IMAGE PROCESSING-BASED SMART PARKING MANAGEMENT SYSTEM

An Undergraduate CAPSTONE Project
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Fall Semester 2022-2023
January, 2023

Faculty of Engineering
American International University - Bangladesh

IMAGE PROCESSING BASED SMART PARKING MANAGEMENT SYSTEM

A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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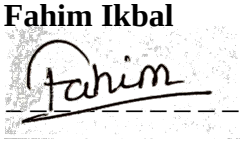

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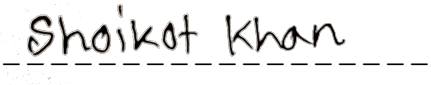

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APPROVAL

The CAPSTONE Project titled **IMAGE PROCESSING BASED SMART PARKING MANAGEMENT SYSTEM** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfilment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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Our parents, as well as friends, were constantly encouraging us throughout the process when we felt discouraged or became frustrated because they knew how much work went into this venture, so that is why we want to extend them thanks too.

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ABSTRACT

Finding a parking space is challenging in a big city like Dhaka. Thousands of cars roam around every day, and there is no way to know whether a parking space is available or not. Another problem can be addressed: people have to waste their time looking for parking even if there is a free space available, as no one knows exactly where the free space is. This project aims to provide a user-friendly, reliable, and smart car parking management system using image processing techniques. This work displays a scale model of an automated car parking management system that can control and manage the number of cars that can be parked in a parking space based on the availability of parking spaces while also informing the driver of the status of slots to facilitate parking.

The motivation of this project is to save time, automate a system that exists and make the existing system more efficient. In every aspect of our life, we are using machine learning and deep learning models to automate systems that are important to us. In this project, we have investigated ways to create a real-time number plate detection system, empty space detection system, frontend backend system and combine all of them to create a more efficient pipeline of an intelligent parking management system that is no human intervention needed and also cost-effective.

Chapter 1

INTRODUCTION

1.1. Overture

In densely populated areas, finding parking can be a real challenge. Parking arrangements that are not well-organized waste both time and energy. This only serves to cause unnecessary traffic bottlenecks. When customers enter a shopping centre, it typically takes them a significant amount of time to locate a parking spot that is free of charge. When it comes time for them to leave the shopping mall or centre after spending several hours shopping, it will be difficult and time-consuming for them to move their parked car. So many people are waiting that it takes longer to get in line and pay for parking. So, occasionally there are traffic jams because there are no parking spaces available in that specific section of the lot. The intelligent parking management system is not functional in the vast majority of the vehicle parking systems that are currently in use. The intelligent parking management system is not functional in today's manual parking systems. Since the majority of them are managed manually, they are highly inefficient. The most significant drawback is the additional time that is lost waiting in these parking lots. Customers must make multiple circuits around the parking lot before locating an available parking spot. In consideration of the needs of consumers, several different kinds of intelligent parking systems have been developed. These systems are designed to find vacant spaces in parking lots. In today's world, finding vacant parking places in parking lots is accomplished through the application of a variety of clever methods. This project uses the existing camera module of a parking lot which detects empty spaces and number plates. These information are sent to the website, and users can book empty spaces online. The primary purpose of this project is to make use of specifically designed software that not only makes picture processing easier but also can determine whether or not an automobile is present in a slot.

1.2. Engineering Problem Statement

The problem with existing parking systems is that they do not show how many parking sports are available. People can easily get confused after entering a parking lot if they do not find any available space. So, people need to know about vacant spots of parking. Also, these systems do not allow users to pre-book a parking spot. Pre-booking system can help car owners from wasting their time looking for an empty space. Designing a parking spot availability system based on image processing is complicated. Because it uses a computer system that must be trained to identify any verified cars from the camera's point of view. D. Hall [1] used image-processing software algorithms, such as W4, the single Gaussian model, and the LOTS algorithm. He addressed the LOTS algorithm as one of the best ways to detect vehicles.

Another problem is that the image processing tool has a significant flaw in the area around the parking lot. The problem is that if the capturing device is outside the building, it could be raining or windy, which is hard to predict. So, the problem of handling parking can be looked at from different points of view.

1.3. Related Research Works

1.3.1. Earlier Research

Y. Geng demonstrated a brand-new parking system that assigns and secures an optimal parking spot based on the driver's demands. It includes the proximity to the location as well as the cost of parking. This mechanism also ensures that the entire parking capacity is utilized. The system is built on the fundamental structure of PGI systems. There is also a Driver Request Processing Center (DRPC) and a Smart Parking Allocation Center (SPAC). The DRPC gathers driver parking requests and real-time data, monitors driver allocation status and notifies drivers of the outcome of their allocations. Based on driver requests and parking resource conditions, the Smart Parking Allocation Center assigns and reserves parking places for drivers [2]. As wireless technology has evolved, wireless-based solutions have been applied in parking guiding systems. V. W. Tang created such a system by combining Crossbow Mote products and the Crossbow XMesh network architecture [3].

The sensor board is outfitted with light, temperature, acoustic, and sound sensors. Wireless sensor nodes are positioned across the parking lots to monitor and detect the occupancy state, collaborate processes, and communicate the data to a management system. Managers and administrators will

have access to information about the parking field, including statistics and real-time data, via the management system [3]. This kind of sensor-based work can be costly at times. The upkeep of these sensors is also a significant issue for this type of system. They require routine maintenance to function effectively. Wireless sensor nodes are installed, with one node in each parking lot. Light, temperature, acoustic, and sound sensors are installed on the sensor board. J.P. Benson employed DSYS25z sensing nodes, which are ATMega 128L microcontroller-based devices with an RF module and antenna [5]. For the same objective, Wang, Zhou, and Li used a Honeywell HMC1021 anisotropic magnetoresistive magnetic field sensor and a microprocessor and transceiver [5]. However, the issue of deploying sensors in each parking lot persists, and it can be very expensive when using wireless technologies because each sensor is usually connected to a processing component and a transceiver.

On the other hand, a wired sensor-based system employs detecting devices such as ultrasonic sensors positioned in each parking lot. This sensor communicate with a centralized control unit, which saves and controls parking occupancy data [7]. This data is then routed to information display panels strategically positioned throughout the parking lot. The information, directions, and parking space directions are provided through the display panels. Yu and Liu [8] used a vortex berth detector in their parking direction system. The MCU processes the sensor signal, and parking information is transferred to the control centre via the CAN bus interface. J. Wolff utilized a magnetic field detector and a wired-based idea to verify their simulation model [6]. The requirement for lengthy and complicated wiring from parking lots to the central control unit is one downside of wired sensor systems. Furthermore, the expense of constructing this technology is prohibitively expensive.

Because an enormous number of sensor units are required, as well as the considerable wiring distance from parking lots to the control centre. Parking management systems based on image processing are also deployed. According to [7], the downsides are that video sensors consume a lot of energy and generate much data, which is difficult to transfer via a wireless network. However, it is a simple procedure for us. Tap into an existing CCTV camera, encode the image to digital video format, and then perform image processing on the video to develop an image-based guiding system. Because current CCTV is used, it is affordable.

Furthermore, the camera is often tethered to central monitoring, avoiding the need for a wireless network. Image-based approaches are used in security monitoring [8], motion tracking [9], and traffic control [10]. Images can also be generated using a laser scan [11], which requires a moving autonomous vehicle. A few current research studies have also concentrated on deploying car parking systems employing video sensor technology. However, there is little information available. S. Funck

proposed a method for calculating car-park occupancy based on a single image captured by a single camera. Using Principal Component Analysis, the system generates a reference image of an empty parking lot, compares the two images, and calculates the occupancy estimate as the ratio of vehicle pixel area to parking lot pixel area [12].

1.3.2. Recent Research

Z. Pala [13] proposed employing RFID technology in a practical application. The main RFID technology components, including RFID readers, RFID labels, a barrier to open the gate, and software, have all been used in this study. The program was designed to manage the management, reporting, and operation activities for parking lots spread throughout the city. The key advantage of this method is that it drastically reduces the manual workload. In addition, this system is very straightforward and quick to install. This system is expensive because it needs sensors to work properly. Also, these sensors must go through regular maintenance. The system will not read and process either vehicle's identity data if two cars pull up next to each other in the parking lot inside the RFID reader's range. Electromagnetic spectrum communications can be easily jammed when energy is used at the appropriate frequency. H. Wang [14] developed a new prototype of a Reservation-based Smart Parking System to optimize parking management. In this system, a new parking reservation policy has been implemented to balance the benefit of the service providers with the users' requirements. The main advantage of this system is that it reduces the time spent looking for parking spaces. Furthermore, the time wasted is shortened, reducing the traffic congestion inside a parking lot. On the other hand, this system is deployed using Bluetooth-enabled modules and Zigbee sensors for each car parking place. So, naturally, this raises system costs and maintenance issues. Also, the authentication method is weak because of the primary sensors used in the procedure. An SMS-based password-based system was utilized by Hanif [15]. Users would only need to utilize the SMS to reserve parking spots, eliminating the need for internet reservations. Once their reservation is verified, they will be given the parking serial numbers and the password to access the parking area. The password will expire, and they will receive an SMS warning if it takes them longer than expected to arrive at the parking location. The system is designed for parking lots to use exclusively instead of having a central system that manages bookings for all parking areas in a region. In addition, the database can expand while operating within the hardware limitations because the system keeps parking information in CMOS flash memory.

R. A. Harahap [16] successfully developed and discussed a parking spot recognition system. The outcomes made keeping an eye on parking lots more straightforward, improved the effectiveness of parking systems, and allowed for the identification and notification of empty parking spaces. According to testing, playing a video stream, including video data, can display information in the text format that offers details on available parking spaces. The Internet of Things (IoT) can be used to advance development. The technology implemented by Bura [17] eliminates the drawbacks of currently available non-vision-based solutions while enhancing vision-based methods like license plate recognition and vehicle tracking. A unique network model was developed to locate open spaces in parking lots. According to the results, the custom network model's inference time is drastically reduced compared to the two conventional systems. They were able to cut down on inference time without significantly decreasing accuracy. Compared to the model mentioned, this newly implemented system is more accurate and operates considerably more quickly.

1.4. Critical Engineering Specialist Knowledge

The project needs in-depth knowledge of programming language. We needed to use two major programming languages to solve the mentioned problem. The parking spot detection and number plate recognition were done by python based coding. Python has an enormous library collection that uses machine learning with some built-in functions. It can perform critical operations on input images using a few number of functions. The OpenCV library was used for this project because it was the best we could think of. Also, it is a vast open-source library for machine learning and image processing. The images of parking spots are manipulated and show real-time availability. Optical character recognition (OCR) model is needed for number plate recognition. The extracted data are needed for booking a parking spot.

The data are shown on the website, done by JavaScript frameworks. Javascript lets us create dynamically updated content. Using this, frontend and backend systems are built. The frontend system lets the user see the live information of a parking lot and book their preferred spots. The backend system receives user requests and matches them with the existing information in the server. Without in-depth knowledge, the project could not have been solved.

1.5. Stakeholders

The people who own the parking lot, the drivers who use the parking lot, and the employees who operate in the parking lot are all considered stakeholders. The location where the property owner is required to do the initial repair. It would be ideal if the location were adjacent to a road. He needs to make parking arrangements. If the parking is completed, he will need to determine the advantages the vehicle owners will have. He will need to hire personnel to run the parking lot. [18] The parking lot owner has a few requirements for those who utilize it. For cars to be able to use the parking, they must first register through the app. During registration, a record of the vehicle's entry and exit times into and from the parking lot will be created, along with other pertinent information, such as the driver's name and the vehicle's identification number. On this basis, a charge will be imposed. [19] When looking for parking at several key locations in the city, motorists frequently have to make many loops through the surrounding streets. It is a significant contributor to the resulting traffic congestion. They do not have to wait in the parking lot while someone parks their vehicle for them. That is why it is possible to make reservations for parking spots online. By going online to make a reservation, the app will first check to see if the parking spot is available in advance. If it is, the parking spot can be reserved, and the reservation will be made for a particular time. If the parking spot has been reserved, a light will illuminate the parking space as soon as the driver enters the parking lot to signal that it is available for use. They do not need to endure this ordeal of suffering. [20] Finding parking should not be difficult for senior drivers. Because of this, the many signals will comprehend that the location is vacant, making it easy for the vehicle to be parked. [21]

1.6. Objectives

This project aims to improve the conditions for image processing based on vacant parking space identification. So that it may be done more accurately. It does this by managing parking lots using image processing. The primary objective of the system that has been proposed is to provide a real-time solution to the current parking challenges, in particular in urban areas where there is a big problem with finding parking. This proposed solution is easily modifiable to accommodate a variety of parking arrangements. The Smart Parking Management System was brought into the market to enhance motorists' overall experience while parking in lots. The number of cars waiting in line in anticipation of snagging a parking spot at the optimal moment will have to be cut down.

1.6.1. Primary Objectives

The primary objectives of this project are:

1. To vacant parking lot can be notified using the server.
2. This system allows anyone to book the vacant parking lot using the server.
3. To detect number plate area.
4. To provide the driver's information about parking spaces available.
5. To save resources and time.

1.6.2. Secondary Objectives

1. To display parking availability information for multiple zones of car parks to drivers.
2. To ensure that parking lots are congestion free.
3. To allow drivers to reserve parking slots before arrival.

1.7. Organization of Book Chapters

Chapter-2: Project Management

Chapter-3: Methodology and Modeling

Chapter-4: Implementation of Project

Chapter-5: Results Analysis & Critical Design Review

Chapter-6: Conclusion

Chapter 2

PROJECT MANAGEMENT

2.1. Introduction

Finding parking places has become increasingly difficult in recent years as more vehicles have entered our lives. To address this problem, practical and intelligent parking solutions are required, such as discovering a suitable parking space, boosting user satisfaction, dynamic route planning, and safety systems. It is anticipated that finding a parking spot in Los Angeles will cost around 730 tons of CO_2, 95,000 hours, and 47,000 gallons (177914 litres) of fuel [23]. In addition, the world's population is rapidly increasing, and the increasing number of automobiles will exacerbate traffic congestion.

Several innovators have created intelligent automotive parking systems. These technologies use cloud computing and the Internet of Things to alleviate the problems and difficulties associated with finding parking in large cities (IoT). The previously mentioned smart parking systems for cars equipped with cutting-edge technology have contributed a new dimension to the research on this subject. However, difficulties must still be resolved before they may be used in real-time.

To avoid this, our goal was to provide image processing-based parking management, beginning with Smart Parking (SP) and progressing to the emerging Automatic Vehicle Parking (AVP) technologies. Unoccupied slot recognition, smart routing, high-density parking, and digitally upgraded parking are all part of the smart parking solution.

An image-based detection system may assess the status of a parking spot occupied by using CCTV recordings and image processing methods applied to the video stream. A computer typically receives the digital picture stream from a camera. After that, the photos are transformed into digital format and transmitted using computer algorithms that detect pixel-by-pixel changes in the image backdrop. Using CCTV for outdoor parking could be a smart move. As a result, only a few cameras can adequately cover a parking lot.

2.2. S.W.O.T. Analysis

Strength

Real-time images of the incoming automobiles are being taken as they enter the parking lot; the number of people already occupying the cars determines whether or not newcomers are permitted to enter. When both sides of the parking lot are occupied, no space is available for any other vehicles. On the website, each piece of information is shown in real time alongside a user ID. The website allows users to reserve a parking spot for a particular amount of time and provides information on the location of the parking spots that are still open. Image processing is utilized not only for collecting car license plates but also for handling payments digitally.

Weakness

The width-to-height ratio changes from car to car and therefore depends on the distance between the vehicle and the camera. In addition, small vertical edges provide a recognizing challenge since they alter the space between edges. In the image, many objects will have an equivalent width-to-height ratio. Therefore, finding the vehicle requires a large object. The camera must be positioned in a bird's eye view to identify vehicles. Another big weakness of this project is finding suitable Bengali OCR. We found it difficult to find the best OCR for our project. The Bengali OCRs are not that accurate compared with English OCRs. Though, developers are doing their best to create a suitable OCR for Bengali text detection.

Opportunities

Parking space has profited from the weight of cash and attention from foreign buyers, equivalent to certain other industrial and financial institutions. However, the vehicle parking industry is not unaffected by the effects and advancements of innovation. In Australia, various apps and license plate recognition technologies are now being implemented, allowing drivers to access parking lots without purchasing a ticket. As operators of parking lots, such changes provide hazards and possibilities [22]. Driver payout, location seeking, and timing alerts would no longer be essential for the user as part of the arrival and destination processes towards the advanced technologies. The actual statistics will be maintained first by a CCTV camera with image processing of the parking lot. In this manner, it aids in avoiding parking infractions and suspicion-raising activities. Additionally, accidents are less likely to occur by avoiding the distraction of looking for the ideal location.

Threats:

A hacker may try to take over our project and create a safety risk or attempt to breach our management system. Somebody attempting to access surveillance cameras may simply find the IP address online and get in. Our project will confront severe difficulties if the controlling system hangs or experiences frequency interference. A problem with this initiative is that not all users may be drawn in by the economic benefits. There are currently a variety of commercially available smart parking systems, such as RFID, magnetometers, and radar, but they are not entirely developed, and our method addresses some of their drawbacks. Based on image processing, the smart auto parking management system we have presented may result in job loss issues because it will run entirely online.

2.3. Schedule Management

Our project was completed following the strategy shown in the grant table below. Our Gantt chart made it simple to control the project's timeline. Because of this, Our Honorable Supervisor proposed creating a project Gantt chart, and ultimately, we succeeded in achieving our intended objective.

Table 2. 1. Gant Chart

	2022												2023	
Task	June 7 – June 12	June 13	June 14 - July 5	July 6 – July 15	July 16 – Aug 5	Aug 6 – Aug 15	Aug 16 – Aug 29	Sep 2	Sep 4 – Sep 16	Sep 17 – Oct 7	Oct 8 – Nov 14	Nov 15 – Dec 1	Jan 2 – Jan 14	January 18
Identifying problem and project selection														
Proposal Submissions														
Literature review														

Circuit planning & design planning														
Circuit analysis														
Hardware research														
Preparing progresses report & defence material														
Progresses Defense														
Determining manufacturing cost & manufacturing														
Assembly & optimization														
Circuit assembling and testing														
Final test														
Submission of project book to external														
Poster & summary														
Final defence														

2.4. Cost Analysis

A standard deviation is calculated depending on our predicted estimate of the project's overall cost as well as the actual cost of installation, which are shown in table no 2.2, using the equation shown below:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(xi - \mu)^2} \quad \ldots\ldots. 1$$

Where N is the population size and μ is the population mean.

Table 2. 2. Cost analysis of the project

SL NO	Product Name	Quality	Estimated Price	Final Cost	Cost Deviation
01	Camera 1	1	1000	800	-200
02	Camera 2	1	1200	1400	200
03	Toy Car	12	400	450	50
04	Frame	1	500	750	250
		Total Cost	3,100	3,400	300

Here,

N=4; Total deviation cost= 300

Average cost deviation = 300/4= 75 (μ)

$$\sum_{i=1}^{N}(xi - \mu)^2$$
$$=122500$$

Standard deviation, σ = 175

Therefore, the overall standard deviation is 175, which is considered acceptable. Here, we can see a Three hundred-taka (BDT) difference between the estimated and final cost values. We estimated our component's price via an online shop which we considered as our estimated cost. We added delivery costs for those components which are available in our market.

2.5. P.E.S.T. Analysis

Political

The political atmosphere of a nation or market has a significant impact on the elements that can affect the long-term sustainability of Smart Parking. Because it conducts business in more than a dozen countries. The smart parking system is vulnerable to the dangers connected with a wide variety of political situations and governmental systems. Our country's government is interested in financing a parking management system with such a high level of sophistication. We anticipate that we will be able to contribute to the development of smart parking if we collaborate with the government in this way. In addition, we believe that obtaining funding for sustainable development efforts of this nature should not be too difficult.

Economy

More than 75% of garbage is produced, 80% of emissions and 75% of energy is used in one city today. Around 20% of the CO_2 emissions in Europe are due to road traffic, of which 40% are due to urban mobility [23]. Implementing intelligent parking management systems is a timely choice that may easily help us reduce time and money. Using this innovative parking management system, we can reduce fuel use, CO_2 emissions, and manufacturing expenses. Additionally, it can boost productivity. It is a cost-effective solution that the average person can efficiently utilize.

Social

The proposed smart parking solution is eco-friendly. Because it does not utilize hazardous gas or fossil fuel, there is no chance of contamination. Furthermore, reducing labour will enable the general public to spend less time overall. This kind of work assists in our driver's technical skill development and might save us time and money. According to the findings, these solutions would enable each vehicle to save an average of 77.2 hours per year and 86.5 euros (9786BDT) on gasoline [24]. The car park provider business also benefits from these innovations by increasing its total annual income by about 9 million euros (101 Crore BDT). Therefore, with this approach, the general public will not waste time and money looking for open space.

Technological:

From experience and understanding towns to digital metropolitan areas, higher than or equal to city areas with a variety of innovations used to enhance industrial prosperity creates jobs and life satisfaction for citizens while taking into account the urban infrastructure and thus its parts. Nowadays, cities produce over

75% of garbage, 80% of emissions, and 75% of the energy used worldwide. Transportation systems are thought to represent the natural outcome of the advancement of cities. In order to increase appeal and viability in terms of social, financial, and natural effects, digitization is essential to smart cities. However, the spread of technology is merely a tool for recreating cities for a modern economy and society that will clearly and powerfully benefit the local people.

2.6. Professional Responsibilities

Professional obligations include the social and ethical need to apply knowledge in a manner that serves the customer and society as a whole without harming either. While completing our project job, we wish to uphold professional standards. Therefore, we also made an effort to follow IEEE standards.

2.6.1. Norms of Engineering Practice

We are developing a green safety program. When it comes to ethics, this project has been appropriately handled. This project's engineering practices and procedures are up-to-date and safe for the environment. The primary objective of this work is to provide low-cost help for smart parking space discovery. The major objective of the Requirements for Engineering Practice is to codify rules for design in the form of ethical principles.

2.6.2. Individual Responsibilities and Function as an Effective Team Member

Table 2. 3. Contribution List

Contributor	Statement of contributor
MD. FAHIM IKBAL	1.5, 1.6, 2.1, 2.2, 3.4, 3.7, 4.1, 4.2, 4.3, 4.4, 5.4, 6.2, 6.2.1, 6.2.2, 6.3, 6.4, Pre-defense presentation slide, Pre-defense Video, Coding.
SAMI-UL ISLAM NAHID	1.7, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 4.1, 4.6, 5.2, 5.3, 6.1, Pre-defense video, simulation test & setup, Hardware Setup, Coding.
SHOIKOT KHAN	1.1, 1.2, 1.2.1, 2.6, 2.7, 2.8, 3.4, Pre-defense presentation slide, Pre-defense video presentation, Poster, Hardware Setup.
SHOFIQUL ISLAM SHOIKOT	1.2, 1.3, 2.2, 2.3, 2.5, 2.6, 5.1, 3.2, Pre-defense presentation slide, Hardware Setup, acknowledgement.

2.7. Management Principles and Economic Models

To finish the project, a group or individual must demonstrate particular qualities related to the specified responsibilities. The implementation of the project's management system and the management concepts will be covered in this section

Leadership

To offer creative solutions before beginning a challenging job like ours is perhaps the most crucial thing an engineer can do. By addressing every one of the problems in this project, we have gotten better at leadership. Which we will need in our later practical and professional lives. Our knowledge capacity will be increased by reading various conference papers, journals, thesis papers, research papers, and topic-related work papers.

Collaboration:

To complete this assignment, the team had several talks. Additionally, we have frequent conversations with our supervisor and External, which has improved our ability to work together. We think a strong sense of working together will help us advance professionally. Furthermore, we had to purchase the project materials from several locations, which improved our interpersonal effectiveness. Finally, to complete this project, we collaborated with others who helped us develop our working abilities.

Planning:

The Gantt chart showed that we completed our task on schedule. We often communicate with our supervisor weekly to get comments on our project efforts. We also let the outside supervisor know when we encountered difficulties while working on the project. Our project has certain limitations, such as the requirement for the number plate detection for Bangla font. Our work does not function correctly if the number plate is away from the camera or the font size is less.

2.8. Summary

This chapter mainly concentrated on the timeline divided by project tasks and deadlines. We provided a complete listing of equipment and its cost per item, performed SWOT and PEST analyses and reported on the distribution of our work. The supervisors reviewed our work once we had completed the written portion of our book. Therefore, project management assisted us in completing our project-related responsibilities on schedule

Chapter 3

METHODOLOGY AND MODELING

3.1. Introduction

We have used several methods to detect empty space and number plates and to make our project's frontend and backend systems. Methods include Image Processing, Optical Character Recognition, use of the MERN stack. In image processing, we have used Edge Detection, Segmentation, Blob Detection and also Thresholding to prepare our images for object detection and finding empty spaces. We also did testing of pre-trained OCR models like Tesseract-OCR, Keras-OCR and EasyOcr. For our Frontend and backend systems, we have used Model View Controller (MVC) pattern, and we have used best engineering practices for our whole project.

3.2. Block Diagram and Working Principle

The whole system is a combination of three interconnected parts of work. This includes the camera and machine learning model, the frontend system and the backend system. The system lets the user book a space for them before their arrival and reduces their waiting time for available space in a parking lot.

The main work starts with the picture taking using the cameras. We have used two cameras to detect parking spots and to detect the number plate. The images from the videos are manipulated so that we have our results. First, we detect the empty space. For this, we have used several techniques, including Thresholding, Segmentation, Blob Detection, Image Subtraction, Erosion and Dilation and Contour Detection. Then, we detected and localized a license plate from the video captured by a camera for number plate recognition. After that, the characters from the license plate were extracted. These extracted characters were recognized by applying Optical Character Recognition (OCR). For this project, we used a pre-trained model named EasyOCR.

The backend system consists Node.js server, which is a framework of JavaScript. It enables us to create a backend server locally. Node server is an entity that we run in a local host. The server gets the data from our machine learning model and stores it, communicates with the database and sends these data to our

frontend system. The server also takes data from the frontend system, which includes if any user entered or got out of the system.

The frontend system uses React.js framework, which is an open-source JavaScript framework. It is used for sending API calls which deal with the data. This system always takes data from the database to determine whether there is any empty space to show on the webpage. The system lets the user sign in and books a parking space if any empty space exists. The booking data goes to the backend system because when the user enters, the system pulls data from the backend system. So, the database needs to be updated to show the real-time scenario.

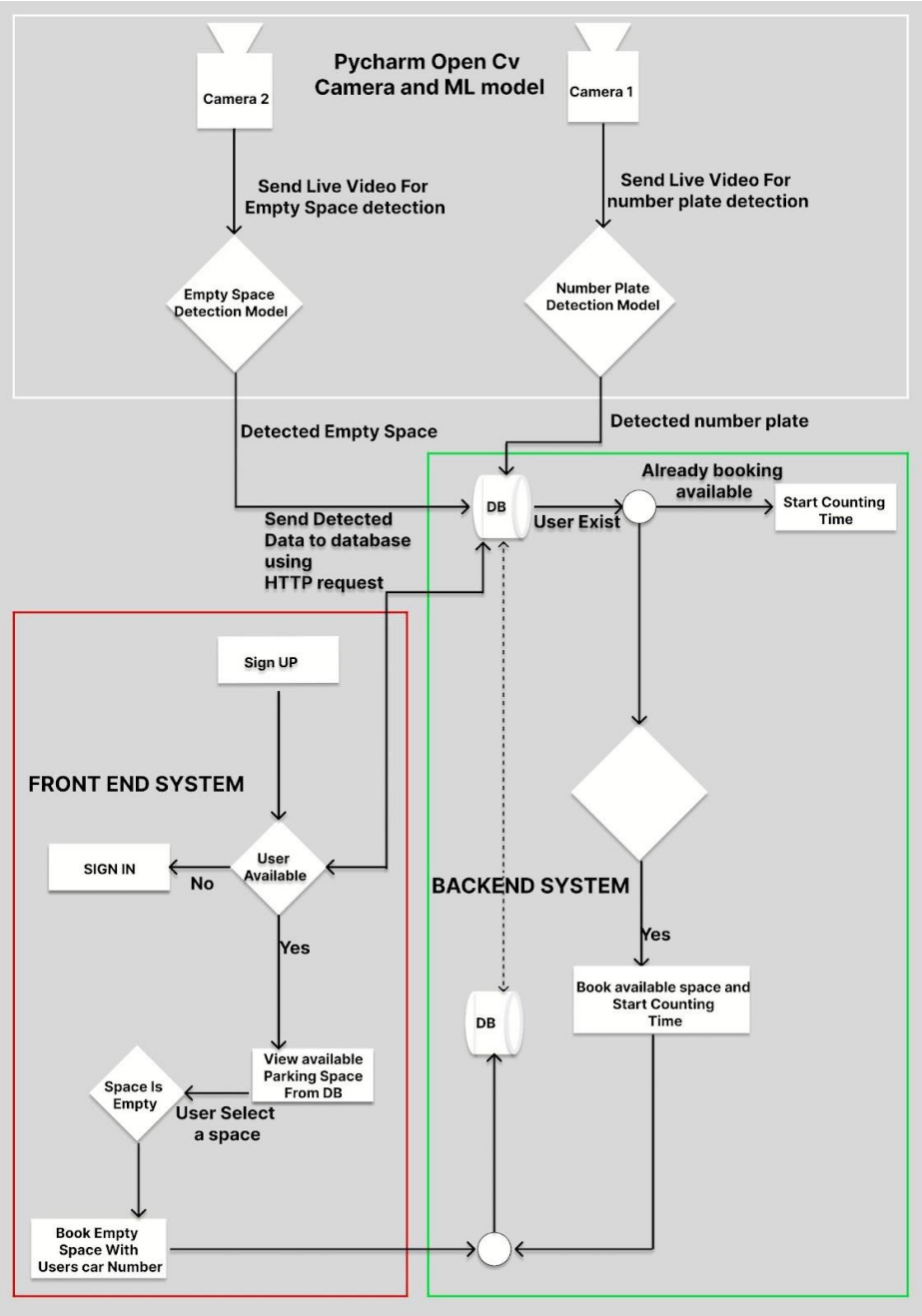


Figure 3. 1. Block Diagram

3.3. Modeling

Our primary purpose of this project was to detect empty spaces and car number plates to show them on the website. To detect space, we use a smart technique called image processing and to detect number plates, we have used Easy OCR. We have made a prototype model to simulate our project. This model gives us a real scenario of arranging a parking garage. We tested our code in this prototype model, and it ran successfully.

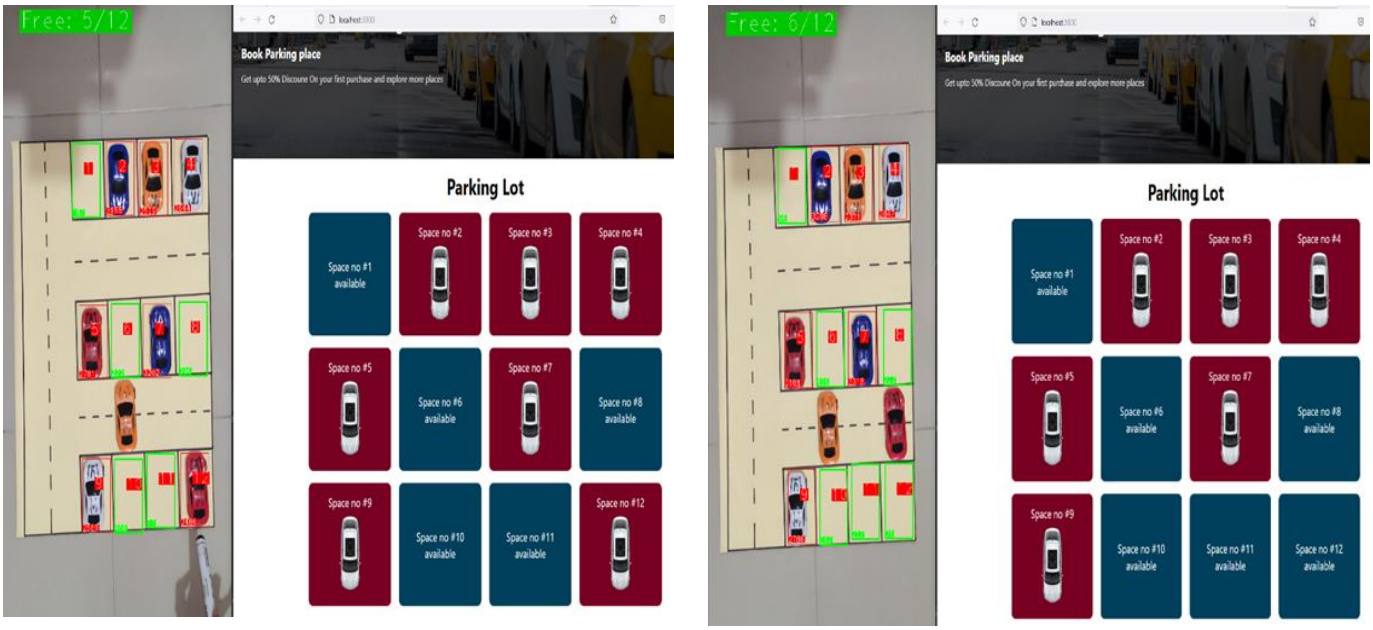


Figure 3. 2. Software Model

Empty Space Detection:

In detecting Empty space, we have used many methods to detect and process the image to find space and cars.

1. Thresholding: In this method, the image is turned into a binary image by setting a threshold for the intensity of each pixel. Pixels whose intensity is below the threshold are made black, and pixels above the threshold are white. In the binary image, empty spaces in the image will show up as black.
2. Segmentation: This method divides the image into different parts and looks at each part separately to find empty spots.
3. Blob Detection: This method uses a technique called "blob detection" to identify and extract empty spaces in the image.

4. Image Subtraction: This method subtracts a reference image from the original picture. Typically, the reference image is an image of the same scene but without the object of interest. The final image will only show white space.
5. Erosion and Dilation: This method employs morphological operators like erosion and dilation to remove small unnecessary elements and fill in small gaps in the image, resulting in a new image that only shows the empty space.
6. Contour Detection: This method uses an algorithm called a "Contour Detection Algorithm". This algorithm finds the edges of an object in the image, and areas without edges are used to show where there are no objects.

Number Plate Detection:

For number plate detection, we used a machine learning model, EasyOCR. Finding number plates, we focused on some techniques to detect both Bangla and English fonts.

1. Edge Detection: This method involves detecting edges in the image using techniques such as Canny edge detection, which can be used to locate the boundaries of the number plate.
2. Template Matching: This method involves comparing the image of the number plate to a pre-defined template of a number plate.
3. Optical Character Recognition (OCR): This method involves using machine learning algorithms to recognize the characters on the number plate.
4. Segmentation: This method involves dividing the image into different segments and then analyzing each segment separately to locate the number plate.
5. Blob Detection: This method uses "blob detection" to identify and extract the number plate from the image.

We have used API to connect our frontend, backend and image processing server. Our API works using HTTP requests to send the data across these servers. We have made our servers real-time to show the changes simultaneously.

Front end and backend system

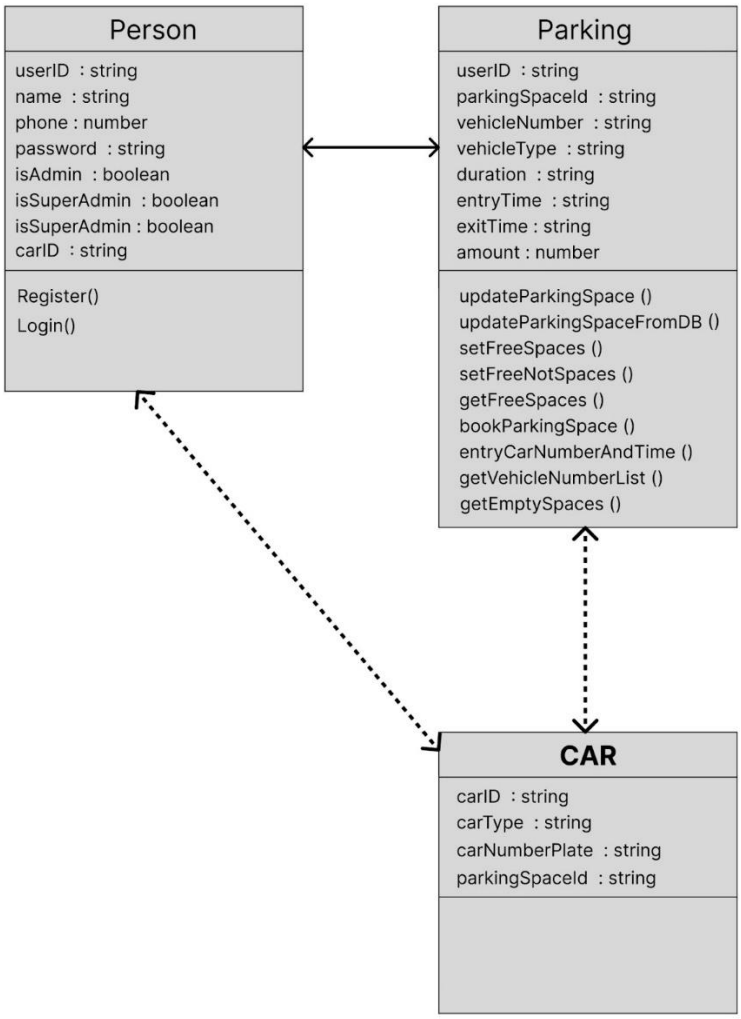


Figure 3. 3. Class diagram of UML model

This UML diagram shows the variables on the top, and associated functions for that variables are shown below the block. Here in person, carID is a foreign key of CAR. In the parking block, userID is the foreign key of person.

The given figure shows the UML model of our backend database. In this model, we can see three entities or classes: person, car and parking. Here one person can have many cars, but for every car, he can create a maximum of one parking. On the other hand, empty parking can have multiple cars. This is how we save our booking data in the noSQL database.

3.4. Summary

In this chapter, we have focused on modelling, block diagram and working principle. The main goal was to detect free space using image processing and number plate detection and store this information on the website. Several techniques have been followed to detect free space to achieve the mentioned objectives. Also, to detect the number plate, a pre-trained model has been used called EasyOCR. Additionally, some crucial theories for designing the project have been discussed.

Chapter 4

PROJECT IMPLEMENTATION

4.1. Introduction

A parking system's architecture consists of several parking space-detecting instruments and procedures. For this, cameras and sensors have been installed that record, analyze, and display data and images to provide actual traffic availability statistics for the destination. Our Smart Parking system consists of interchangeable components that smoothly integrate parking, directing, payment, statistics, and a vast array of extra services and options. Therefore, the Smart Parking solution as a whole is truly the sum of its parts and a leader in the parking and service industries. Hardware and software both employ the operating concept described in Chapter 3.

4.2. Required Tools and Components

List:

Visual Studio Code

Pycharm

Webcam

Algorithm or model:

EasyOCR

Image Processing

OpenCV

Visual Studio Code: Visual Studio Code by Microsoft is an IDE used to build many software, including computer programs, websites, online applications, web services, and mobile applications. Compilers, completion tools, and other features are included to make the software development process easier. Visual

Studio Code is a simplified code editor that supports development tasks such as debugging, task execution, and version control.

Pycharm: PyCharm is an Integrated Development Environment (IDE) for python that gives Python developers a wide range of important tools. These tools work well together to make a practical environment for developing with python, the web, and data science.

Webcam: A webcam is a small digital video camera that is connected directly or indirectly to a computer or computer network. Users must install the software that comes with their webcams on their computers in order to record video or stream it from the internet. Webcams can record both moving pictures and still pictures in high definition.

OpenCv: The term "computer vision" refers to a method for comprehending images and videos, as well as how these are stored, modified, and data derived from them. AI is frequently built on computer vision. It is now widely used in robots, self-driving cars, and even photo editing software.

EasyOCR: EasyOCR is a Python-based package that allows one to use a prepared OCR model. We wouldn't have to bother about training the model. We could use OCR with improved accuracy in just a few program codes. Python, as well as the PyTorch libraries, are used to build EasyOCR. Having a CUDA-capable GPU, the underlying PyTorch deep learning package can significantly improve text identification and OCR speed.

Image Processing: The term "image processing" directs to a series of functions carried out on an image to produce an improved version of the image or to derive some helpful information from it. It is often seen as arbitrarily altering an image to achieve an aesthetic standard or support a preferred reality. Both of these goals can be accomplished by using image editing software. However, a more accurate definition of image processing would be to describe it as a means of translation between the visual system of humans and digital imaging devices. Image processing is a method that involves importing images into a computer system using various image acquisition tools. After that, the image is analyzed, and necessary changes are made. Additionally, the output result is a modified image based on the analysis of the original image.

4.3. Implemented Models

Throughout this work, we created hardware and simulation models in the situation where we just partially simulated the systems and implemented the hardware part.

4.3.1. Simulation Model

The first job of our work was to detect empty spaces in a parking lot. The below picture is a part of our simulation model. It is a part of many parts of the technique we have used. This is a threshold picture of the main picture. We put threshold to see the white pixels of the car. The image shows that if there is a car available, there is a high number of white pixels available, and the others are black.

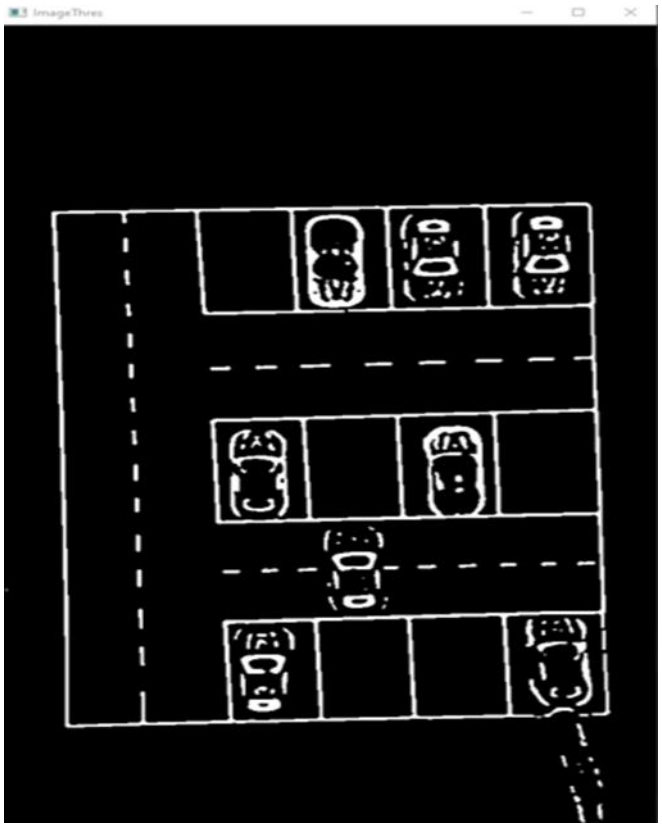


Figure 4. 1. Thresholding Image

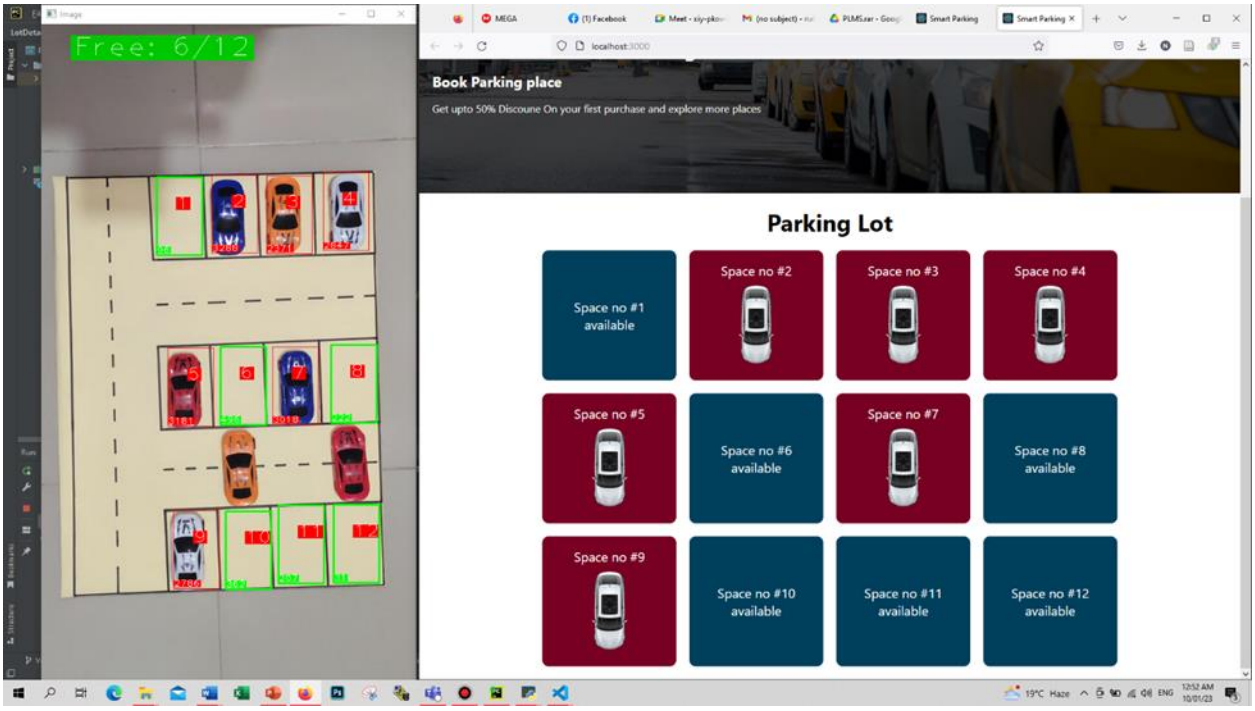


Figure 4. 2. Available parking spot showing on the website

After the spaces in the parking lot were detected, these data were sent to the frontend system. From the frontend system, users can know if space is available, and bookings can be made. In addition, the system sends real-time data to the frontend system.

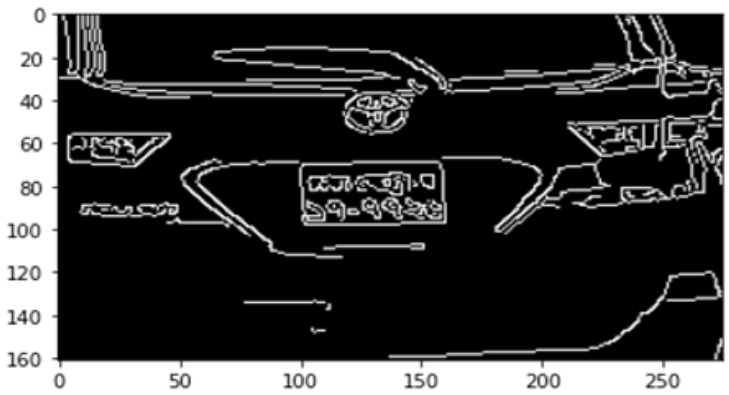


Figure 4. 3. Edge Detection Image

The above picture is an edge-detecting image for number plate recognition. We detect the edges of these highlighted portions. After detecting the edges, we determine the boundary areas of it. We take this boundary area only and omit others. This boundary area is then linked with our EasyOCR

4.3.2. Hardware Model

The hardware model had to be done simultaneously with our simulation model. At first, it consisted of only a miniature parking lot made of cork sheets and some miniature toy cars. The miniature parking lot has been drawn well enough to give it a realistic look. In the earlier process, we took videos with mobile and ran them in our system successfully.

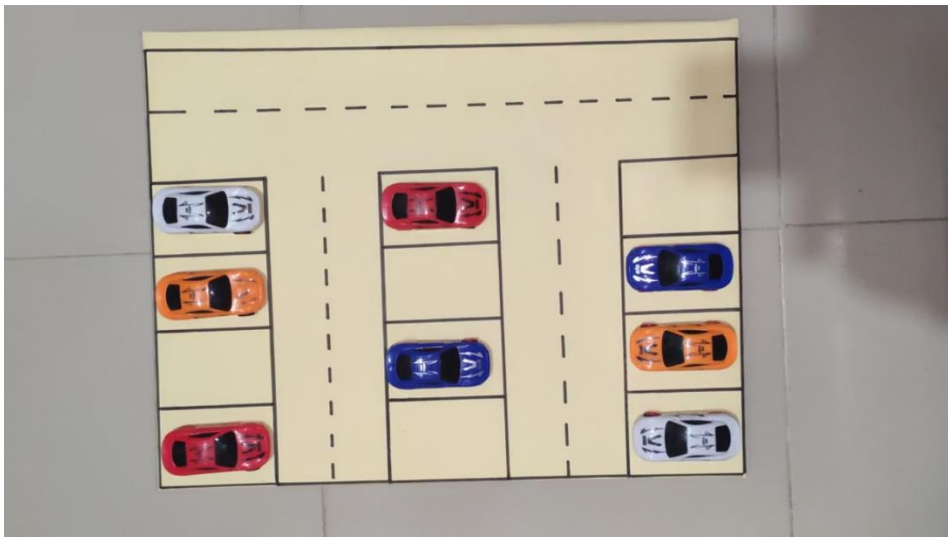


Figure 4. 4. Early-stage hardware model

We made a frame for our miniature parking lot in the second phase. In this phase, we implemented two cameras with the frame to keep them stable, which would help us to get a clear view. One camera was placed at the top to get the bird's eye view for empty space detection. Another camera was placed at the entry point of the parking lot. This camera gets the video of the entering car and detects the number plate.

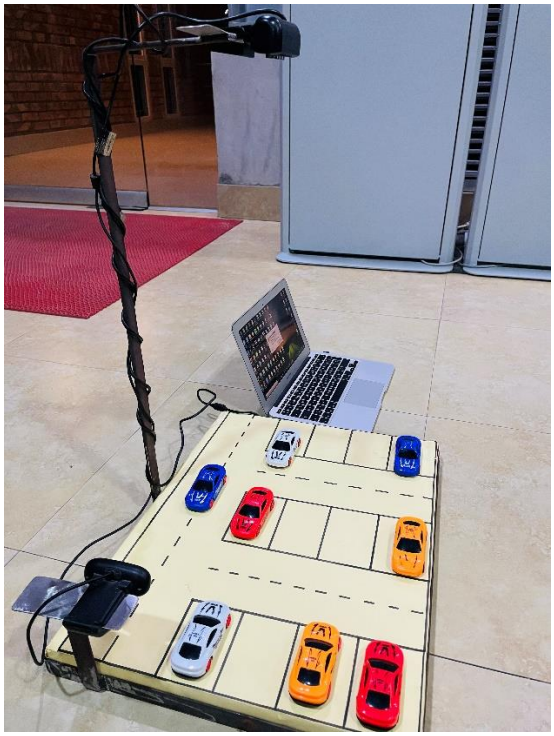


Figure 4. 5. Final hardware setup

4.4. Engineering Solution in accordance with professional practices

Throughout our project, the main goal was to reduce the search time for empty parking spaces for people. We know how long it takes to find a parking space in cities like Dhaka. This is a global problem. In our system, one can easily find out if there is an available place in a parking lot. As a result, they do not have to waste their valuable time searching for parking spots. Also, people can book a space for themselves before arriving. We tried to solve the problem with our engineering knowledge. We had to design the solution in such a way that it goes in accordance with professional practices.

4.5. Summary

In this chapter, we have mainly discussed implemented model. Entering the car parking area, every vehicle can see slot availability on the webpage. If a car reserved a slot, then the webpage will show that particular slot is blocked to the drivers. The driver will choose an empty slot by himself and park at his desired one. A camera will take the reading in which slot the car has been parked and store the data in the database. According to the described process hardware model also has been implemented.

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

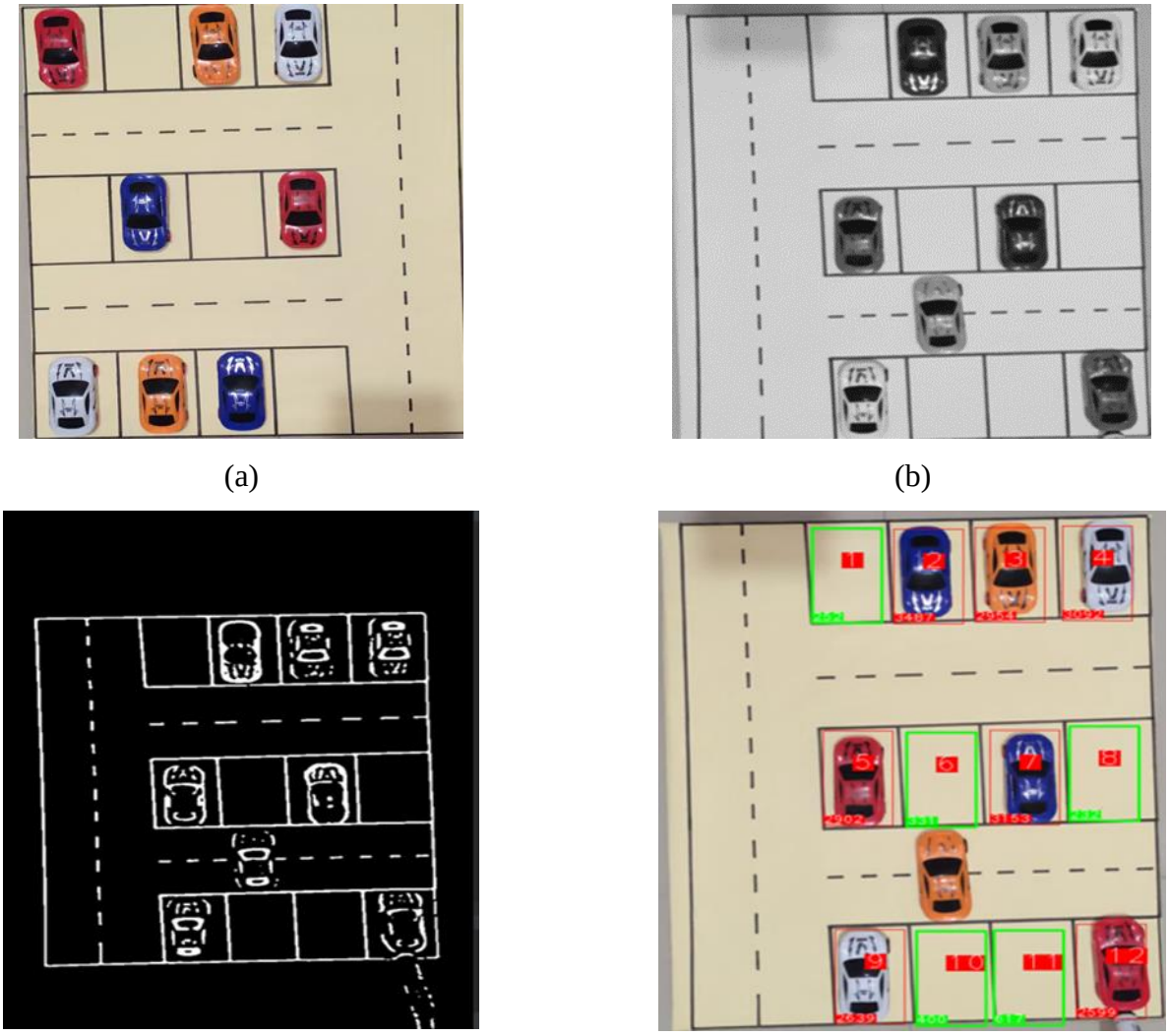
5.1. Introduction

This chapter discussed the simulation and the hardware model result analysis. We took images from the webcam and counted pixels with OpenCV so that we could find free space. We have used different OCRs for number plate detection to find the best result. We came up with a solution that EasyOCR is giving the best outcome compared to other OCRs. Because EasyOCR is better at recognizing Bengali text than others. We used the MongoDB database to locally host our server. They fetch back data from the database and send it to the frontend system. In the front end, the system lets users sign in or sign up according to their existing information. Furthermore, the user can book any particular space, and these data go to the backend system. All of the information shows in real-time on the webpage.

5.2. Results Analysis

5.2.1. Simulated Results

Empty Space Detection:



(a) (b)

(c) (d)

Figure 5. 1. (a) Camera Input (b) Grayscale Image (c) Thresholding (d) Pre-determined Parking Spots

We have used a smart technique called image processing to detect the parking space. Firstly, from the webcam video, we declared a particular space for each parking space (shown in green in fig). Our target is to count the pixels of the image to find whether a car is available. The parking space

was then cropped to count pixels according to their edges and corners. If fewer edges and corners exist, there will be a low pixels count, so there will be no cars. To start the technique, the images are converted into grayscaling and added blur in it.

After that, we put threshold to see the white pixels of the car. The image shows that if there is a car available, there is a high number of white pixels available, and the others are black. We have also added median blur so that there are fewer unwanted white pixels. Lastly, we have thicker the white pixels by adding dilate in them for counting the pixels.

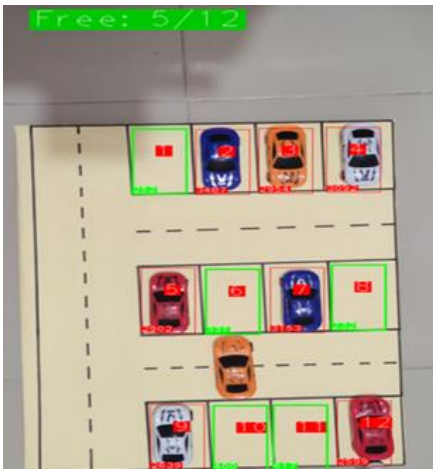
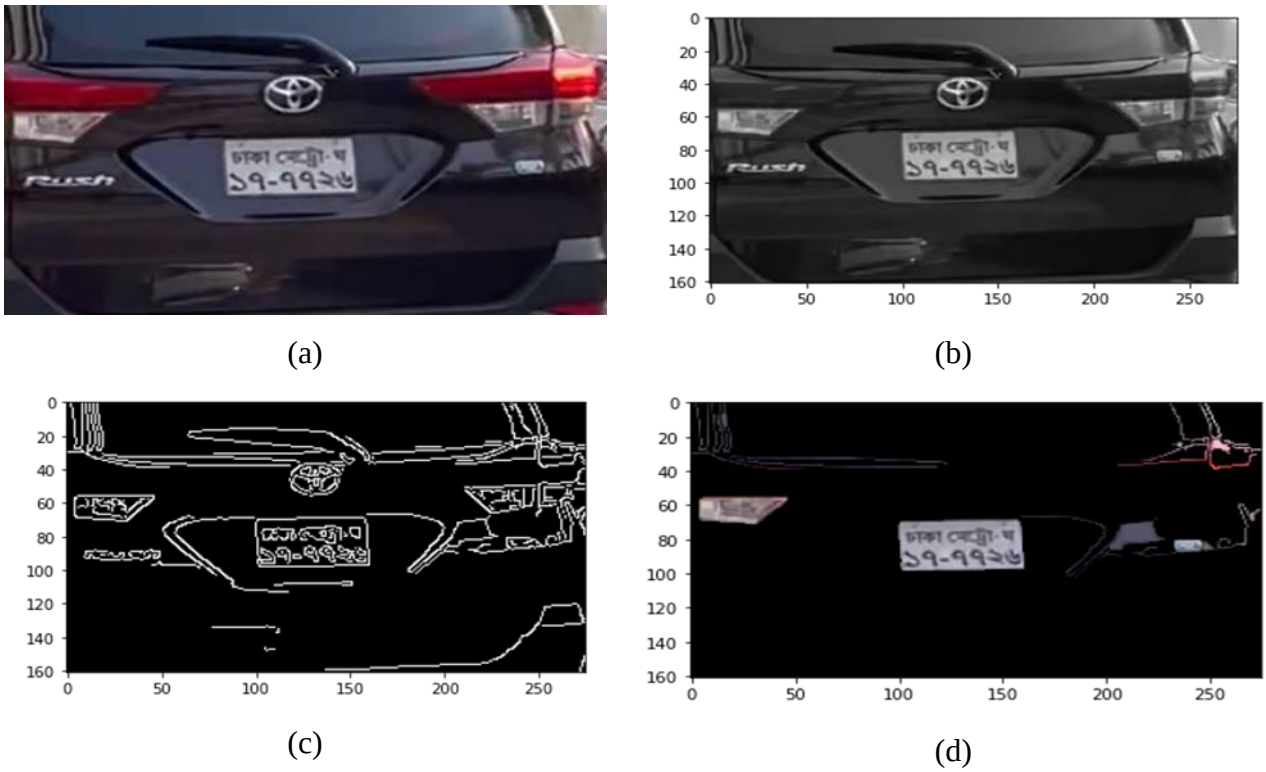


Figure 5. 2. Showing available spaces

Finally, we set a condition that if there is a high number of white pixels available, our system will show there is a car. If there is less number of white pixels, our system will consider it as a free space, as shown in the picture.

Number Plate Recognition:

For Bangla Number Plate:



(a) (b)

(c) (d)

Figure 5. 3. (a) Input Image (b) Grayscale Image (c) Edge Detecting Image (d) Input of OCR for Bangla Number Plate Recognition

Output:

[([[208, 66], [264, 66], [264, 114], [208, 114]],

'ঢাকা মেট্রো ঘ ১৭৭৭২৬',

0.8865651]

For English Number Plate:

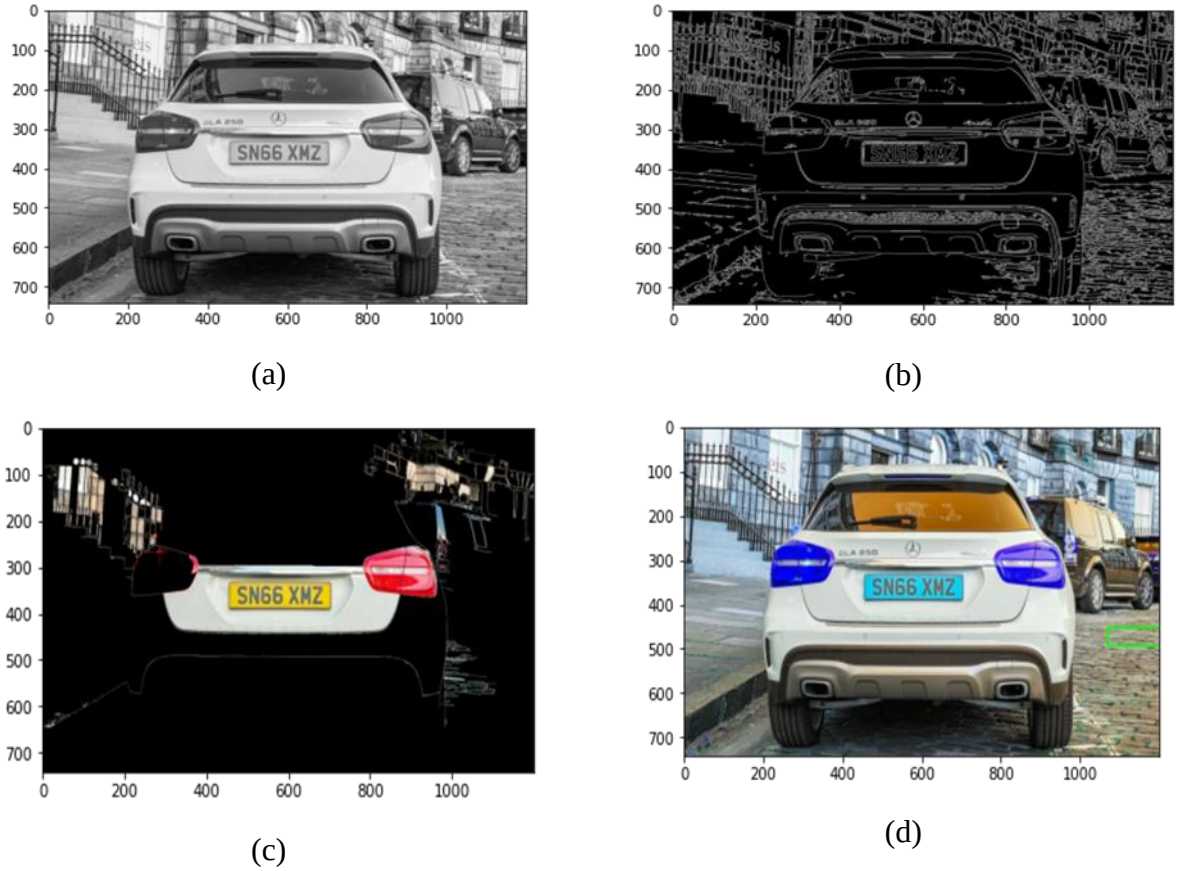


Figure 5. 4. (a) Grayscale Image (b) Edge Detecting Image (c) Cropped Image (d) Image with Bounding Box for English Number Plate Recognition

Output:

[([[470, 336], [694, 336], [694, 390], [470, 390]],
'SN66 XMZ',
0.9425007156447562)]

We take the input image and then grayscale it to highlight its different colours for both Bangla and English OCR models. Next, we detect the edges of these highlighted portions. After detecting the edges, we determine the boundary areas of it. We take this boundary area only and omit others. This boundary area is then linked with our EasyOCR. EasyOCR is a pre-trained model, so we do not

have to train it ourselves. So when we link the final image with OCR, we get our result in the output section.

In the output section, we can see several numbers describing the number plate's position. Now, we crop the image based on the bounding box created by the position and send the cropped image through our OCR model. Finally, we have the Bangla and English both registration number, which matches our picture.
The 0.8865651 is the output confidence level of EasyOCR for the Bangla number plate. Also, 0.9425007156447562 is the confidence level of EasyOCR in the English number plate. This number shows how confidently the OCR can detect the number. This is measured on a scale of 0 to 1.

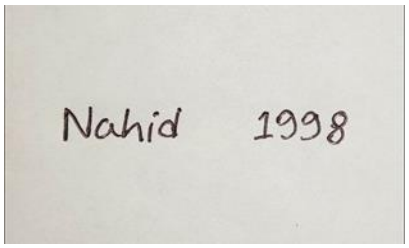
5.2.2. Hardware Results

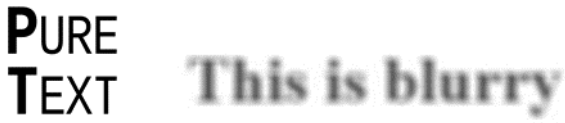
The hardware was implemented simultaneously with our software model. Basically, we have made a prototype for our whole system. We used two cameras, a prototype parking lot and several toy cars for the hardware system. From the camera, we took images to analyze them. In our machine learning model, we observed that a high-resolution camera was needed. For number plate detection, we need a clear image to analyze it. When the image quality is low, it is quite hard for the OCR model to read the text from the number plate.
Also, for empty space detection, a high-resolution camera was needed. We did pixel counting for this process. We pre-determined a rectangle box in a specific parking space. In this rectangle box, we counted pixels. When a car enters the box (or parking space), the number of pixels increases which are higher than a pre-determined value given by us. So, higher-resolution cameras are needed for the whole system to run smoothly.

5.3. Comparison of Results

We have done a comparative analysis of existing machine learning models with various datasets that we have created using our domain knowledge. The comparative analysis shows the behavior of ocr models and how they response with our dataset.

We have tested 3 most popular OCR models, Tesseract-OCR, Keras-OCR and EasyOCR to compare the output to determine which OCR to use.





We have used these images to test the OCR models. And the behaviour of the models is shown in the given table.

Table 5. 1. Comparison between EasyOCR, Tesseract-OCR and Keras-OCR

Input Type (image)	Actual Value	EasyOCR	Tesseract-OCR	Keras-OCR
Number Plate(HQ)	HR26DK8337	HR26DK8337	HR26DKB337	HR260K8337
Number Plate(LQ)	RB-850-Z	RB-850-Z	RB-850-7	Empty
Text Image(HQ)	PURE TEXT	PURE TEXT	PURE TEXT	PURE TEXT
Text Image(LQ)	This is blurry	This is blurr9	Empty	Empty
Hand Written(HQ)	Nahid 1998	Nahid 1998	Nahid 1908	Nahid 1998
Hand Written(LQ)	Nahid 1998	Nahid 199	Empty	Empty

Depending on the actual value and predicted value from OCRs, if the prediction value is equal to the actual value, we put 1, and for empty and wrong results, we put 0. Using 0 and 1, we created another table.

Table 5. 2. Comparison between OCRs in absolute value

Input Type (image)	EasyOCR	Tesseract-OCR	Keras-OCR
Number Plate(HQ)	1	1	0
Number Plate(LQ)	1	0	0
Text Image(HQ)	1	1	1
Text Image(LQ)	0	0	0
Hand Written(HQ)	1	0	1
Hand Written(LQ)	0	0	0

From the above data table, we have created this graph below to compare the OCR models and then determine which OCR model performs the best.

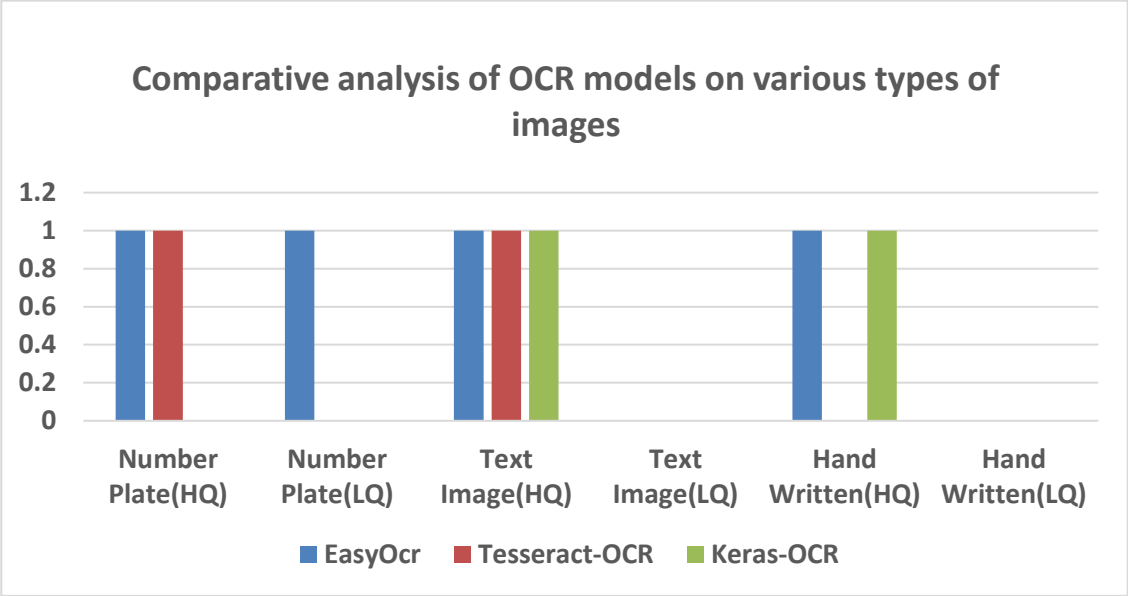


Figure 5. 5. Comparative analysis of OCR models on various types of images

We also did a comparative analysis of OCR confidence in detecting a number plate before and after applying our image processing method. The given table below shows the before and after result of the confidence level of EasyOCR on our selected dataset. This comparison helps us to identify the improvement that has been made with our method.

Table 5. 3. Analysis of confidence level of before and after Image Processing

Car	Before	After
1	0.564781	0.7894736842105263
2	0.56578154	0.79448211
3	0.5578154	0.7549054
4	0.08777841	0.82449897
5	0.284978	0.8295656
6	0.32587865116	0.689588843210
7	0.556548917	0.7894736842105263
8	0.58659489	0.556541947368
9	0.04645446	0.72829242736
10	0.349591652	0.8865651

From this table, we can see EasyOCR is doing better performance after the image has been processed, and its confidence level increased by around 35-40% on average. Analyzing this table, we can compare the confidence level graphically.

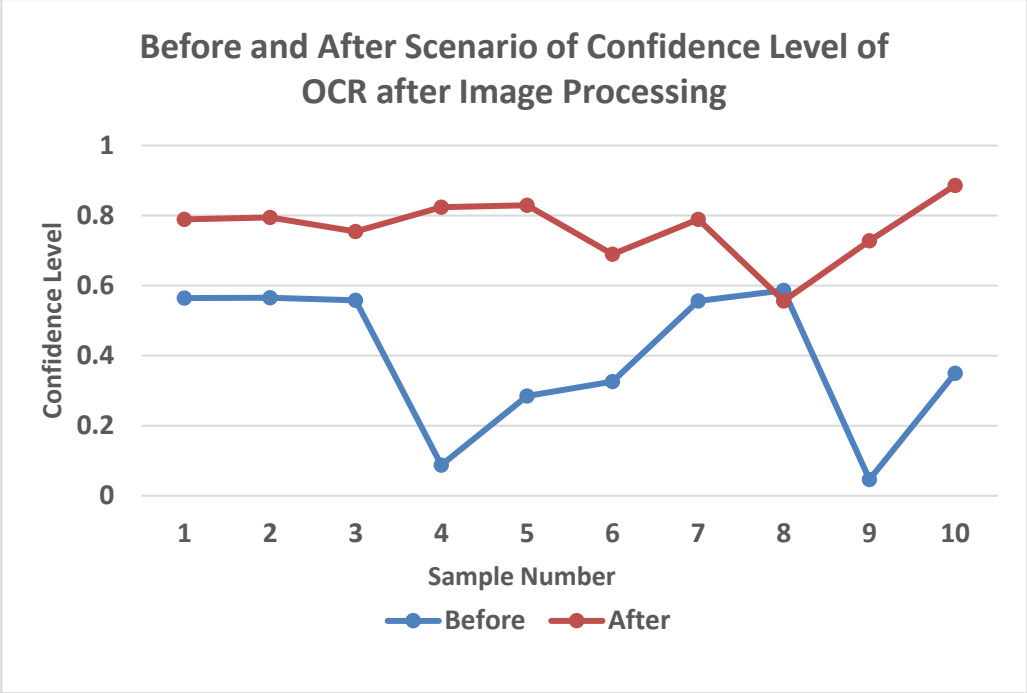


Figure 5. 6. Before and after scenario of confidence level after Image Processing

From the graph above, we observe that the blue line shows a better confidence level than the red line. The blue line indicates the OCR's confidence level after image processing. Before image processing, we can see that the confidence level seems inconsistent compared to after image processing. So, graphically, it can be judged that the EasyOCR performs better after image processing.

5.4. Summary

We have been able to detect empty spaces. Also, we have been able to detect number plates for both Bangla and English texts. We have established a connection between servers with Python and JavaScript. Using HTTP requests, we have been able to show real-time updates of the parking system on our website. Also, we have created a frontend and backend system that can be used by users to interact with our system. We have done comparative studies between different OCR models. Finally, we found how much the EasyOCR model performs better when image processing is done.

Chapter 6

CONCLUSION

6.1. Summary of Findings

The main purpose of this project was to develop a smart parking management system. The necessary components for a successful smart car parking system implementation have all been completed. The registration of cars may now be done online, and it is highly user-friendly. The database can be expanded with registered data. The car driver can easily see the empty slots on the webpage display. The frontend system allows the admin to see which vehicle has been parked in which space.

6.2. Novelty of the work

The system will be used in line with the existing CCTV network and can be a low-cost solution for homeowners. Those homeowners who cannot use complex and advanced systems to implement the security system can use our solution at a low cost. All the CCTV models are company software dependent, but if we set this system camera, we can use a smart car parking system at low cost through webcam. CCTV system is very costly, and many things can be done. There are many features, and we will not compete with them. We are trying to take a portion of the market that request low-cost product. Our system provides free parking space detection and number plate detection to run without any human touch. We tried to make this system easy, so anyone can manage parking space online. It can be done on a laptop with low specifications. This project's work is distinctive in combining every component of a smart parking system. There have been researching projects for each element, but no project has combined all the features into one.

6.3. Cultural and Societal Factors and Impacts

The concept was developed considering societal and cultural factors. Nowadays, all vehicle owners and drivers use Google Maps for navigation, indicating that they are all using the internet. So, users or stakeholders should not have any problem using the online space finding or car registration process. This ensures that none of the features is at odds with any cultural or societal elements.

This project aims to address the ongoing parking challenges in large cities like Dhaka. The proposed design has a great societal impact as it will solve most of the current parking issues, allowing users to register online and enter the parking area automatically without human help. In this way, the proposed design can be impactful. With this solution, people will save time, and there will be less CO_2 emission into the environment.

6.4. Limitations of the Work

We have created a prototype-based project using hardware of the micro variety, but we have not tried to use it for industrial or commercial purposes. As a result, we are unsure how the project will function in this practice. Also, all the processes are done by the internet, and if somehow the internet connection goes down, this process will not work. This is the most crucial limitation of this work.

6.5. Future Scopes

Although this project has the most critical components of a perfect smart auto parking system, it still lacks a few crucial components. One of them is a system of payments. The traditional manual payment method will be required for car owners and users. Additionally, the security check-up option is absent. These could be viewed as potential future scopes for this project.

6.6. Social, Economic, Cultural and Environmental Aspects

6.6.1. Sustainability

We are all aware that climate change is not just a fact but also a growing danger to our lives and the way we have known them up until now. Therefore, finding strategies to enhance our routines is necessary if we are going to be successful in extending the life of our lovely planet. In this piece, we'll talk about the positive effects that smart parking has on the environment.
The following is the issue, to put it in the simplest terms possible: We are continuing to release greenhouse gases into the atmosphere, which is causing the temperature of the Earth to rise at an alarming rate. As temperatures rise, additional changes will occur, making it more difficult for living forms to endure and eventually for anything to survive on this planet at all.

Now, there is no question that one of the activities that contribute to the production of emissions is driving a vehicle. One can reasonably inquire as to why we are discussing environmental responsibility in the context of a sector that is undoubtedly a component of the automobile industry. The solution is not complicated at all. We are powerless to prevent people from driving cars; what we can do, however, is make driving more environmentally friendly by minimizing the negative effects that parking a car has on the surrounding environment.

6.6.2. Economic and Cultural Factors

One of the most common reasons for unnecessary driving in urban areas is the search for a parking place. When someone doesn't know where to look for a parking spot, they drive around until they find one. According to estimates, cruising for a parking place adds around 3.5 to 14 minutes to a drive, and that additional time implies higher emissions.
Cars seeking parking contribute significantly to urban congestion and increase the driving time. Congested streets cause cars to accelerate, decelerate, and idle, which is an extremely inefficient driving style. In addition, it consumes more gas than driving at a constant speed, causing more atmospheric pollutants.

It is widely assumed that 30 percent of downtown traffic comprises cars hunting for available parking. That's a lot of extra time and stopping and beginning. A digital parking solution has a significant positive impact. Unnecessary cruising can be eliminated by displaying parking availability in real-time. This decreases driving time and congestion, easing the environmental load. The cumulative impacts of improved parking traffic flow can majorly impact urban air quality and long-term sustainability.

In this project, we have focused on IEEE standards, ensuring that we put public health, wealth and welfare first. For example, our system will reduce car owners' waste of time looking for a parking place. With this system, they can easily book a place without any headache for parking spots.

6.7. Conclusion

An innovative idea like the automated car parking management system s something new for a country like Bangladesh. The system is already in use in first-world nations. In Bangladesh, the initiative has a lot of potentials. Bangladesh's parking structure is analogue. Human operators control the entire process. In an analogue car parking management system, mistakes, mismanagement, and favours to particular people are frequent. A major problem is also the length of time it takes to park a car. But in automated car parking management systems, nearly everything is handled by machines. Cameras are used to detect people at the gate, and if the data matches server registration numbers, the gate will open. The project's objectives have been entirely met from the beginning to the present. If adopted, the method will benefit Bangladesh greatly and aid in easing the country's parking-related traffic congestion.

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Appendix A

iThenticate Plagiarism Report

Group 7

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