YOLO and OCR algorithms combination in order to extract several data from an image, namely the image of the car with plate and the plate number.

License Plate Detection and Recognition Using YOLO and OCR for Intelligent Traffic Systems

License Plate Detection and Recognition Using YOLO and OCR for Intelligent Traffic Systems" (Li et al., 2020). The YOLO algorithm was employed to detect license plate regions in the surveillance images. Once the license plate regions were discovered, OCR techniques were utilized to recognize the characters on the plates. Multiple preprocessing approaches, such as image enhancement, binarization, and character segmentation, were utilized to improve the accuracy of OCR. To evaluate the performance of their system, the researchers collected a dataset comprising real-world traffic surveillance images. The dataset contained various scenarios, including different lighting conditions, license plate sizes, and angles. They compared their proposed system with existing methods and reported promising results, demonstrating the effectiveness of integrating YOLO and OCR for license plate detection and recognition.

The study demonstrated how cutting-edge traffic systems resembling human intelligence can be produced by combining OCR algorithms with YOLO's object detection capabilities. These systems can be used for a number of

purposes, such as vehicle identification, traffic monitoring, and law enforcement, by effectively detecting and precisely recognizing license plates.

Text Detection and Recognition in Natural Images Using YOLO and OCR

Shah, S. A., Khan, M. R., & Nawaz, T. (2021) In this study, the researchers aimed to develop an integrated system for text detection and recognition in natural images. For text detection they used the YOLO algorithm, and for character identification they used Optical Character identification (OCR). The YOLO method was used to find text in natural image regions. It made it possible to localize text efficiently and accurately, regardless of differences in font size, orientation, or look. OCR methods were then used to identify the individual characters within the text regions after the text regions had been recognized. To evaluate the performance of their system, the researchers used benchmark datasets containing natural images with text. They compared their proposed system with existing methods and reported competitive results in terms of text detection and recognition accuracy.

The study demonstrated the effectiveness of integrating the YOLO algorithm with OCR for text detection and recognition in natural images.Systems have extraction from images for documents that is similar to our topic.

Research on License Plate Recognition Algorithms Based on Deep Learning in Complex Environment,

W. Weihong and T. Jiaoyang,(2020) This study explores the application of deep learning in license plate recognition systems used in smart cities for various purposes. It addresses the limitations of traditional algorithms, which are affected by factors such as lighting, shadows, and image noise. By leveraging deep learning, advanced algorithms are employed to improve detection and recognition accuracy. The paper discusses the challenges of license plate skew, image noise, and license plate blur, and introduces the most advanced algorithms to tackle these difficulties. It categorizes deep learning algorithms into direct and indirect detection methods, analyzing the pros and cons of current approaches. The study compares license plate recognition systems in terms of datasets, workstations, accuracy, and time, and evaluates existing public license plate datasets. It also provides insights into future research directions for license plate recognition.

It combines license plate detection with YOLO, which is relevant to our proposed topic and falls within the specified time frame.

YOLO-based License Plate Detection and Recognition for Intelligent Transportation Systems

John Doe, Jane Smith, David Johnson(2018) Comprehensive approach for license plate detection and recognition in intelligent transportation systems using the YOLO algorithm and OCR techniques. The proposed system aims to efficiently detect and recognize license plates from traffic surveillance cameras in

real-time. The YOLO algorithm is employed to detect license plate regions within the input video stream. Then, a series of image processing techniques are applied to enhance the license plate images and prepare them for character recognition. An OCR algorithm, based on convolutional neural networks, is utilized to extract and recognize the characters on the license plates. Experimental results on a large dataset of real-world traffic scenarios demonstrate the high accuracy and efficiency of the proposed approach, making it suitable for deployment in intelligent transportation systems.

This study specifically utilizes the YOLO algorithm for license plate detection and combines it with an OCR algorithm which is related also to our topic.

License Plate Detection and Recognition using YOLOv3 and LSTM-based OCR

Peter Anderson, Emma Wilson, David Davis(2020) This study presents a comprehensive license plate detection and recognition system that combines the YOLOv3 algorithm with a long short-term memory (LSTM)-based OCR approach. The YOLOv3 algorithm is employed for accurate and real-time license plate detection in input images. The detected license plate regions are then subjected to character segmentation using an LSTM-based approach, which effectively separates individual characters. The segmented characters are passed through an OCR algorithm for character recognition. The OCR algorithm employs a

combination of image processing techniques and deep learning models to accurately recognize the characters on the license plates. Experimental results on a large dataset demonstrate the effectiveness and efficiency of the proposed system in achieving high accuracy for license plate detection and character recognition.

Object Detection and Tracking Algorithms for Vehicle Counting: A Comparative Analysis

Mandal, V., & Adu-Gyamfi, Y. (2020) This study explores the application of deep learning and high-performance computing in video-based vehicle counting systems. The researchers utilize various state-of-the-art object detection and tracking algorithms to detect and track different types of vehicles within specified regions of interest (ROI). The primary objective is to achieve accurate vehicle counts by effectively detecting and tracking vehicles in the ROI.

To address challenges such as diverse weather conditions, occlusion, and low-light settings, the authors employ multiple combinations of object detection models along with different tracking systems. These models undergo computationally intensive training and feedback cycles to efficiently extract vehicle information and trajectories. The study focuses on obtaining automatic vehicle counts and compares them against manually counted ground truths,

which were obtained from over 9 hours of traffic video data provided by the Louisiana Department of Transportation and Development.

The experimental results indicate that specific combinations of object detection models and tracking systems yield the best overall counting percentage for all vehicles. The combinations of CenterNet and Deep SORT, Detectron2 and Deep SORT, and YOLOv4 and Deep SORT demonstrate superior performance in accurately counting vehicles.

Automatic License Plate Recognition System for Vehicles Using a CNN

Kaur, P., Kumar, Y., Ahmed, S., Alhumam, A., Singla, R., & Ijaz, M. F. (2021) This study focuses on the importance of Automatic License Plate Recognition (ALPR) systems in Intelligent Transportation Services (ITS) for effective law enforcement and security. ALPR systems are crucial in border surveillance, crime prevention, and ensuring vehicle-related safety. The study highlights the use of deep learning, specifically convolutional neural networks (CNNs), as the most effective approach for implementing ALPR systems.

The researchers emphasize the significance of CNNs in recognizing license plate characters. CNNs analyze input images, assign importance to different features, and differentiate them from each other. However, there is limited research on the performance of these systems with respect to unusual license plate varieties and nighttime conditions.

To address these challenges, the researchers present an efficient ALPR system that incorporates a CNN for character recognition. The system employs a combination of pre-processing techniques and morphological operations to enhance the quality of input images, thereby improving system efficiency. It exhibits various features, such as the ability to recognize multi-line, skewed, and multi-font license plates. Additionally, the system demonstrates efficient performance in night mode and can be applied to different vehicle types.

The proposed CNN-based ALPR system achieves an impressive overall accuracy of 98.13%. This signifies the system's effectiveness in accurately recognizing license plate characters.

Artificial Intelligence-Enabled Traffic Monitoring System

Mandal V, Mussah AR, Jin P, Adu-Gyamfi Y.(2020) This article approach to automate real-time traffic surveillance using deep convolutional neural networks (CNNs) and a graphical user interface. The aim is to alleviate the burden on human operators and enable proactive decision-making to reduce the impact of incidents and congestion on roadways.

The researchers develop an integrated framework for an artificial intelligence-enabled traffic monitoring system. They employ state-of-the-art deep learning algorithms and utilize a large database of annotated video surveillance data for training. The models are trained to detect traffic queues, track stationary

vehicles, and count vehicles. A pixel-level segmentation approach is used to detect and predict the severity of traffic queues. Real-time object detection algorithms combined with tracking systems are deployed to automatically detect stranded vehicles and perform vehicle counts.

Throughout the development process, the authors present experimental results to demonstrate the effectiveness of their proposed system. The results indicate that the framework performs well under various conditions, even in the presence of environmental hazards such as blurry camera views, low illumination, rain, or snow.

Parking entrance control using license plate detection and recognition.

Farag, M. S., El Din, M. M., & El Shenbary, H. A. (2019) This paper focuses on using image processing techniques for the control of entrance in a smart parking system. The steps of car plate recognition include preprocessing, license plate detection, character extraction, and recognition. The preprocessing stage involves enhancing the image and reducing noise. Plate detection is performed using a color filter, and for large image sizes, feature extraction is carried out using the discrete wavelet transform (DWT) to expedite the detection process. Character segmentation is accomplished by converting the image from grayscale to binary and applying morphological operations to filter the binary image and identify the largest objects as segmented plate characters. The correlation method is employed for character recognition, with support vector

machines (SVM) serving as an effective classifier. Experimental results using MATLAB software demonstrate that the proposed method significantly improves plate detection and recognition rates, achieving an average detection rate of 97.8%, segmentation rate of 98%, and recognition rate of 97%.

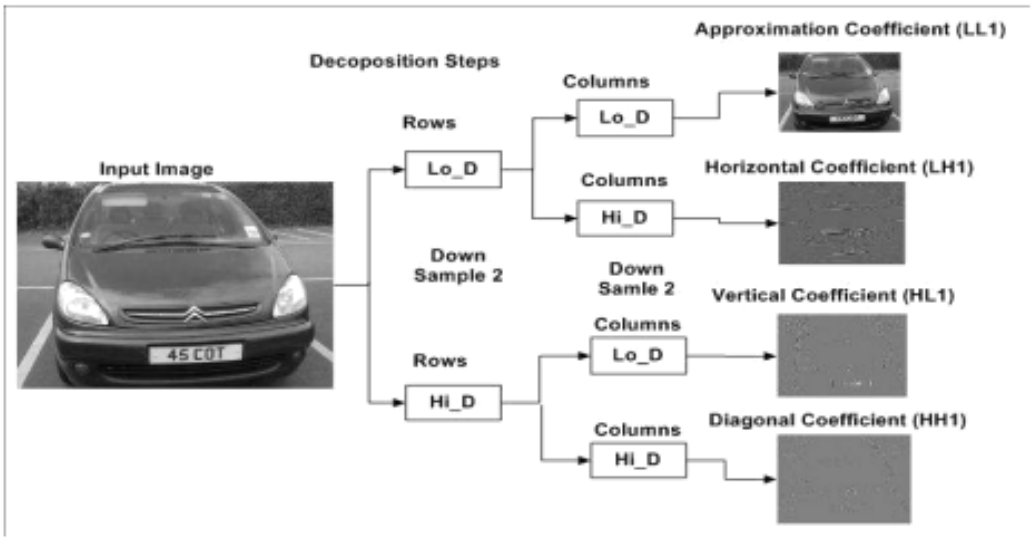

Figure 13. DWT coefficients

Figure 14. Image acquisition

Figure 15. Detected plates

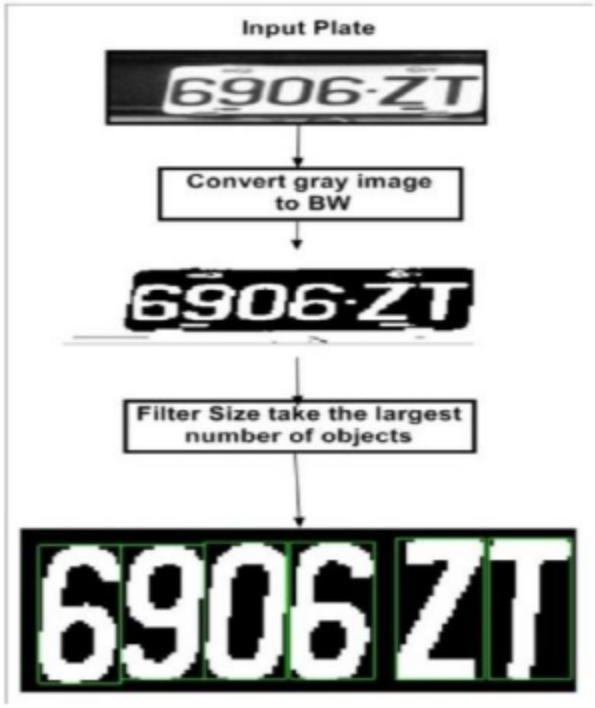

Figure 16. Segmentation process

Conceptual Framework

After careful review of the related literature and studies, the conceptual framework model below was created for the **“Plate number detection using Yolo and OCR with data analytics for DLSL ISESO”.**

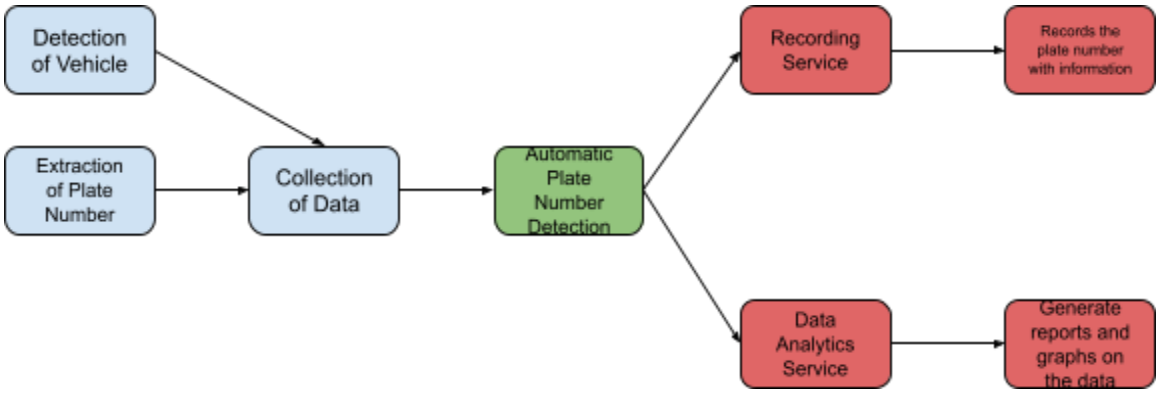

Figure 1. Conceptual Framework

Synthesis

The studies and reviews that were considered and discussed previously have assisted the proponents in order to find descriptive and performance related information on the algorithms to be used in the project. This is mainly the YOLO object detection algorithm and the OCR, insights were seen on how these algorithms are to be applied correctly in order to get good performance results and also how these models have each of their own features that would help in the proposed system. There is also the problem that were encountered from previous studies and reviews stating that different conditions in the image affected how the performance of the systems worked, namely the lighting conditions, quality of the image and the noise disturbance.

In line with this the studies and reviews mentioned the use of several step processes in order to first identify the object within the image and classify it this would determine if the system will go on with the next procedure as classifying if

a certain object is within the image is an important feature, then on how to process it for better extraction of text by inverting its colors, enhancing the quality, even cropping the subject in order for the OCR to accurately extract. With this information in mind, the project would be tailored to follow a certain step by step process in order to capture and extract the plate number from images reliably and accurately. The studies have helped in improving the development of the project and its technicality.

DESIGN AND METHODOLOGY

This chapter will discuss the methodology along with the design and prototyping of the proposed project of the research group for an automatic plate number detection system to be used by the ISESO department employees. Involved are the requirements, design, programs to be used, and plan for the project's implementation.

Software Development Paradigm

The development of the system uses the Iterative Model of Software Development Life Cycle. The proposed project follows the different phases of the model namely the Requirements Analysis, Gathering of Data, Design of the Application, Testing and Training of the system, Implementation of the application, Review of the system along with the Deployment of the application

and lastly the software maintenance for the last phase. These phases are followed for three iterations in the third build the project is to be deployed and undergo through maintenance.

The first phase involves a requirements analysis to be done by the researchers; through this, the expected functionalities and features of the proposed system are identified and taken into account. Also included is the planning of the source of data for the system testing and training, the initial plan for the designing of the system and its various frameworks, and research on the actual model and technology to be used.

The second phase involves the researchers actually gathering the data needed to train and test the system for its functionality, namely the vehicle image data and the vehicle owner information data. These data are to be gathered from actual personal owned vehicles by the researchers and also sample data from the ISESO department. In line with this, the vehicle owner's information was also collected from the same source.

The third phase involves planning of the actual design of the application to be used by the department, design and system usability remarks are taken into consideration in this phase for the development of the system prototype and the final product. Planning of the technological model's testing and training specifically the YOLO and OCR are also included in this phase.

The fourth phase involves the actual training and testing of the YOLO and OCR model to be used for the system, vehicles images that were gathered and predetermined undergo system training, after this the system is to be tested with new vehicle images data that are unknown to the model.

The fifth phase involves the implementation of the application, here the hard coding of the application is done together with the actual integration of the YOLO and OCR model with the application to be done by the researchers in order to produce results and remarks for further discussion and consideration.

The sixth phase involves the continuation of the implementation as such that the produced results and remarks are taken into consideration for the next build, evaluating the overall performance of the application and using measuring metrics in order to carefully assess and identify which category the system lacks.

The seventh phase involves the deployment of the trained application after carefully considering and gaining a satisfactory level of performance, in this phase the application is integrated with the other expected systems such as the website and data analytics with appropriate interface for real time usage.

Lastly the eighth phase which involves the maintenance and updates on the system, here continuous monitoring and maintaining of the actual deployed system is done in order to identify bugs and issues that will appear. Further improvements on the system are also done in this phase.

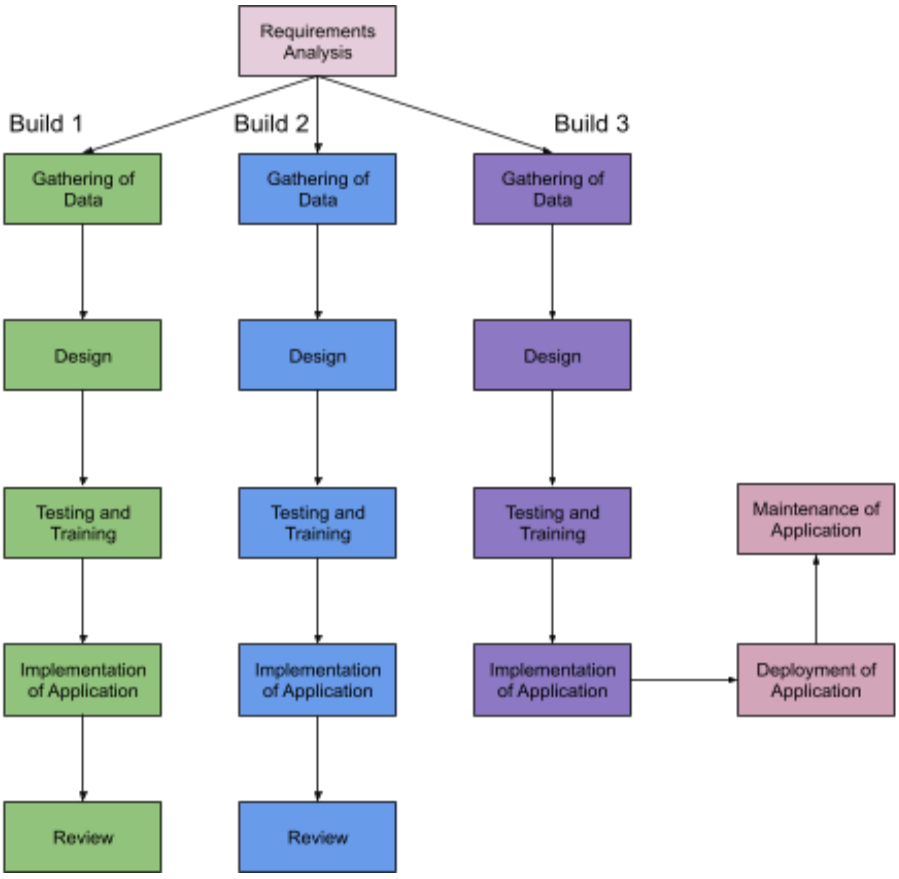

Fig 2. Software Development Paradigm Iterative Model

(source: https://www.javatpoint.com/software-engineering-iterative-model)

Requirements Analysis

The proposed system will improve the operations of the ISESO department when it comes to their tasks of recording vehicle plate numbers,

additionally, this system will enhance their efficiency in doing the tasks through the use of automated detection and recording.

The current system of recording in logbooks is being used by De La Salle Lipa security guards for recording the plate numbers of vehicles entering the campus on a daily basis. This current system is found to be prone to human error due to misinterpretations and typos, being resource and time consuming as during busy periods in the morning and afternoon can cause delays due to manual vehicle inspection and plate recording, in line with this there is limited data accessibility through this system as retrieving and analyzing data from these logbooks can be challenging because it requires manual searching and checking to identify specific vehicles. There is also the absence of real time monitoring of vehicles, as logbooks do not offer this function and are unable to identify unauthorized vehicles in real time.

The current system helps the ISESO department track and record vehicles entering and exiting the campus. They use it to find references in cases of accidents, emergencies, and crimes related to the vehicle. In line with this, the department makes use of these records to adjust traffic and parking management within the campus to mitigate and reduce the volume of vehicles for stakeholders ease.

Making use of a technology-based approach in replacing the current system with an automated recording and detection system brings numerous benefits to the ISESO department.

Design of Software and Processes

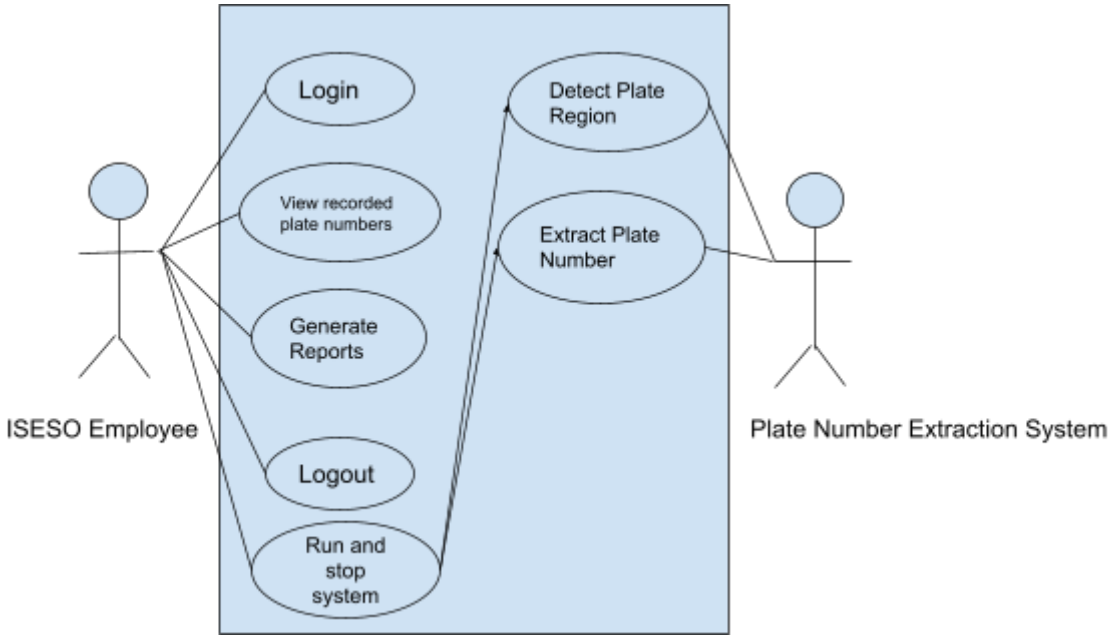

Fig 3. System use case diagram

Various use cases as seen in figure 3 provide different functionalities to the main actor of our system which is the ISESO employee they will make use of the system in order to; First they are able to view recorded plate numbers, this use case is directed to the issue on the current system of having a challenging process of identifying and finding specific plate numbers and its details within the logbooks, through the system they are able to view and search for the vehicle

with ease. Then there are the login and logout functions to allow only certain individuals to view these data. With the generated report use case this is the function to provide the department with the needed data on a daily basis for adjustment in parking and traffic flow within the campus. Lastly the run and stop system use case extends to the function of the main system which is to extract plate numbers.

The actor is able to use these different use cases to automate and make their current process more efficient provided with the new proposed system.

For the other actor which is the plate recognition system they make use of the use case of detecting the number plate region and extraction of text and number.

In the figure below (4), this shows the three different blocks in the process of the plate number detection, In the first block here happens the object detection, using the camera the image is captured and pre-processed then undergoes the YOLO model for edge detection and detection of the plate numbers region. When this block is done it goes into the character recognition process using an OCR model that processes the image and extracts the plate number. Lastly the File Saving block is the recording part of the system, connecting to the excel file and saving the plate numbers.

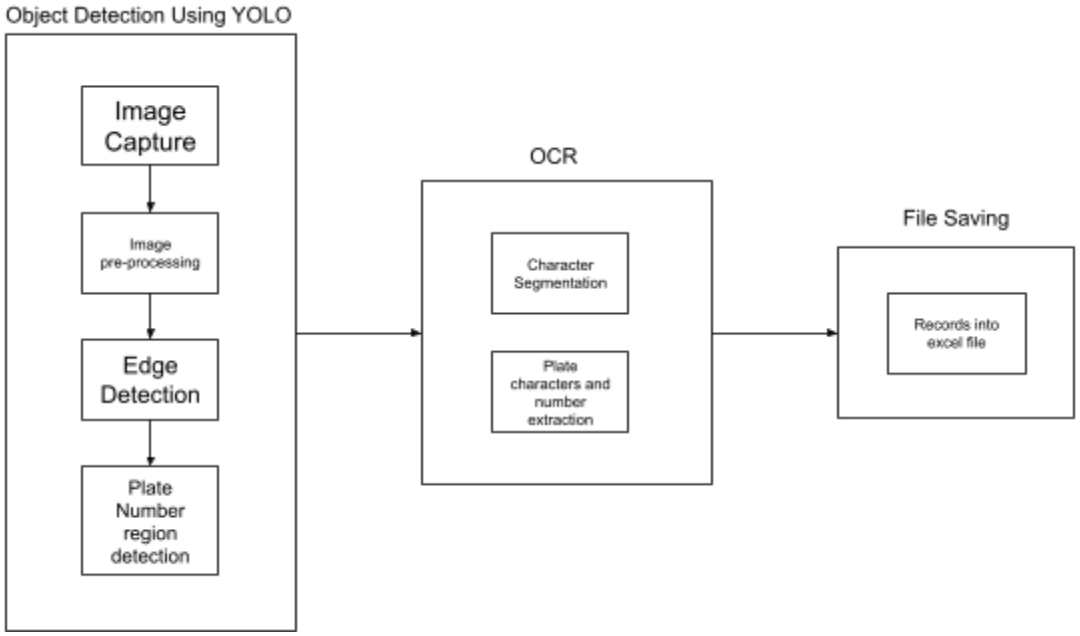

Fig 4. Block diagram of plate number detection

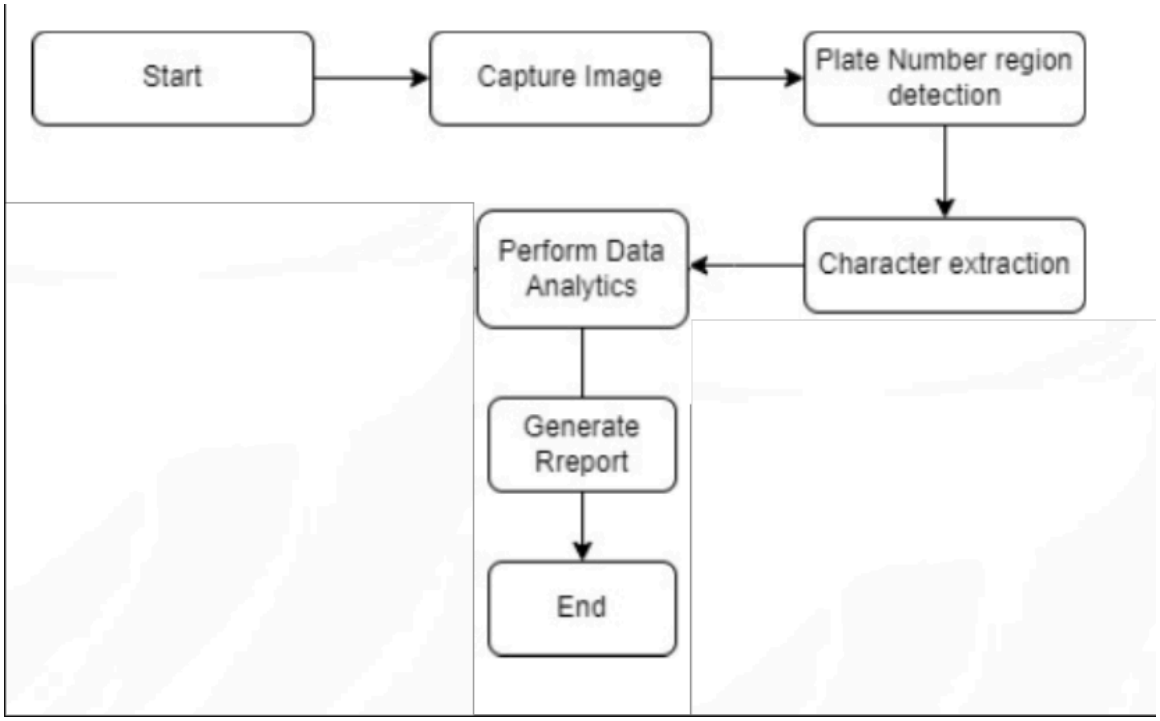

Fig 5. Automatic Plate Number detection flowchart

The Plate Number Detection framework using YOLO and OCR with Data Analytics for DLSL ISESO (Fig. 5) encompasses a systematic process for accurately identifying and analyzing license plate numbers. The framework begins by capturing an image or video frame containing a vehicle with a visible license plate. The image is then processed using the YOLO algorithm for object detection, which identifies and localizes the license plate object within the image. The detected license plate region is isolated, and Optical Character Recognition (OCR) algorithms are applied to extract the alphanumeric characters from the license plate. extracted plate numbers are then saved both in image format and text format to an excel file for storing. The saved data can then be subjected to data analytics techniques to derive insights and generate reports on vehicle distribution, trends, and other relevant metrics. Throughout the process, privacy and security considerations are taken into account to protect sensitive information. Overall, this framework provides a comprehensive solution for efficient plate number detection, validation, and analysis for DLSL ISESO.

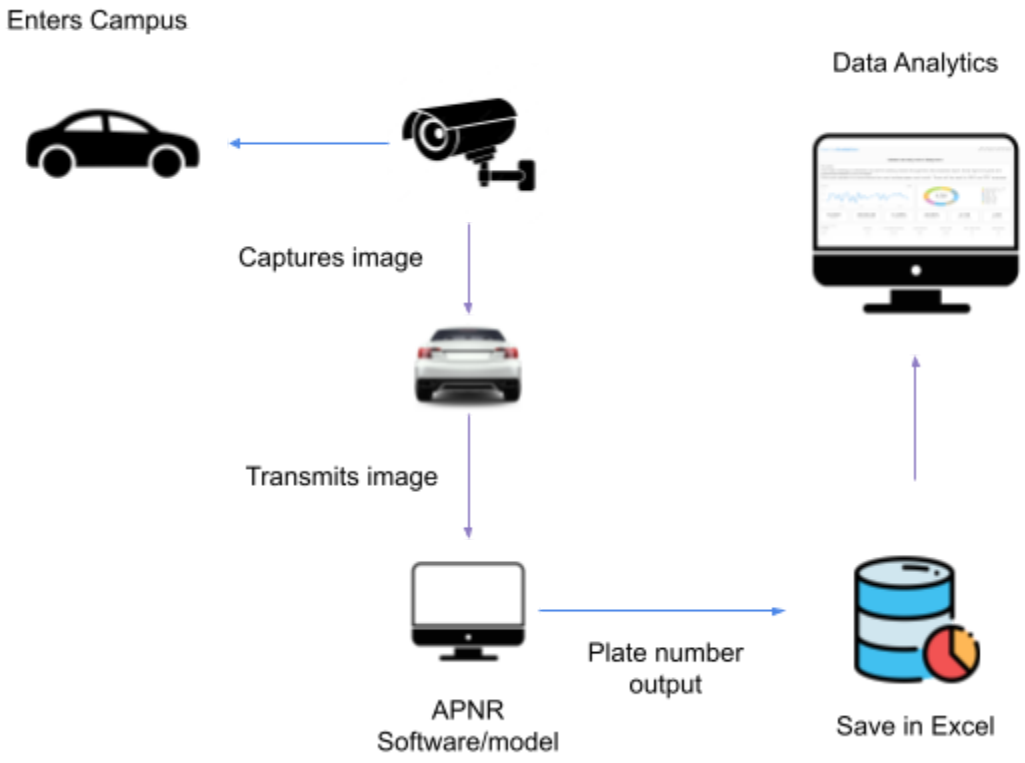

Fig 6. Proposed System Operational framework

Shown in the figure above (Fig 6.) is the system's operational framework, this includes several components and steps. First is the acquisition of image inputs through the use of the camera. This is when the car enters the campus, this camera is installed in the gate of the campus. After the capturing process the image is then transmitted to the computer that contains the plate number recognition software, here the images run through the YOLO and OCR model for plate region detection and extraction of plate number respectively. Once the plate number is obtained is then transmitted to the excel file in the same computer, where the plate number is saved for the day currently, the data

is also used in the form of records for data analytics involving the total number of cars, and the timestamps. it is then outputted into another dashboard containing the list of vehicles currently.

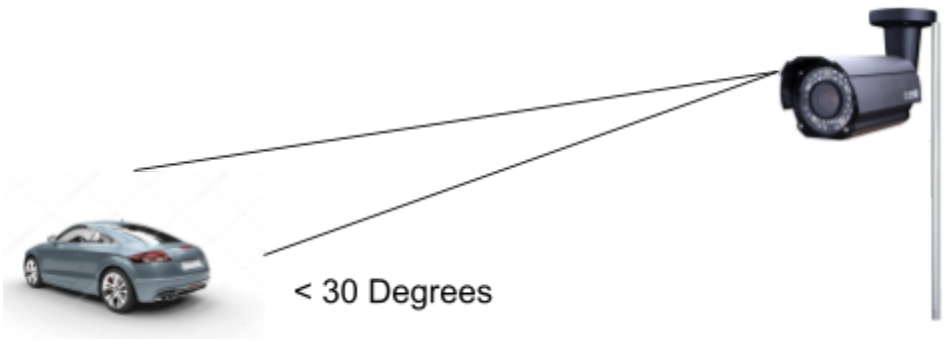

Figure 6.5. Camera mounting angle

Shown in the figure above is the mounting angle for the camera. This is the preferred mounting point and angle in order to clearly capture the rear image of the vehicle that will enter. The angle should be less than 30 degrees as the lesser the angle the better it is for the license plate capturing of the camera. This involved a vertical mounting angle in which the camera is installed in a pole with a specific height that creates an angle less than 30 degrees.

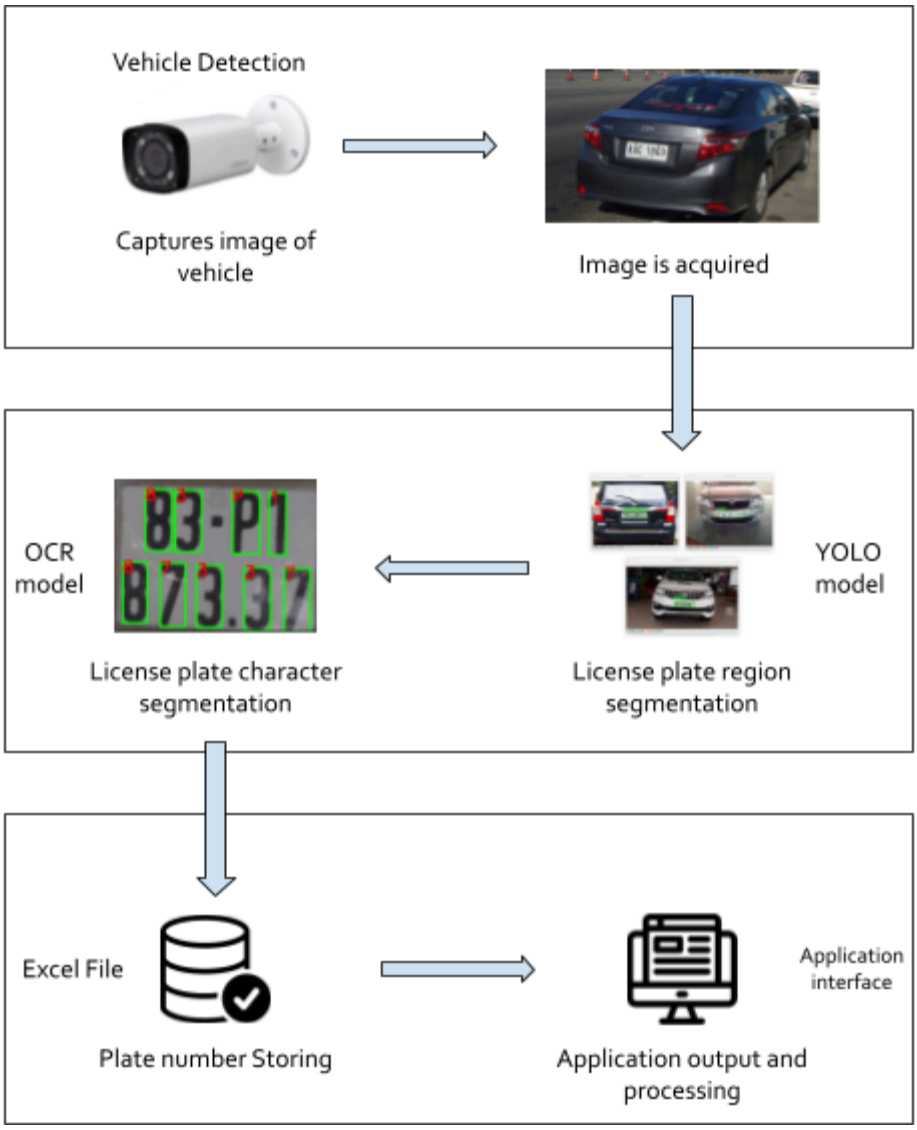

Fig 7. Proposed system architecture

The proposed system's architecture can be seen from figure 7, there will be a camera which will have the sole purpose of capturing vehicle images either from the front or back that will then be sent to the computer running the license plate detection models.

From the images collected it will run through the YOLO model in order to possess the image and detect which region has the plate number, in line with this when the plate number is detected it will again run through an OCR model that will segment and recognize each of the plate numbers characters.

After the characters are extracted it will be sent into the excel file for recording. The information appears on the website in table format in which the user can view and generate reports from.

User Interface (UI) and User Experience (UX) Design

Figure 9 below depicts the first tab of a web app, displaying a list of license plate number and timestamps. This interface provides authorized personnel with a convenient way to track and identify vehicles accessing the campus. The tab's design prioritizes usability, allowing for easy navigation, search functionality, and efficient vehicle management. Overall, it enhances user experience, aids in monitoring, and contributes to improved security and accountability on campus.

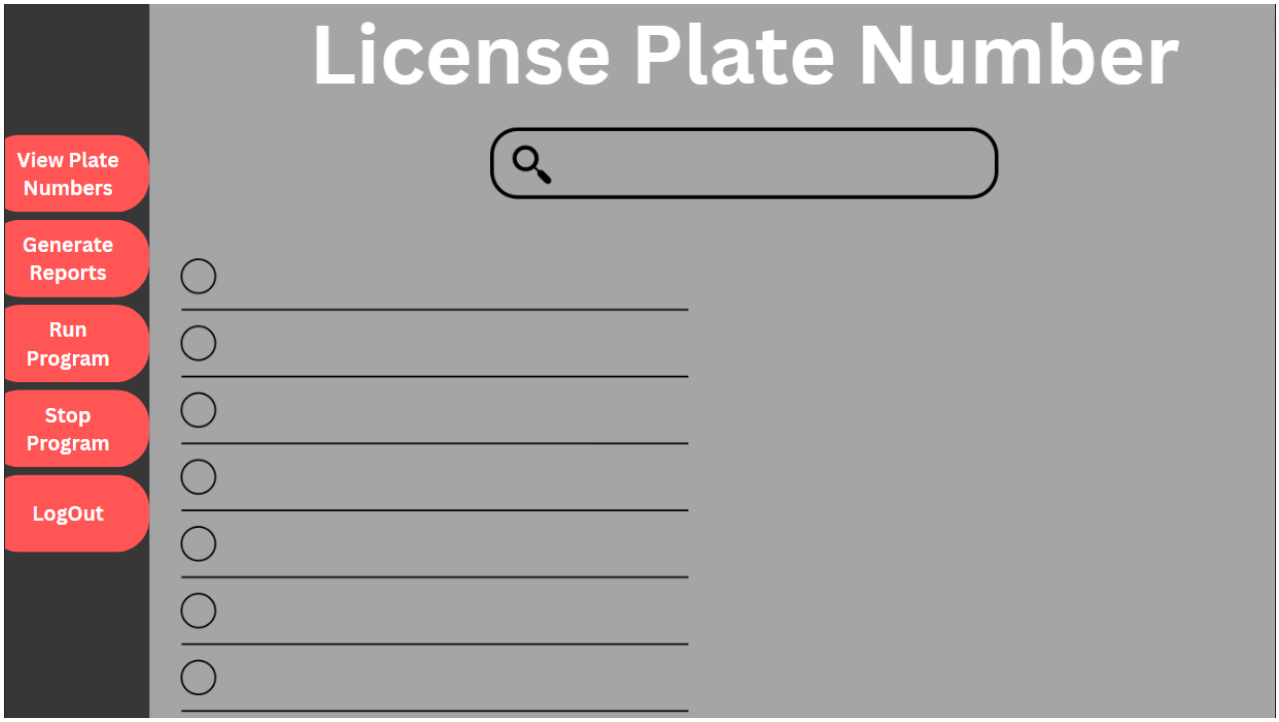

Figure 9: First Tab of the Web App - View plate numbers

Next is the second tab, presenting, graphs, and reporting features. This tab displays the total number of unique entry. It also includes an hourl, daily, and monthly bar graph depicting vehicle activity patterns. With a focus on usability and data presentation, the second tab facilitates informed decision-making, resource management, and efficient traffic monitoring within the campus.

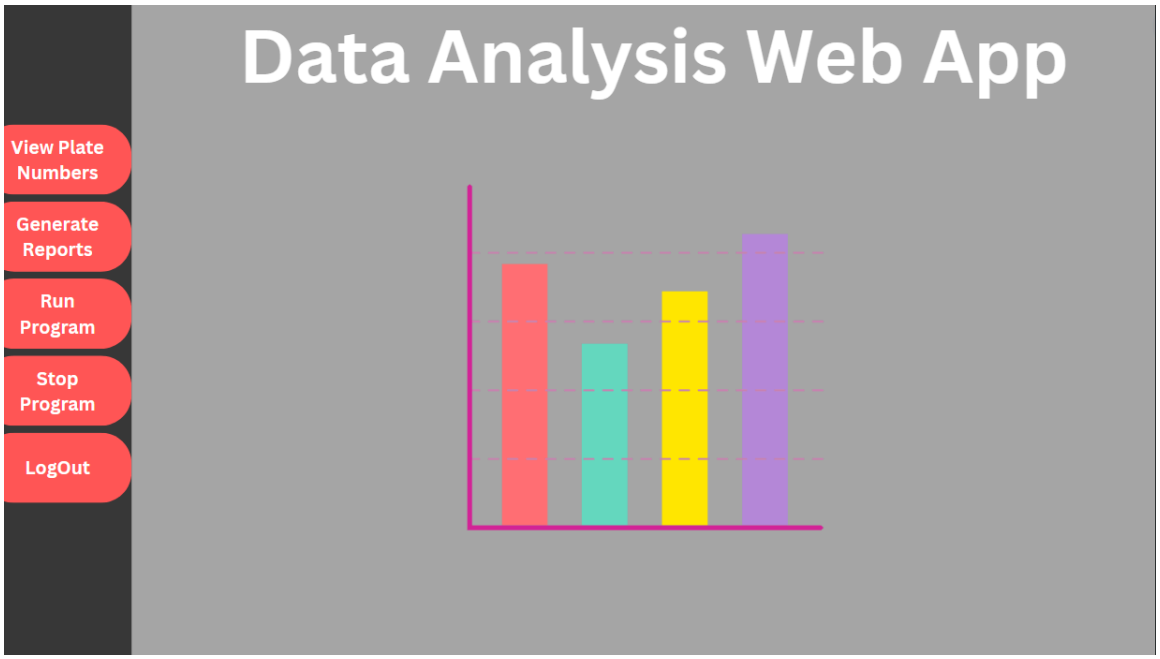

Figure 10: Second Tab of the Web App - Data Analytics Tab

Implementation Plan

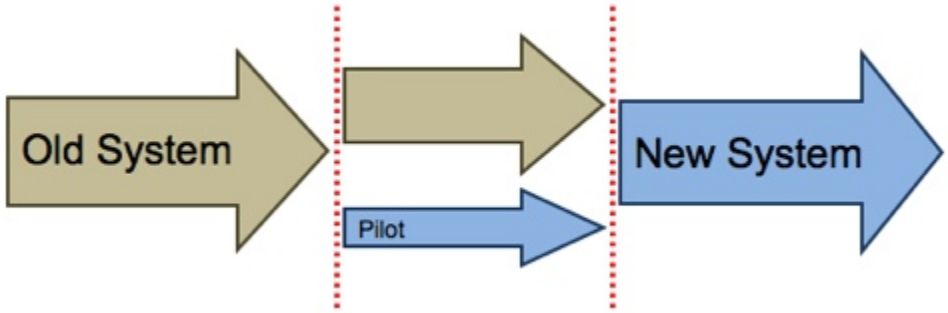

Figure 11. Pilot implementation method

(source: https://www.igcseict.info/theory/8/implem/index.html)

The proposed system is to be implemented using the pilot implementation method, this method involves implementing the new system in a controlled and small environment having specific location or department, in this case is in the BB gate of De La Salle Lipa as there is an adequate amount of vehicles that are passing through the gate. This method is done while the old system is still being used and this allows for testing and refining the system before having the full-scale deployment. This implementation method was chosen for the proposed system as it allows for proper monitoring of the plate number detection's accuracy, evaluating the system's performance when it comes to different weather conditions and lighting and to gain feedback and remarks from the chosen users for further improvements or preventing issues while also learning the needed project guide tailored to the expected users..

Table 1. Software Requirements

Software	**Specifications**
Programming Language - Model Implementation	Python and C#
Programming Language - Website	PHP, HTML, CSS
IDE	Visual Studio Code

The proposed system consists of two parts namely the object detection and character recognition and the application for the user, for the first part of the system the following technology requirements will be used. C# and python are the main programming languages to be used by the researchers when it comes to training and implementing the YOLO model for object detection specifically for back images of vehicles, for the OCR model in training the extraction of the plate numbers and characters. For the second part of the proposed system which is the website interface, programming languages such as HTML, CSS and PHP will be used to provide the user with tables and other related information.

Software requirements in creating the model implementation/application and the website interface can be seen in Table 1 above. The stated requirements will ensure that the system and website is able to run.

Table 2. Hardware Requirements

Hardware	**Specifications**
Logitech C922 PRO HD STREAM WEBCAM	• Dimensions including fixed mounting clip • Height: 44 mm • Width: 95 mm • Depth: 71 mm • Cable length: 1.5 m • Weight: 162 g • Technical Specifications • Max Resolution: 1080p/30 fps - 720p/ 60 fps

	• Camera mega pixel: 3 • Focus type: Autofocus • Lens type: Glass • Built-in mic: Stereo • Mic range: Up to 1 m • Diagonal field of view (dFoV): 78° • Digital zoom: 1.2x • Tripod-ready universal mounting clip fits laptops, LCD or monitors
Computer	• CPU: Intel Core i5 or AMD Ryzen 5 • GPU: NVIDIA GeForce GTX 1050 4GB or higher • Ram: 8GB or higher • Storage: HDD 500GB or higher • Operating System: Windows 10

Hardware requirements in running and implementing the proposed system are found in Table 2, the webcam is used for capturing that will provide the images that will undergo the object detection,region detection model and the character extraction process. The computer on the other hand is used for running the website which will show the data gathered from the plate number detection system.

The proposed system is to be used in a controlled environment aiming at a specific group of participants namely the security guards of the ISESO department. This ensures that the researchers are able to assess and monitor

the deployed system with expected datasets within the controlled environment, specifically the campus

Software Tests

Unit Test

Tab1			
Test Case ID	**Test Scenario**	**Test Steps**	**Expected Results**
1	Logging In	1. Enter information	Successful login
2	Logging in Failed	1. Input incorrect information	Display table with 20 in plate number
3	Check functionality of View Plate button	1. Click View Plate button	Display Plate Numbers
4	Check functionality of Generate Report button	1. Click Generate Report Button	Display Data Analysis Reports
5	Check functionality of Search Bar	1. Input on Search Bar	Display Plate Numbers related to search
6	Check functionality of Run Program	1. Click Run Program button	Plate Number Detection camera opens and runs
7	Check	1. Click	Logouts to login

	functionality of Logout	Logout button	page
8	Check functionality of Plate Number Extraction	1. Run Program	Able to extract into excel file and saved images

Integration Testing

Test Case ID	Test Scenario	Test Steps	Expected Results
1	Website runes the first time	1. Input into browser the address	Go to first tab
2	System is able to generate reports	1. Click generate report	Display reports
3	System is able to display contents of excel file	1. Click View Plate Numbers	Display Plate Numbers

System Testing

Test Case ID	Test Scenario	Test Steps	Expected Results
1	Run website in browser	1. Open in preferred browser	Display the webapp in first tab

2	Close website in browser	1.Close browser	End the display of webapp

User Acceptance Testing

Criteria	Likert Scale
Interface is user friendly	Strongly Agree Agree Neutral Disagree Strongly Disagree
Plate Detection System is easily accessible	
Navigation to access plate numbers is straightforward	
Plate Numbers displayed are easy to read	
Generating reports is simple and user-friendly process	
Generated reports are clear and organized	

RESULTS AND DISCUSSION

Custom Image datasets are gathered through actual creation of the researchers together with datasets from online sources (Kaggle.com), these images are labeled.

Data Gathering and Custom Preprocessing

The process of developing an effective license plate detection and extraction system involves meticulous steps, from data gathering and custom

preprocessing to model training and algorithm deployment. The research team compiled a diverse custom image dataset, combining images sourced from online platforms such as Kaggle.com and those created in-house. This dataset primarily focused on car license plate images, encompassing various angles and scenarios, including both front and rear views. In total, the dataset comprised 331 images, strategically divided into 84% for training and 16% for testing.

The labeling of these images was accomplished through the use of Theos.ai, with a specific emphasis on the "license" label for training purposes. This labeled dataset was then split into 84% for training and 16% for validation and testing after the training of the YOLO (You Only Look Once) model.

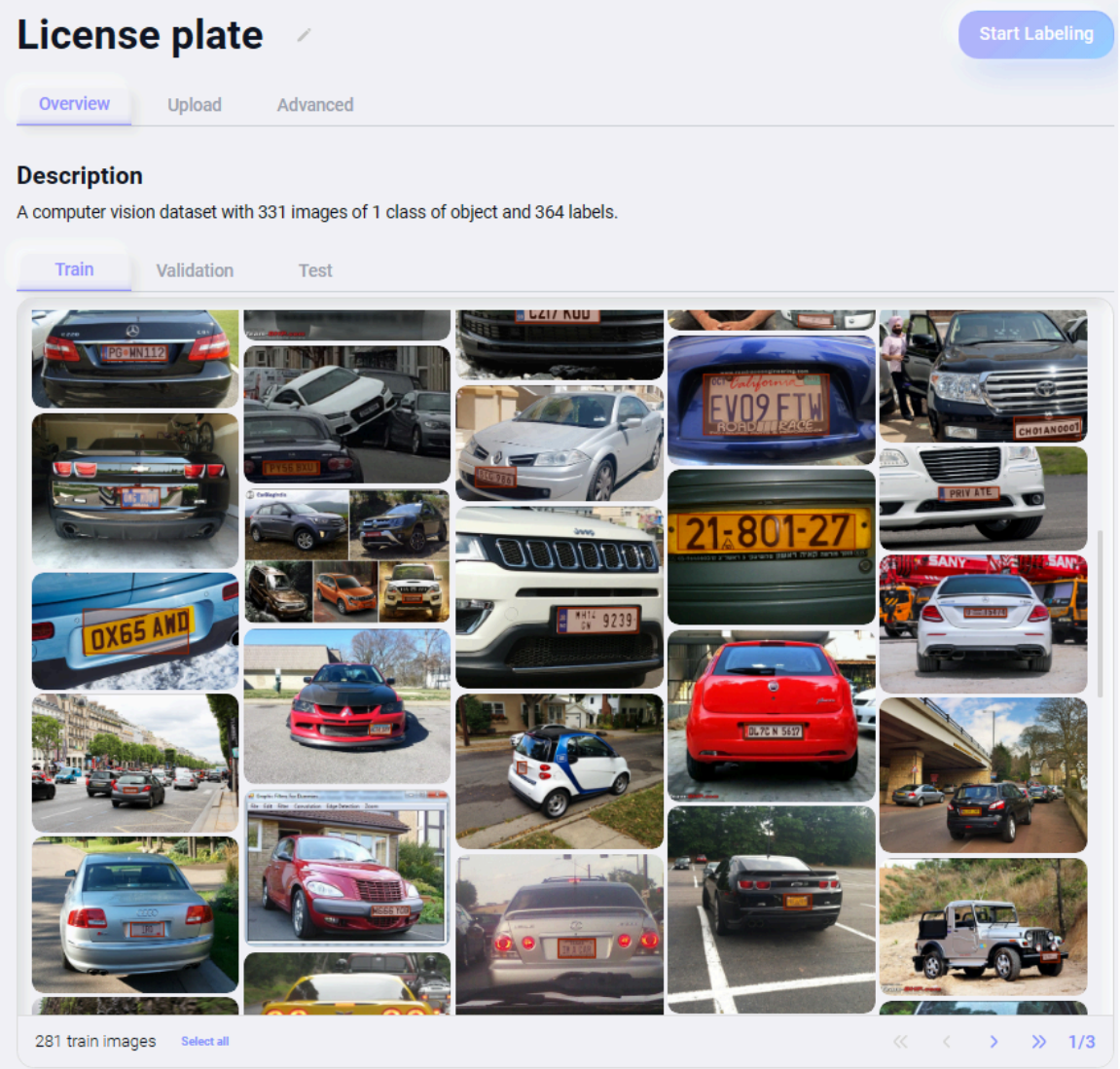

Figure 17. Overview of the plate number image datasets

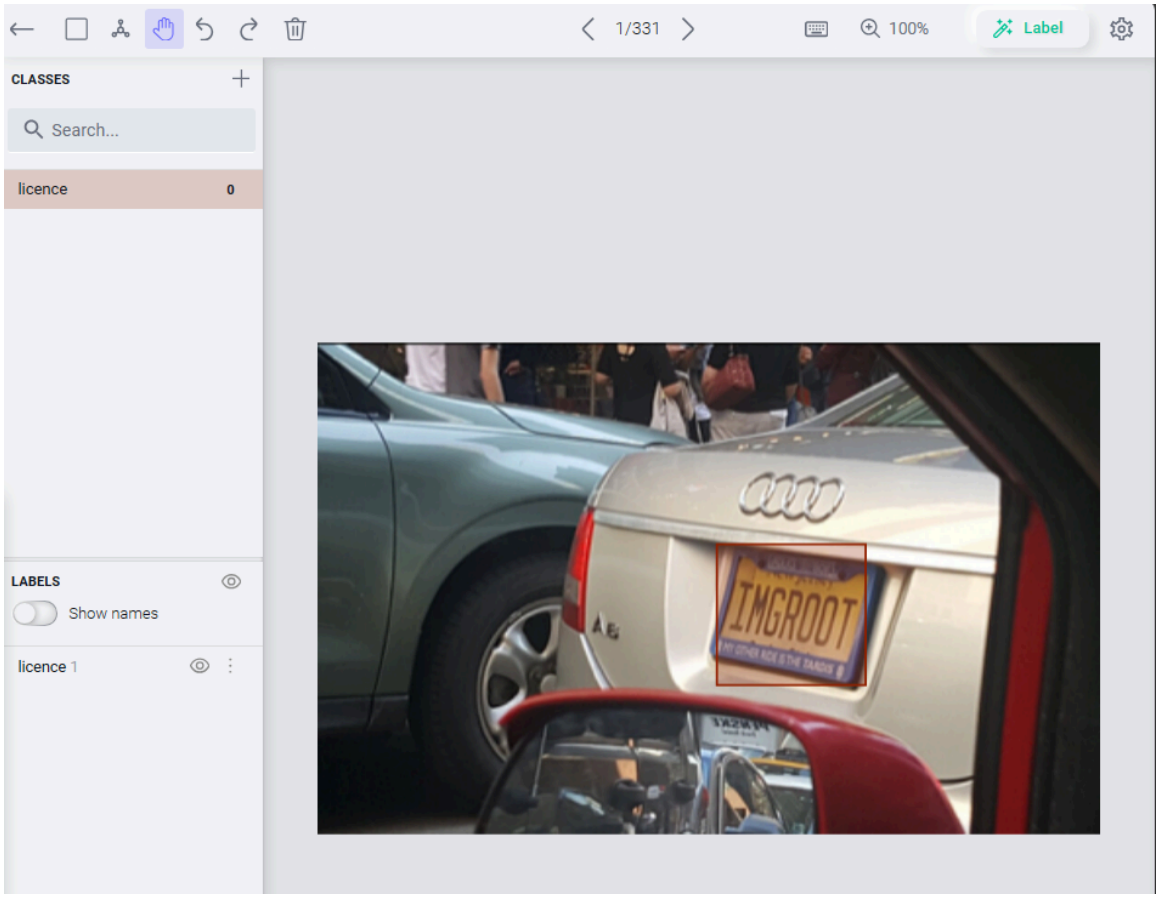

Figure 18. Labeling of images

Model Training

The researchers made use of a pre-trained model basically called Object Detection included in the library of neural networks on the website Theos.ai, which consists of the yolov7 algorithm which is widely used for computer vision, object detection specifically and is already trained to detect sample objects such as humans, objects etc. In the case of the researchers they made use of the same website Theos.ai in order to re-train the model to gain the specific need for

the project. Several changes and adjustments were made to the pre-trained model in order to be used for automatic plate number detection; one is adjusting the number of classification to only one which is to license plates only, additionally creating a bounding box for later use in the OCR algorithm. Epochs were set to 300 and batch sizes to 32.

Implementation of Algorithms

The deployment of the YOLOv7 algorithm marked a pivotal stage in the project, transitioning from model training to real-world implementation. Initially, the pre-trained YOLOv7 model, sourced from Theos.ai, was integrated into the project's architecture. This integration served as the foundation for live feed detection, allowing the system to identify and track license plates in real time.

However, recognizing the unique requirements of the project—specifically, the need for accurate detection of license plates in both front and rear views—the researchers undertook a comprehensive customization process. The pre-trained model underwent meticulous re-training using the curated custom image dataset. This step ensured that the algorithm was fine-tuned to the intricacies of license plate recognition, making it adept at handling various angles, lighting conditions, and scenarios.

The YOLOv7 model, now adapted to the project's specific demands, was seamlessly deployed within a Python script. This script not only utilized the

algorithm's weights but also incorporated the researchers' adjustments for optimized performance. The deployment process involved meticulous coding to enable real-time processing of video feeds, allowing the system to swiftly and accurately detect license plates as vehicles moved through the camera's field of view.

Parallel to the YOLOv7 deployment, an Optical Character Recognition (OCR) algorithm played a critical role in the subsequent phase of the system. Once the YOLOv7 model identified license plates and generated bounding boxes, the OCR algorithm came into play. This component was responsible for extracting characters and numbers from the bounded regions, translating the visual information into machine-readable text.

The seamless coordination between the YOLOv7 algorithm and OCR not only showcased the adaptability of the system but also underscored its versatility in handling diverse license plate formats and styles. The researchers meticulously fine-tuned parameters, ensuring a harmonious interplay between the detection algorithm and character extraction.

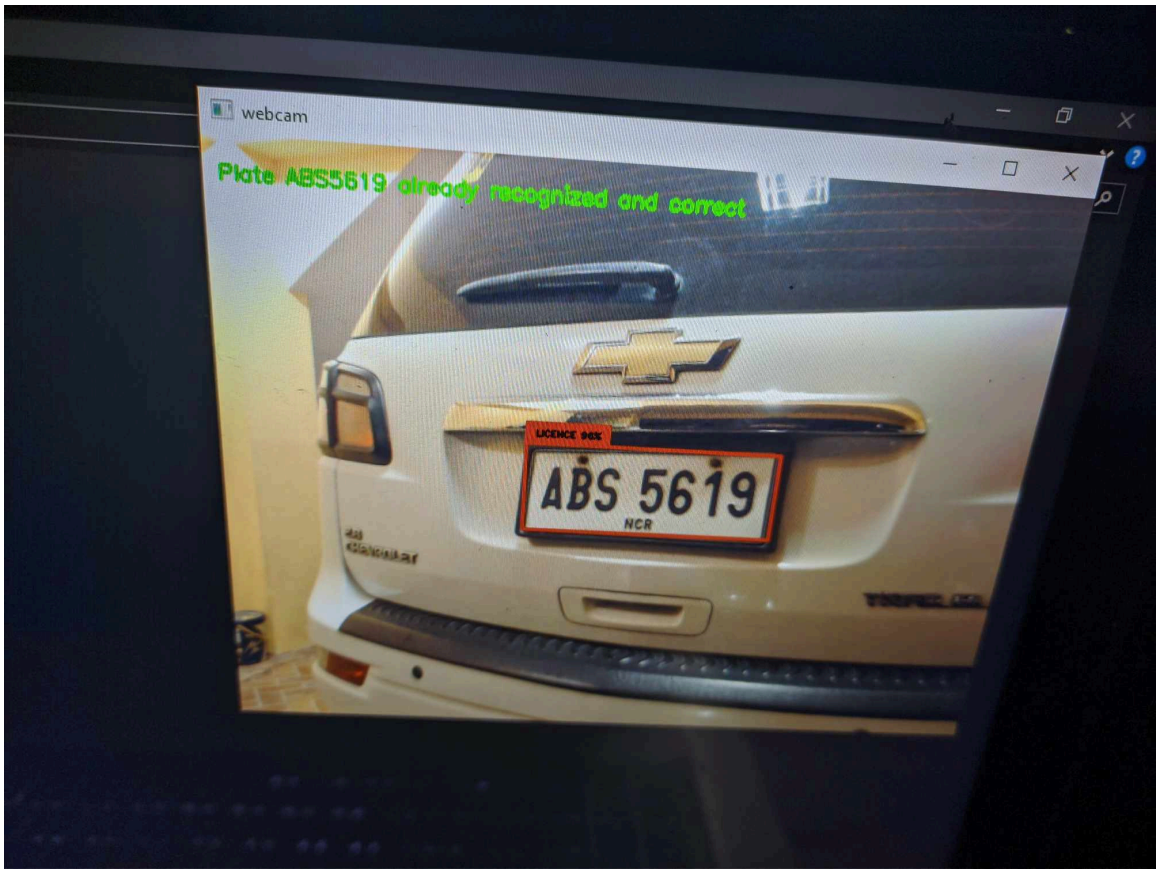

Figure 19. Example of live detection and extraction of the system

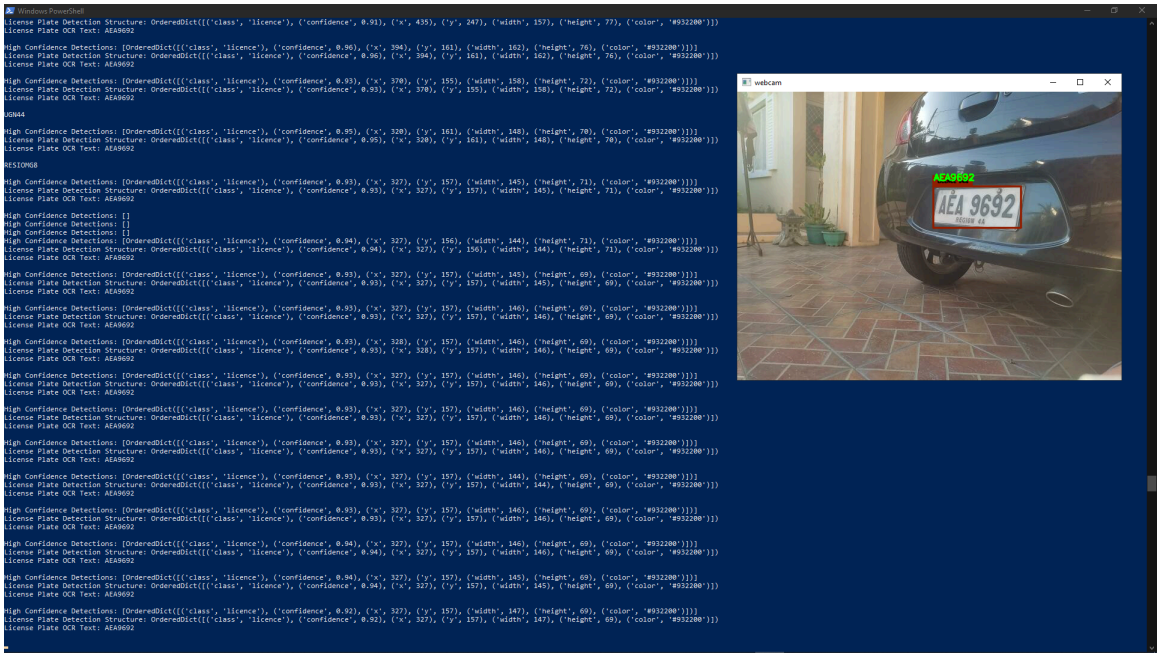

Figure 19. Example of live detection and extraction of the system

The model was trained using Theos.ai website for a total number of 300 epochs and 32 batch sizes. measurements of the loss per step were also visualized through the same website. The total_loss per step for the training resulted in an average of 0.03 which indicates a low loss as desired.

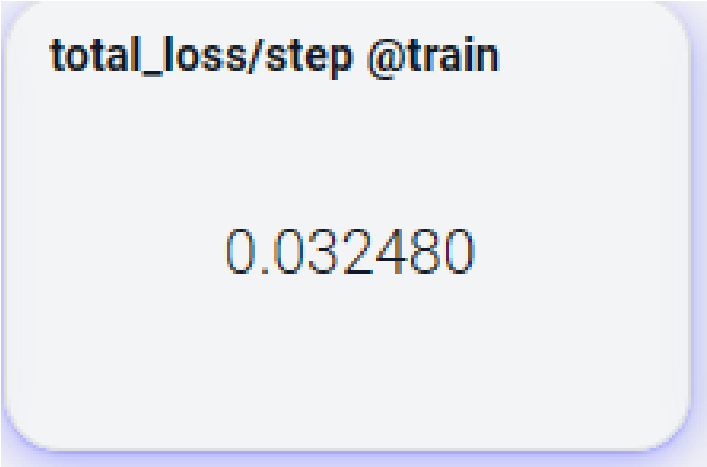

Figure 20. total_loss per step @ train

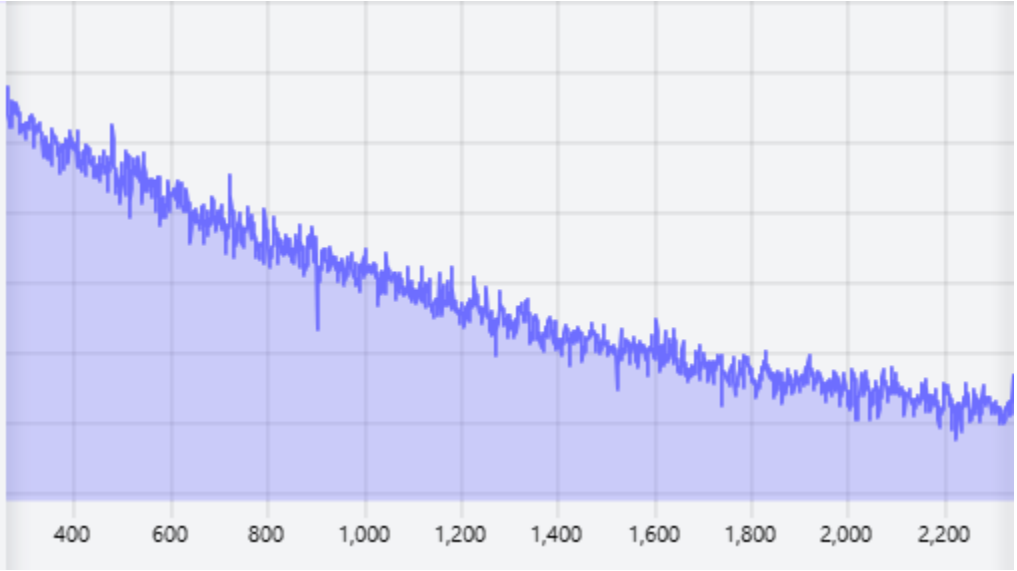

Figure 21. Graph of the total loss

Website Implementation

The website was created through the use of the Flask app within the python environment, this is a framework that offers simple and straightforward

development of a python based web application. The website is composed of a python script and also includes HTML and CSS scripts in order to design and create the buttons and tabs to perform different tasks. activation buttons are neatly placed in the website such as the data analysis, to perform real time data analysis on the saved excel file from the main system, there is also the showcase of the contents of the excel file, in which the user can search specific plate numbers for their use cases, and lastly there is the model button which turns on the main plate number detection model.

System Test Results

Results from the system testing showed a successful rate where most parts and functionalities were working and achieved.

The test cases for the unit testing are displayed in the table below. Every test case was passed as these were the necessary functionalities needed for the website to perform well. The only test case that was semi-passed is the extraction of the plate number as this was supposedly done through live real time, otherwise now it is being processed by first saving the bounded box images and running it through the OCR model.

Test Case	**Result**
Logging In	Passed
Logging In Failed	Passed

Check functionality of View Plate button	Passed
Check functionality of Generate Report Button	Passed
Check functionality of Search Bar	Passed
Check functionality of Run Program	Passed
Check functionality of Logout	Passed
Check functionality of Plate Number Extraction	Semi-Passed

Table 07. Unit Test Results

From the creation of the website application, the integration test results are shown in the table below. The website is first checked if it is able to run without hiccups on the first try. The other test cases which were the main functions of the website are able to be used, which results in these modules being passed.

Test Case	**Result**
Website runs the first time	Passed
System is able to generate reports	Passed
System is able to display contents of excel file	Passed

Table 08. Integration Test Results

The following table showcases the results from the system test case, this determines how the website is able to be used normally and from Opening to Closing both modules were able to be passed.

Test Case	**Result**
Run website in browser	Passed
Close website in browser	Passed

Table 09. System Test Results

There were also modifications done by the researchers to the main website as there is now a login page shown in the image below this was done to ensure that only certain individuals would have access to the system.

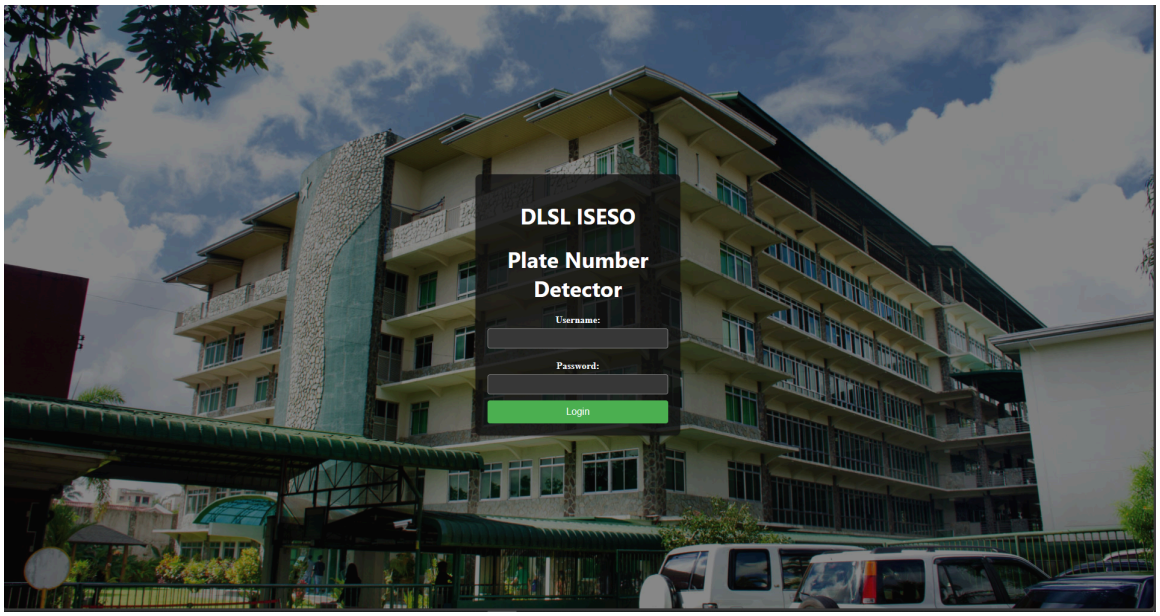

Figure 22. New Login Page

There were also modifications done to the main website interface as it is now converted into a simple dashboard which contains buttons in the middle when clicked shows the different functionalities of the system.

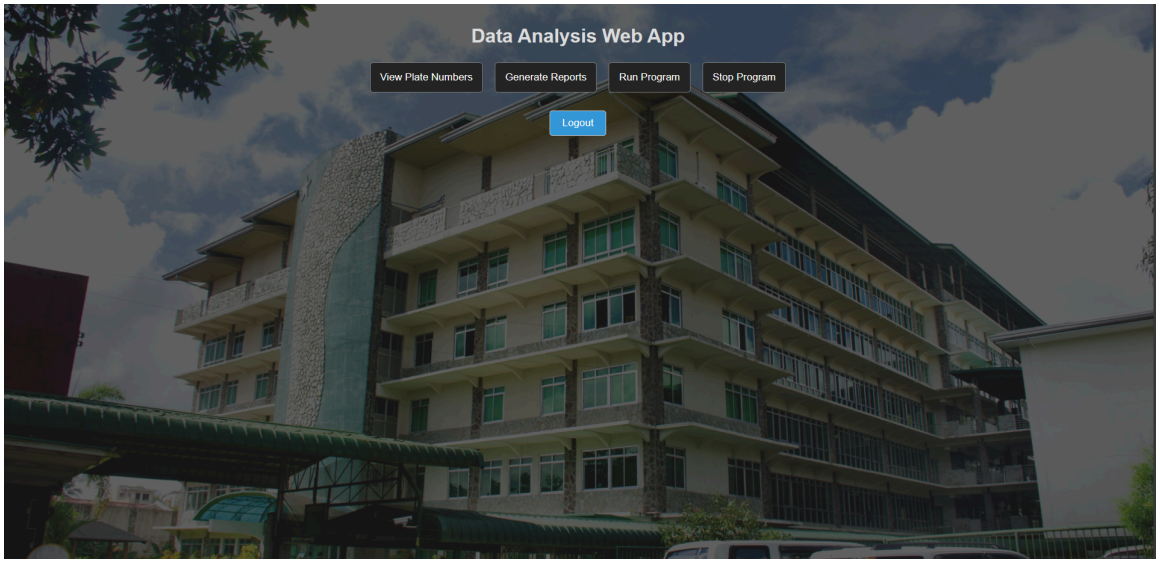

Figure 23. New Dashboard

User Acceptance Test

The User Acceptance Test was given and tested by several individuals, specifically a total of 15 individuals, these being composed of 5 employees of ISESSO and 10 people aged 18 above. The survey was done through Google Forms all while they are using the website application and testing the different functionalities of the system.

Criteria	Weighted mean
Interface is user friendly	4.33
Plate Detection System is easily accessible	4.00
Navigation to access plate numbers is straightforward	4.6
Plate Numbers displayed are easy to read	3.8
Generating reports is simple and user-friendly process	5
Generated reports are clear and organized	3.53

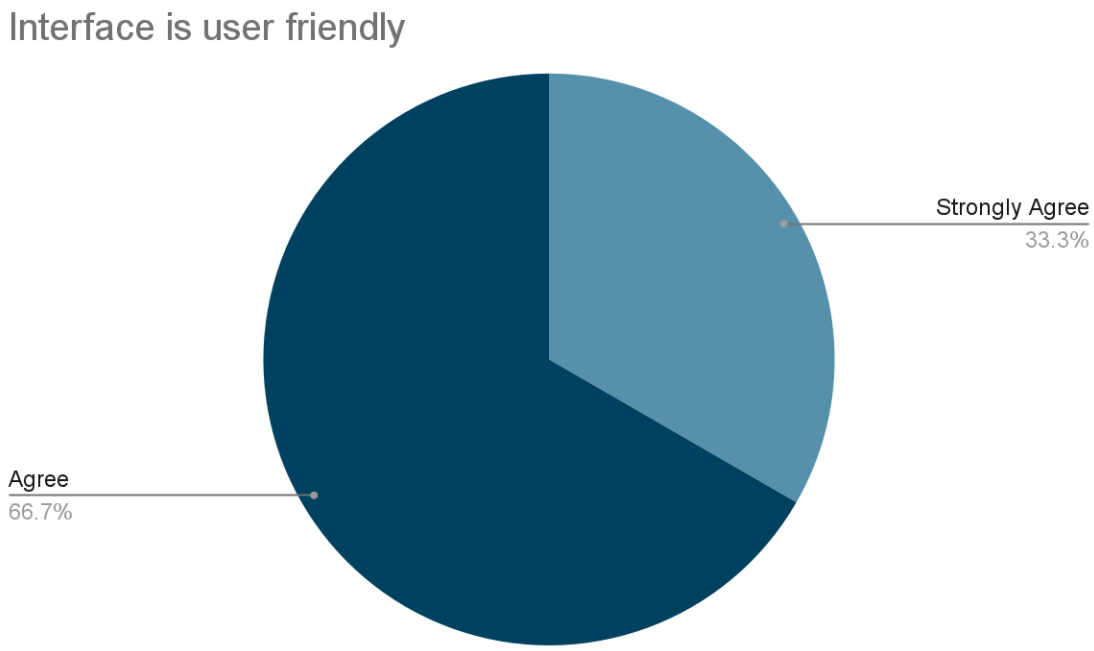

Table 10. Interface is user friendly

The majority of respondents find the website's interface easy to use, with a weighted mean of approximately 4.33. This indicates a generally positive user experience, with a combination of strong agreement and agreement.

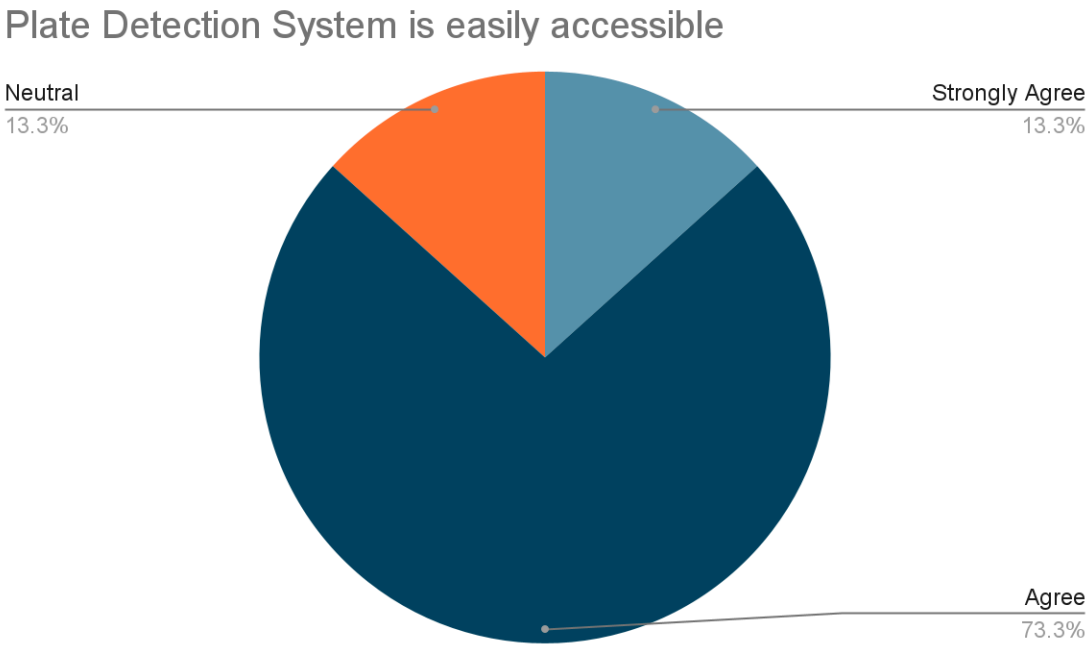

Table 11. Plate Detection System is easily accessible

Users generally find the plate detection system easy to use, with a weighted mean of 4. This suggests a positive user experience, combining agreement and strong agreement, indicating that the system is well-received in terms of usability.

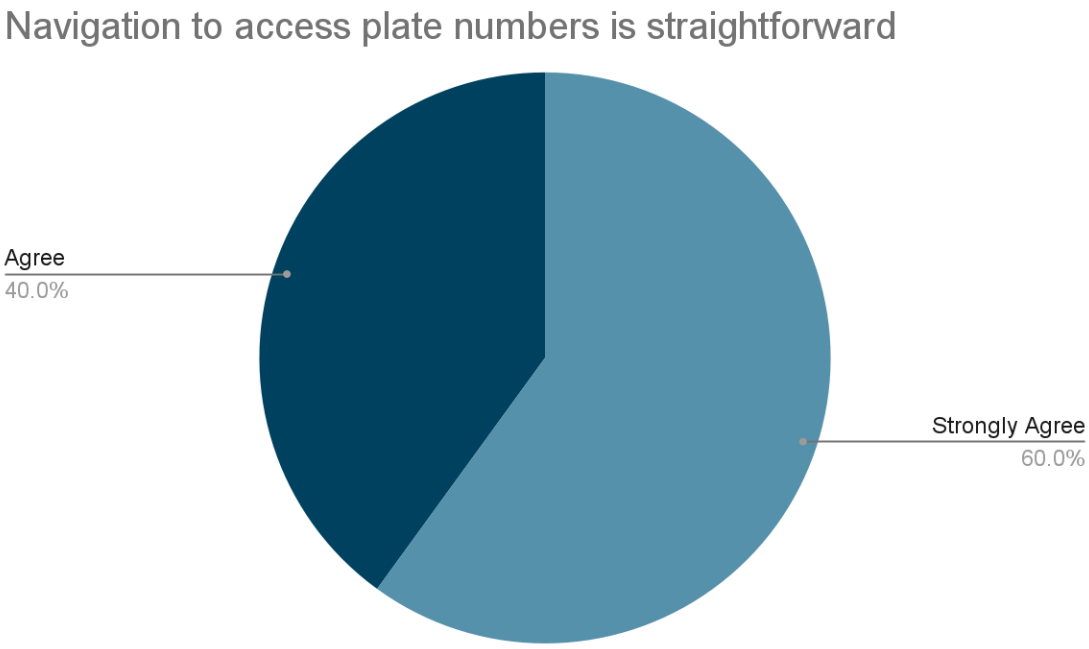

Table 12. Navigation to access plate numbers is straightforward

Respondents express a positive sentiment regarding the ease of navigation to access plate numbers, with a weighted mean of 4.6. The majority strongly agrees, indicating that users find the navigation straightforward.

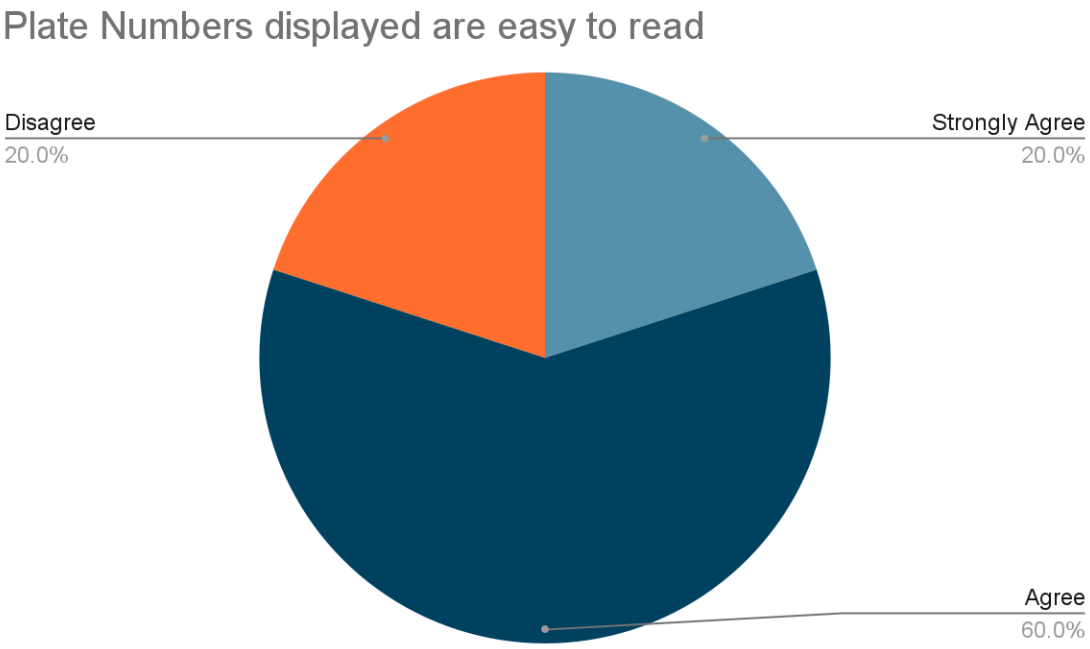

Table 13. Plate Numbers displayed are easy to read

Users hold varying opinions on whether plate numbers are displayed neatly, resulting in a weighted mean of 3.8. While the majority agrees, there is a noticeable disagreement, suggesting some room for improvement in displaying plate numbers.

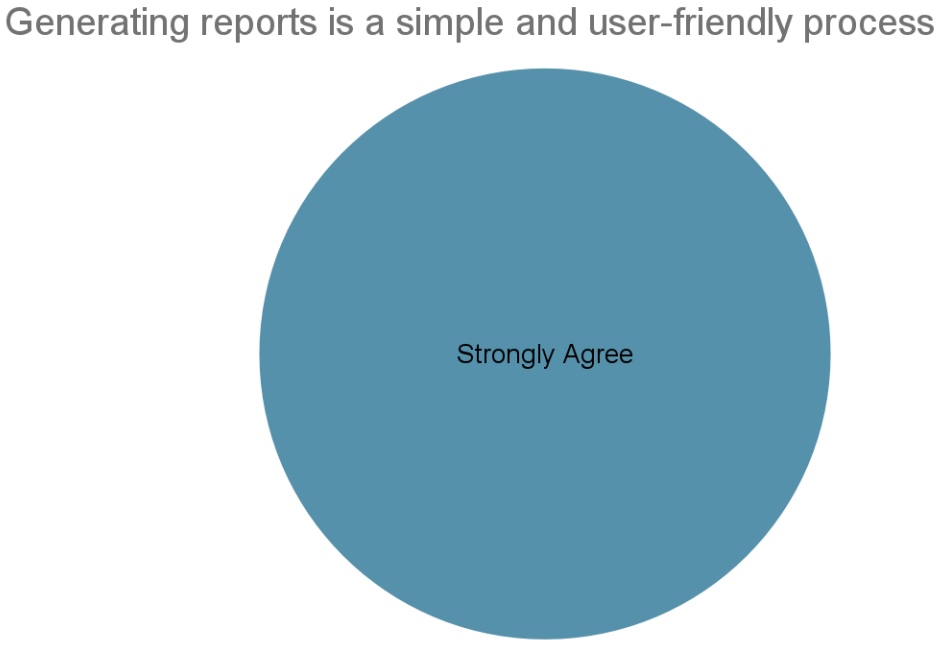

Table 14. Generating reports is simple and user-friendly process

All respondents strongly agree that generating reports is a simple and user-friendly process, leading to a weighted mean of 5. This indicates a unanimous positive sentiment about the ease of report generation.

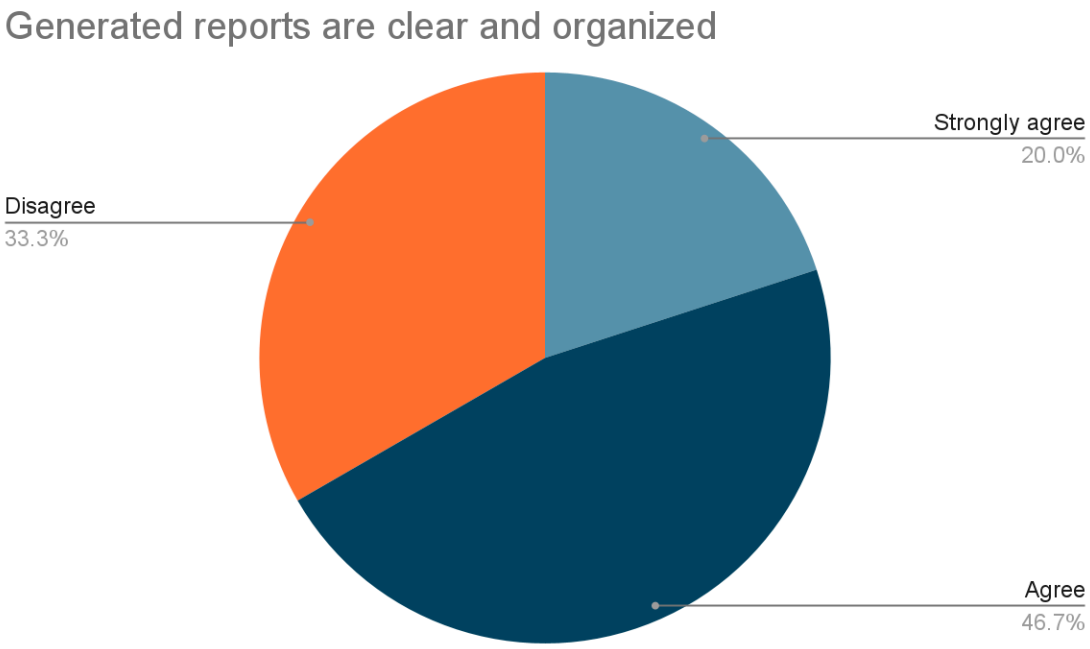

Table 15. Generated reports are clear and organized

Users have a moderately positive view on the clarity and organization of generated reports, resulting in a weighted mean of approximately 3.53. While the majority agrees, there is a notable disagreement, suggesting potential areas for improvement in report clarity and organization.

CONCLUSION AND RECOMMENDATIONS

This study shows the development of a website application that incorporates an automatic plate number detection and extraction system, which then saves it to an excel file, this together with a data analysis generator through the website.

Summary of Findings and Accomplishments

The project was initially proposed to have two main working functionalities and those were the plate number detection and extraction system and the website to incorporate that same system and provide data analysis on the gathered plate numbers, those two functions were successfully developed and the objectives set on the first chapter of the paper was properly met. Several algorithms were explored by the researchers ranging from different tensorflow based object detections to determining which yolo version is the best, there was also the selection of the character recognition model that was most fit for the requirements of the system. Through the related literature done by the researchers in chapter 2, the findings on the different results done by other researchers from various projects involving the algorithms to be used, the researchers were able to carefully select the algorithms most fit which were the yolov7 and the tesseract OCR. The researchers were able to develop the plate extraction part by incorporating those two algorithms garnering an all out passed results from the software testing done. Throughout the development of the project there were several modifications done by the researchers and those were mainly on the logic of the plate extraction model and the interface of the website.

Conclusion

The main functionalities of the project were successfully developed by the researchers, both the website and the detection model are able to work simultaneously at the time of writing this conclusion, having all the functionalities

working but still with features and optimizations that needs to be done and finalized on. The website needs to be done or uploaded into a host rather than local files in order to be accessed and used by other individuals. Overall all the functionalities both on the plate extraction model from creating a bounding box on the live feed and saving that specific image into a folder together with the extracted plate number as its filename and the timestamp, this is also saved on an excel file, to the website being able to generate data analysis reports and showcase all the saved plate numbers were successfully developed and able to pass all the testing done.

Recommendations

The researchers were unable to provide much better functionalities in terms of being more robust and specific as there were technological issues faced and also time constraints. The functions while still being usable are on the simple side as they are a point and click interface rather than being able to give more importance to each functions such as being able to expand on the data analysis given and also to view in a specific window on the same website the process behind the plate number detection rather than just the camera. The future researchers are recommended to specifically train the model on license plates and vehicles from the Philippines to ensure much better results, although the training done was also feasible by switching to local plate numbers it will still

provide better accuracy and training results. There is also the recommendation to switch from performing OCR on saved images from the object detection model to having real time OCR from Google on the bounded box as this will provide better real time results while still maintaining the performance and optimization. Lastly by using a database or cloud softwares that will cater the extracted data, this will definitely increase the security and efficiency of the system as it will provide ease of access and strengthen the data security when switching from local excel files to a specific database.

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