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Smart Parking System for Air University

Bachelor of Science in Computer Science

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Certificate

We accept the work contained in the report titled "Smart Parking System for Air University", written by Mr. Aezaz Ali and Mr. Zubair Bin Hamid as a confirmation to the required Standard for the partial fulfillment of the degree of Bachelor of Science in Computer Science.

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Abstract

The main idea of the Smart Parking System for Air University (SPARKAU) is to provide a way for drivers to park their cars with more ease. It is said that “Time is money” so everyone gets frustrated when they give their time and effort in return for nothing. In basic parking systems, there is no check and balance for the available slots. The driver starts looking for the free parking slot by the hit and tries method if he manages to find a parking slot available, it is a lucky try but on the contrary, most of the time driver does not find a slot available. He returns from the parking with aggression and frustration. It wastes the fuel as well as the time of the driver. People facing this problem becomes very irritated because of the necessity to use parking daily. This problem also correlates with the parking area of Air University. Whenever the driver enters the university premises, he looks for the parking area to park his car, but it often results in time and fuel wastage. The driver examines the whole parking area but does not find a single slot available to park his car. It becomes very annoying when the driver exits from another side of parking without parking his car.

Our system will save both time and fuel of the driver. It will help the drivers to park their cars in the parking space available. The driver would not have to waste his time looking for every parking slot. He can acknowledge the availability of the slot by just using our software. The driver will open the web application of SPARKAU, search for the most suitable free parking space, and easily park his car. This system is very different from hardware-based methods because it saves the installation as well as the maintenance cost of hardware. In the hardware-based smart parking systems, sensors are installed in the parking areas. Microcontrollers are used to check the flow of parking and updating the availability of the free slot. This system requires hardware but its installation and maintenance is a budget problem.

In our situation, the university parking had already deployed CCTV cameras for security purposes. We used these cameras as a source of input for our software, process the input on our algorithm, and provide the user with a website having the information about free space available.

Whenever a car enters or leaves the parking, the CCTV cameras are recording the videos continuously. Our software will use these videos. On the server-side, when our software takes the input, it processes the videos and calculates the newly available and occupied parking slots. Whenever a change in the parking slot occurs. A request is sent to update the database. While on the client-side, an API service is running continuously, which asks for the new data from the database. Whenever the database is updated, the new data is sent as an API response. The response then updates the web application about the newly available parking slots.

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Special thanks to families and friends for their unconditional love and support for us.

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Aezaz Ali

Islamabad, Pakistan

June 2020

“Every problem has a solution. You just have to be creative enough to find it”

Travis Kalanick

Table of Contents

List of Figures

List of tables

Chapter 1

Introduction

This chapter contains all the fundamental information about the **Smart Parking system for Air University** (SPARKAU). It contains the basic motivation for planning this project. It explains the basic smart parking systems, the types of smart parking systems, and our smart parking system. It includes the limitations, objectives, and life cycle of our project.

1.1 Project Overview

Due to an increase in the number of departments in our university, parking problems are bound to exist alongside. The development of departments increases the number of students and faculty members in the university. It results in too many vehicles inside the university. More vehicles on the campus result in added problems associated with the parking area of the university. The parking area gets crowded with vehicles. The driver cannot tell whether he will find an available free slot.

Smart parking is a software and hardware-based system in which the system guides the user about the availability of the parking. Whenever the user enters the parking, he takes a guide by the system for the vacant car slots. Smart parking is a very efficient parking tool that is used in various foreign countries.

There are two types of smart parking systems, which guide the users about the free parking slots. One of them is a hardware-dependent sensor-based smart parking system while the other one is a software-based system. The smart parking system based on IoT sensors (hardware) is commonly used in the parking areas of the building. Most of the buildings have the parking area in the basement of the building. It is preferable to guide the user so that he knows whether the parking is available or not. The LED screen or LCD screen is put up at the entrance to guide the user about parking.

In the software-based smart parking system, users have a certain application or a website to look for parking. He can examine the parking area to find a free slot using the application or website. In most cases, Open space parking like universities, offices, or parks has software-based smart parking systems.

Smart Parking System for Air University also known as SPARKAU is a software-based smart parking system that helps the members of our university to park their cars easily and properly. It is developed according to the parking area of the university. Whenever a person enters the university, the first thing that blinks in his mind is to find a free parking slot closest to his department. He can look for the available slots with our smart parking system. The user can access the web or mobile web interface of SPARKAU using the mobile phone or tablet. He can analyze the different parking zones for the available free slot. He can examine the parking zones to find the nearest free parking slot with his department.

1.2 Problem Description

When the university initiated the step of developing new departments on the campus, the total sum of university members also increased. More people in the university results in more vehicles in the university. The parking area of the university gets filled up with cars. It is impossible to tell about the availability of the free parking slot without examining the parking area. The daily routine of looking for free slots is time wastage and fuel wastage.

Smart parking is the key idea to efficiently utilize the parking system. The user will be able to look for the free slot without wasting a minute. By using SPARKAU, the user will not feel the frustration and annoyance of roaming around to find a proper slot for parking. It will save a lot of time for the user. Another advantage would be the reduction of useless burning of fuel of the user’s car.

1.3 Project Objectives

SPARKAU will turn out to be a time-saver application. It will help many university members in the coming days. Students, faculty members, and admin members of our university will use it. The key objectives of this project are

- To help the people of our university to find a free parking slot
- To solve the daily routine issue of looking for free slots.
- To make the CCTV cameras used more efficiently by using them as the main input source of this project.

- ➢ To save the time and fuel of university members
- ➢ To help the university members get rid of this useless frustration caused by the parking problem.
- ➢ To research on computer vision and enhance our knowledge.

1.4 Scope of the project

SPARKAU will consist of a front-end web application and a backend-python code server. Web Application will be responsible for handling both the mobile view and the table view. It will display the parking slots contained in different zones Each zone represents a specific parking area. The web interface will consist of four zones displaying different areas of parking. Each zone will cover at least 5-10 parking slots. The range is not specific because our parking does not have any CCTV cameras to cover the right side lane view except the one moving camera. The python code server will use a Computer Vision algorithm Called YOLO [2] (you only look once: An image classification algorithm) for backend processing. However, there are some issues shown by YOLO when used for our parking area. These issues are;

- ➢ The CCTV cameras are fitted sidewise and tilted which generates a tilted view of the parking
- ➢ The cars hidden behind the car cannot be classified
- ➢ YOLO sometimes confuses to differentiate between two cars because of an inappropriate car parked
- ➢ YOLO could not classify the objects whose edges are not well defined and apart from other objects

Some of these limitations are hardware-based which are out of the scope of this project, e.g. CCTV camera is fitted sidewise. It is very difficult for YOLO to detect all the cars with side angle images. One of the other limitations is the inappropriate parking of cars, which is again out of scope for this project.

Some other issues are the placement of CCTV cameras in the unive9p[srsity Parking. As the CCTV cameras were already deployed by our university admin.so it was out of the scope of the project. Other issues include having rainy days which results in blur views, night views, big trucks or cars in front of small cars, and fewer cameras to cover the parking area.

1.5 Project Life Cycle

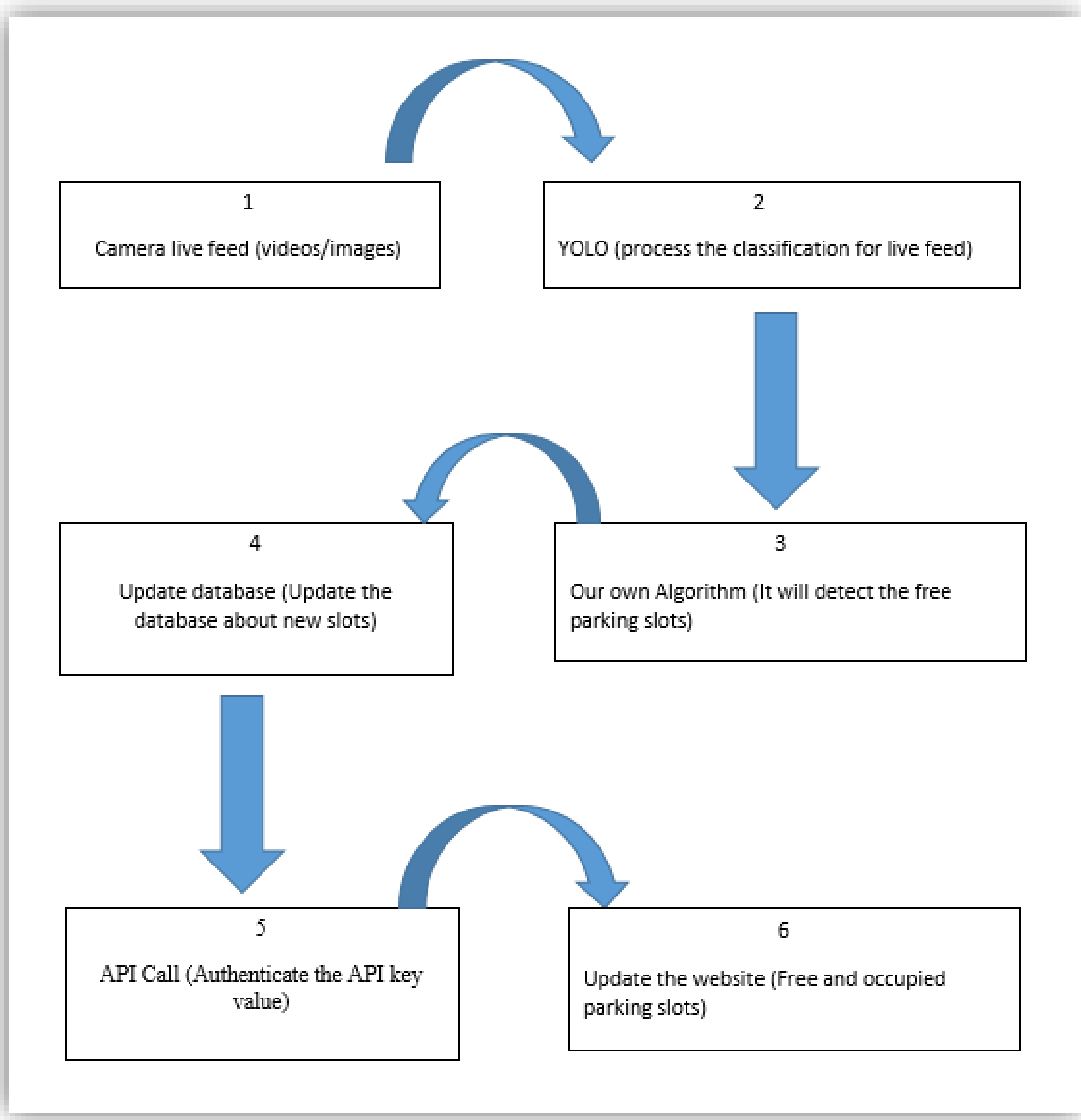


Figure 1 Life Cycle of SPARKAU

This chapter provided an overview of the smart parking systems and their types (commonly hardware and software-based). It also has a brief explanation of the current system on which the project is working, its limitations, and its advantages. Finally, it concluded with the life cycle diagram of the whole system.

←**Chapter 1 End **→

Chapter 2

Literature Review

This chapter explains a few of the smart parking applications along with their method of working. The paragraphs given below have a very brief summary of the basic methodology of these applications. The survey table has all the features that can be examined based on the study of these applications. Finally, this chapter includes all the problems within the existing systems.

2.1 SPARKAU

SPARKAU is a computer vision-based Smart Parking System (SPS) in which the system will classify the cars through the videos/images from already deployed CCTV cameras in the parking area. From the information extracted, it will detect the availability of free slots. It will then update the user interface about the availability of free parking slots. The user interface is a front-end website/ mobile web App.

SPARKAU is divided into two sub-components. One of them is the Computer vision-based backend python code, which will do all the backend difficult work processing, while the other one is the front-end website which will be used to display the parking slots.

2.2 What is Computer Vision?

Computer vision is a disciplinary scientific field that deals with how computers can gain a high-level understanding of digital images or videos [3]. It is a very vast field in computer science. Various projects around the globe being developed are purely in computer vision such as parking systems, auto-driving vehicles, self-driving drones, etc.

In Computer vision, the algorithm is trained on images having labels on it so it can recognize every pixel and the features of the image. Therefore, the algorithm remembers those features for that class. When training is completed, the algorithm is being tested and validated whether it recognizes the image or not. Most of the algorithms are considered to be good if their accuracy is high up to 80%.

Computer Vision is used in various fields such as automatic driving vehicles for disabled people, surveillance robots for security purposes, text scanner for converting the image text into the editable form, health care medical centers for diagnosing of cancers and other diseases, in laboratories for making antidotes of disease, etc.

2.3 Related Work

Every year, many universities are developed around the globe. Most of the universities tend to enhance their ranking by developing new departments, labs, and buildings. The growth of these factors increases the overall population of students, faculty, and staff members inside the university. With decreasing parking supply and increasing enrollments and faculty and staff members, universities are beginning to realize the importance of properly allocating available parking [4].

Intelligent Parking System (IPS) is a smart parking system that was developed for the University of Texas at Austin in the year 2003. Information about the parking slots can be given to the drivers by the use of IPS. IPS reduces the congestion in parking areas, insufficient utilization of the available parking, and road congestion caused by searching for free slots [4]. IPS works with the help of the **variable message sign** (VMS), which serves as a "wayfinding" device. Wayfinding means providing information about the path to free parking slots. IPS system operates using loop detectors, ticket splitters, and cash registers as vehicle counting equipment located at each garage or parking. A controller interface is also required since the equipment is not capable of calculating a "space available" number. This interface counts and calculates space availability in real-time as each car enters or exits the parking. This number count is transmitted via modem to a central computer. The central computer then sends the required signal along to the variable message signs with the help of Microsoft-based Ramp Management Software. The operator can control the system from the central computer at any time. He can read and modify sign messages, correct parameters, check the state of an entire mounted electronic sign mast or parking facility, and can take appropriate action as required. The below given are the benchmarks for the Intelligent Parking System.

Programming language	Html,asp.NET
Responsive	yes
Performance	real-time information travel
Hardware included	Yes

ML algorithm	No

Table 1 Benchmarks for Intelligent Smart Parking System

IPS system consists of a server page that can control the parameters, messages being displayed on variable message signs, LED screens, parking counts, and all the systems. The server page will get the information and it will update the HTML view in real-time. Whenever the user presses the refresh button on the website. The script will update the web page and the user will be able to see the availability of parking on the web browser. Intelligent Parking System will consist of an HTML web page for the user. The web page will respond according to the resolution of the user's device.

The performance of the Intelligent Parking system is very accurate and good. It informs the users about the availability of free parking in real-time. It updates the web page as soon as the user presses the refresh button.

The intelligent parking system mostly contains hardware-based components. The VMS system, LED displays, the modem used for signal transferring to the main computer, ticket splitters, and gate arms.

There is no Machine-learning algorithm included in this project as it simply extracts information from hardware. Most of the software part is a simple web page that displays the availability of parking.

Parking may seem a trivial matter, but it is a serious problem for many students. Smart Parking Systems(SPSs) disseminate real-time parking spot availability to drivers searching for parking[5]. Generally, various SPS applications are available for shopping malls or airports. Sensors and parking meters are commonly used in these applications to analyze the availability of parking slots. Parking meters are considered to be inaccurate in examining the available parking slot while on the contrary, sensors are a good option to develop an accurate SPS application. But sensors have disadvantages to embed in open parking spaces because of weather conditions.

One of the other applications is **University Car Parking Application** (UCPA) developed by Chinmayee Lingman (2018) in University-Corpus Christi, Corpus Christi, Texas[6].In UCPA, the driver would have an application that would serve as a parking slot guidance. A map of the parking lot would be shown at the entrance of every parking. This map would also be accessible through the mobile application. The map would have slots marked on it. The driver can choose any of the available slots. It will generate QR-code. This QR-code is scanned and the selected slot is reserved.when leaving, the QR-code is scanned again, which will free the slot. if someone else parked their car on the reserved slot. The person who has reserved the parking can report a complaint against the driver by sending a picture of the number plate to the admin of the university. After the complaint, the user will be given a new page with available slots. He will be able to reserve the slots by scanning the QR-code by the same process.

The application will be developed for only android smartphones and tablets. It would have a QR code scanner and QR code generator. QR codes would be generated by a map based on the selected slot. These codes will be scanned by the android mobile application which would reserve the parking slot. This application is compatible with several versions of Android from Android 5.0 – Lollipop to recent Android 7.0 - Nougat.

The login screen/signup screen and all the images of UCPA are given below

Figure 2 Application Interface

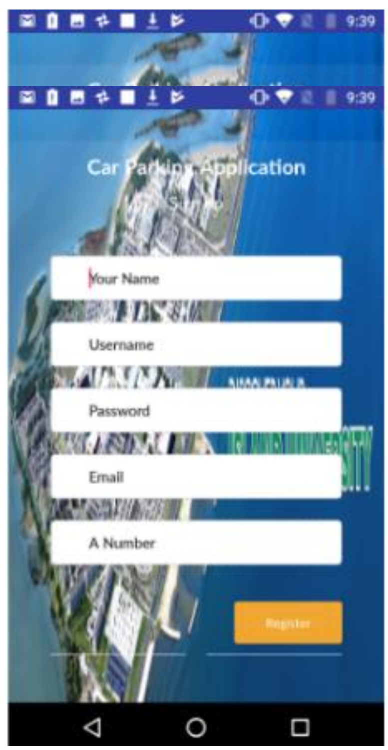


Figure 3   Application Interface

The first screen is the login screen in the Application. It will ask the user to enter its credentials. If the user has not yet registered, then the user would click the register button and the registration screen will pop up. It will ask the user for its personal information. After complete registration, the user would be able to use this application.

After login. The Application will display the home screen. It will have parking lots or parking zones on the left side with numerical values on the right side representing available parking slots. When a user clicks on a slot on the map. A specific QR code would be generated. The user would scan that QR-code to book that slot.

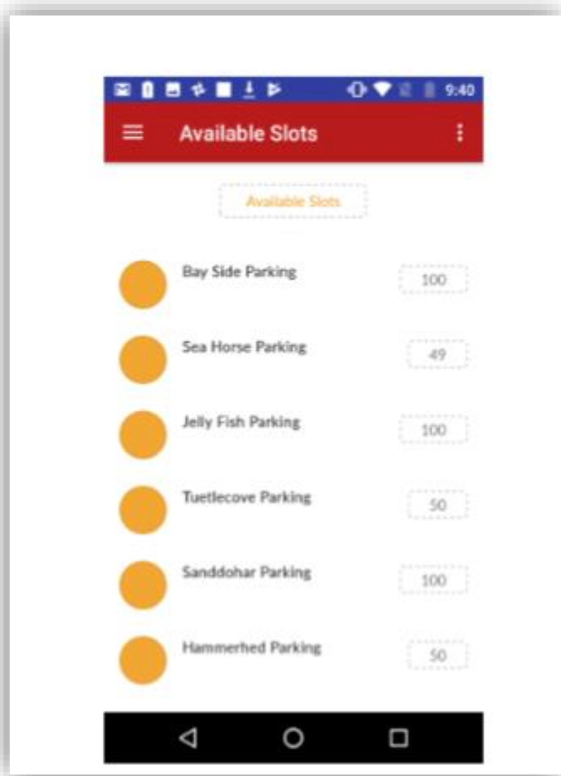


Figure 4 Parking lots with available free slots

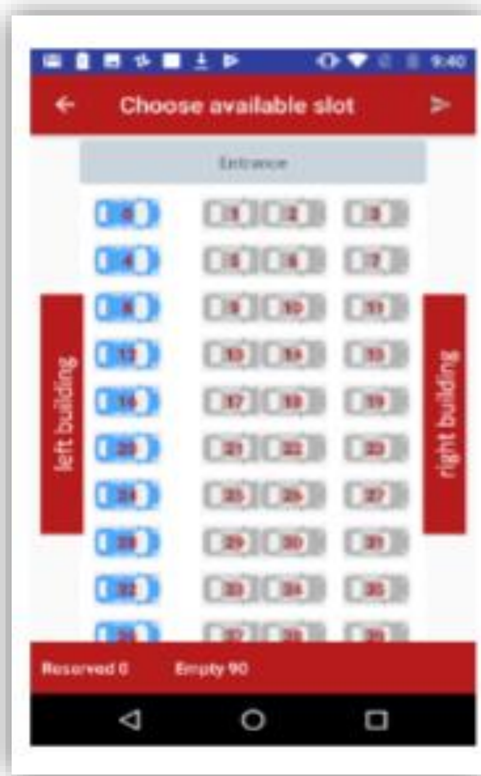


Figure 5 Slot selection

Figure 6 QR code Scanner

Programming language	Java,Xaml,Json
Responsive	Yes
Performance	Based on reservation
Hardware included	No
ML algorithm	No

Table 2 Benchmarks for University Car Parking Application(UCPA)

The main focus of this application is the android platform. The languages used for android mobile development are Xaml and Java. QR code scanners and QR code generators will be developed in java. It will also have a centralized database. The database will be implemented in the firebase. The response will be based on the reservation time of a driver. It is a purely software-based product. There is no hardware included in this product. It is also a non-machine learning product.

IoT(Internet of things) is the newly emerging technology of the modern era. With the advancement in technology, it has become very easy to collect an enormous amount of data for experimental purposes. Multiple solutions exist to the problem of finding parking space availability. They are broadly classified into Vision-Based approaches and Sensor-Based approaches[8].

The methodology used in the **Application based Smart Parking System using CAN bus** is a sensor-based approach, which consists of microcontrollers, ultrasonic sensors, and external devices. Communication occurs between devices through Bluetooth

Users can look for the availability of parking through the Android Application. The Application will use the Google Map API to display the parking area and the current location of the user. It will be used to reserve the parking slot. Users can also complain about the illegally parked car on his reserved slot. The data of the users e.g. personal information, payment information will be stored inside the firebase database.

Arduino Uno will be used to collect the sensor's data and for communication between external devices and other modules. Arduino device will be configured to connect with our android devices using Bluetooth feature. There are 5 Arduino devices formed as an interconnected node network for communication. These devices are configured with ultrasonic sensors to detect the presence of a car on the slot. If parking is reserved, Map will display the slot as red light while green light represents the free slot. Communication about the free and reserved parking slots will be transferred through Bluetooth signals from the Arduino device to android phones. The application will calculate the time of entry and time of exit for every vehicle and a bill will be generated automatically at each exit of the car. The backend scripts will run on NodeJS.

The login image and the parking zones display is given below:

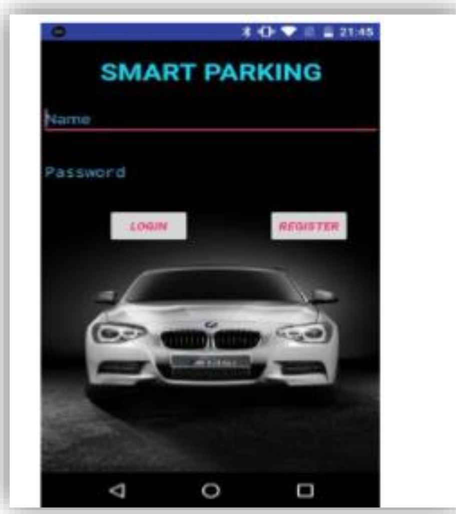


Figure 7 Login Screen

Figure 8 Parking Zones

Programming language	Arduino c++,Java,Xaml,NodeJs
Responsive	Yes
Performance	Based on reservation
Hardware included	Yes
ML algorithm	no

Table 3 Benchmarks for Application-based Smart Parking System

The programming language used for coding the microcontroller is c++, while the front end interactive application developed for the user is in the android platform. NodeJs is used for retrieving data from the firebase cloud database. It is a responsive mobile application. The system's performance is very good because of the sensors. It is mostly hardware-based product but interface for user interaction is an android application. There is no Machine learning Algorithm used in this product.

Finding a vacant parking space nowadays is time and fuel consuming. This problem may cause drivers to get annoyed and eventually improper parking will appear[8]. **Smart Parking System for the University of Kufa** is a system that will use a wireless smart parking system to tackle the parking problems. Ultrasonic sensors will be used to analyze the situations of parking. Arduino Uno will also be used in this system.

Ultrasonic sensors will provide information about vacant parking slots, improper parking detection, directions towards vacant parking, and payment facilities. These ultrasonic sensors will be installed on each parking slot to detect the presence of the car.

There are two LCDs used in this project. One is deployed on the main gate to show the status of parking space while the second one is deployed on the street to display the available free slots. Arduino Uno will process all the hard work. It will process the feedback signals and performs some calculations. The LCD will display the currently available free slots. There are two Arduino Uno used in this smart parking system. One of the Arduino act as an information processor and information sender. While the other one act as an information receiver. After receiving the information. It updates both the LCDs for the occupied and the available parking space.

The benchmarks for the Smart Parking System For University of Kufa are given below in the table

Programming language	Arduino c++
Responsive	Yes
Performance	Real-time
Hardware included	Yes
ML algorithm	no

Table 4 Benchmarks for Smart Parking System ForUniversity of Kufa

The programming language used in this Smart Parking system is the Arduino programming language c++. Its performance is very good, It responses to the user in real-time. Almost all the project is based on hardware. There is no Machine Learning Algorithm used in this project.

Smart Parking System For UF Campus is an application that was developed by Lili du and scot Washburn in 2019 for the University of Florida[7]. The author divided this task into three main subcategories. First is the monitoring of parking, second is the parking demand, and thirdly implementing the smart parking Applications for the desired demand.for monitoring purpose, parking space utilization at any time, vehicle entrance and exit data, vehicle identification data(includes size) and motorcycle parking data were analyzed to get some useful information. for this purpose,space-specific technology at entrance/exit points, RFID, and video cameras were used. The second subtask was understanding parking demand. The collected data was analyzed and it was feed into some Machine learning algorithm to graphically represent the data. The data represented more comprehensive patterns of parking utilization, such as variation of the parking usage throughout the day. The last task was to implement a Smart parking Application or website that would provide real-time parking space availability and prediction suggestions.

The benchmarks for Smart Parking System for UF campus are given below;

Programming language	Html,CSS ,Php,Java,Xaml
Responsive	Yes
Performance	Real-time
Hardware included	Yes
ML algorithm	Yes

Table 5 Benchmarks for Smart Parking System for UF Campus

The interface for the user is a website and an android mobile application. Generally, the programming languages used for android development are java and XAML. While the programming languages used for web development are Html, CSS, and Php. The interface would consist of a map that will display the available parking slots. It will be very fast in responding to real-time situations. Whenever a car exits the parking, the hardware sensors will detect that and it will update the interface about the free parking slot.

Given below is the Survey Table for all the Applications reviewed above

Applications	Name	Programming language	Responsive	Performance	Hardware	Machine Learning Algorithm
Application 1	Intelligent Parking System	Html,ASP.NET	yes	Based on QR-scan	Yes	No
Application 2	University Car	Java,XML,JSON	yes	Based on Reservation	No	No

	Parking Application					
Application 3	Smart Parking System Using CAN bus	Arduino c++,Java, Xaml,NodeJS	yes	Real-time	Yes	No
Application 4	Smart Parking System for university of Kufa	Arduino c++	yes	Based on Reservation	Yes	No
Application 5	Smart Parking System For University of Florida Campus	Html,CSS, Php,Java,Xaml	Yes	Real-time	Yes	Regression

Table 6 Survey Table

From the review of all the Applications, we can see that most of the products are sensors based hardware included. These products are very costly in case of cost-effectiveness. They also require the installation of theses sensors and microcontrollers as an extra expense.

Many Applications have manually checked parking slot availability such as in Intelligent Parking system with QR-code scanner. If a user forgets to scan the QR-code before exit, the system will not know whether the slot is free or not. It will not be an effective smart parking system. There are many other disadvantages of these applications. Many of these disadvantages will be tackled in the Smart Parking System for Air University (SPARKAU). It will be a minimum cost product with real-time information processing. The interface will be updated as soon as any vehicle leaves the parking. We will use a Deep learning model called YOLO[2]. There are no specific hardware requirements for SPARKAU because it will utilize the already installed hardware (cameras) in the parking.

This chapter reviews different types of smart parking applications along with their benchmarks such as performance, hardware, and machine-learning algorithm included. It explained the basic working of every application and finally presented a survey table with all the benchmarks.

←*****************************Chapter 2 End******************************→**

Chapter 3

Requirement Specification

There is always the current best existing application of each category. To build a new product, a new approach has to be followed and a new system is developed. In requirement specification, all the requirements of the SPARKAU are gathered The same approach is followed in this chapter. Firstly, the existing best system is explained and the proposed solution is presented along with its Function and non-functional requirements. Use cases of the proposed solution are also given in this chapter.

3.1 Existing System (best)

The best Smart Parking System Application based on accuracy, time efficiency, and fuel-saving is the Smart Parking System for the University of Kufa [8]. **Smart Parking System for the University of Kufa** is also a hardware-based system that will use a wireless smart parking system to tackle the parking problems. Ultrasonic sensors will be used to analyze the situations of parking.

Ultrasonic sensors will provide information about vacant parking slots, improper parking detection, directions towards vacant parking, and payment facilities. The ultrasonic sensors would be embedded in each slot of the parking area to detect the presence of the car. The signals would be sent from ultrasonic sensors to the Arduino Uno.

There are two Arduino Uno used in this smart parking system. One of the Arduino act as an information processor and information sender. While the other one act as an information receiver. The first one which will act as an information sender will receive signals from sensors. These signals will be processed and sent to the other Arduino Uno. When the other Arduino receives the information, it updates both the LCDs for the occupied and the available parking space

There are two LCDs used in this project. One is deployed on the main gate to show the status of parking space while the second one is on the street to display the number of available free slots.

3.1.1 Limitations and drawbacks:

Smart parking systems based on sensors are very accurate and can perform very well. Many factors are considered when implementing a system for a real-world problem. The priority is to maximize the utilization of resources. The major drawback of the smart parking system with hardware is that system is too expensive to implement. Most of the parks, offices, and universities have a very big area to cover for parking. The overall cost of implementing such systems will go beyond the expectations. Another major drawback is the malfunctioning of the hardware such as sensors or boards. It is very time-consuming when it comes to changing the malfunctioning hardware. Its troubleshooting becomes a very big issue. An inspecting engineer would have to come to inspect the system. After the troubleshooting of the whole system, the next step would be the installation of new hardware. Which would also cost extra money to the organization. So it can be said that the smart parking system with sensors and hardware are not well suited for large buildings and big organizations. To improve this system, a new proposed system has been implemented. It has overcome all the drawbacks of the previous system and it is cost & time-effective.

3.2 Proposed System

Many of the smart parking systems have been implemented using different computer vision algorithms. Computer vision can also be said as the backbone of the smart parking systems. The images and videos are the input data for the algorithm, they process the data and provide the desired output.

SPARKAU (**S**mart **Park**ing system for **A**ir **U**niversity) will solve the parking problem very efficiently. People will be able to park their cars to the vacant parking slot without any difficulty. SPARKAU will process the videos to calculate the available free slots. Then, it will provide the interface to look for a parking slot.

SPARKAU will overcome all the issues in the previous system. It will be a time-effective, cost-efficient, and easy to use the system. It will be completely a software-based System without any hardware or sensors. The only hardware that would be used in this system is CCTV cameras that are already deployed by the university admin. The system will process the videos coming from these cameras. It would only require a simple computer system that could run the software. It would take the input as video from the CCTV cameras already deployed in the parking. It would then process those images through the algorithm, which will detect the objects in the image. Then it will get processed from our algorithm which will calculate the occupied space as well as free space. In the end, the results of the parking area would be uploaded on the website. The website will get updated every 30 seconds. The system will be very efficient in terms of cost as it would be free from any type of hardware.

SPARKAU has various minor functions that result in free parking slots. But major functions of SPARKAU are;

- Object detection
- Vacant Slot calculation.
- Updating the web.

In the first step, the system takes the input from the CCTV camera of the parking. Input is parameterized with the constraints. YOLO processes the video and it gives the output in the form of detected objects in the video.

Then in the second step, the video is then fed into our algorithm. It will process it to calculate the number of cars on the slots and the free space available for more cars. After calculation, it then outputs the occupied and the available slots.

Finally, that information is passed to our website through API (Application Programming Interface). API authenticates the request with the API-key; our website calls an API service that makes a get request to the database. The database then checks for the API key for validation. If validated, the website is updated and the user can look for the slot to park his car.

3.3 Requirement Specifications

The smart parking system for Air University also known as SPARKAU will consist of a **Web Application or a mobile web application.** It will be used by many people from Air University. Many people use the parking area of our University to park their cars. They just randomly enter from one side of the parking area hoping to find an empty slot. Most of the times it happens that they cannot find a vacant slot to park their car. SPARKAU will help them find a space for car parking.

3.3.1 Functional requirements

Functional requirements inform about the basic functionality of the product. Function requirements tell the usage of the system and the system works. The functional requirements of SPARKAU are as follows:

Identifier	FR-01
Title	Runs on the live feed
Requirement	The system takes its input from the CCTV cameras live videos
Source	CCTV camera
Restrictions and Risk	Camera malfunctioning
Dependencies	CCTV camera
Priority	High

Table 7 Functional Requirements 1

Identifier	FR-02
Title	Detect free slots
Requirement	The system simply detects the object after which our algorithm outputs the free available slots
Source	videos
Restrictions and Risk	Rainy weather, improper parking
Dependencies	Python 3.7
Priority	High

Table 8 Functional Requirements 2

Identifier	FR-03
Title	Send data to the online database
Requirement	To make the data available for the website
Source	JSON objects
Restrictions and Risk	Stable Internet with good upload speed
Dependencies	Internet
Priority	Normal

Table 9 Functional Requirements 3

Identifier	FR-04
Title	API call
Requirement	Website will make an HTTP get the request to get the data from the database
Source	Cloud objects
Restrictions and Risk	Authentication
Dependencies	API providers
Priority	normal

Table 10 Functional Requirements 4

Identifier	FR-05
Title	Update the web interface
Requirement	Website updates the interface as soon as a vacant parking slot is available
Source	Array
Restrictions and Risk	Array not filled with correct data
Dependencies	Internet
Priority	high

Table 11 Functional Requirements 5

3.3.2 Non-Functional requirements

Nonfunctional requirements are the basic attributes and qualities of a system. Nonfunctional explains how well a system performs. Some of the non-functional requirements of SPARKAU are :

Identifier	Non-FR-01
Title	Fully automated system
Description	It does not require any human interaction. An automated independent running system.

Table 12 Non-functional Requirements 1

Identifier	Non-FR-02
Title	Cost-effective
	Should bear a minimal cost to implement. Mostly use already develop CCTV cameras

Description	

Table 13 Non-functional Requirements 2

Identifier	Non-FR-03
Title	Robustness
Description	A very fast system that updates the website as soon as a car occupies a space.

Table 14 Non-functional Requirements 3

Identifier	Non-FR-04
Title	Responsive
Description	The website turns into a mobile web application as soon as dimension changes into a phone size

Table 15 Non-functional Requirements 4

Identifier	Non-FR-05
Title	Resemblance
Description	The website and mobile web Application resembles the original parking area.

Table 16 Non-functional Requirements 5

Identifier	Non-FR-06
Title	Simple Interface
Description	A very easy to use interface with a simple view for the user.

Table 17 Non-functional Requirements 6

3.3.3 Advantages

The main objective of this project is to ease the university students and faculty members in finding a free slot to park their cars It is a smart parking system based on an algorithm that works on the principles of computer vision. The Advantages of the project are given below

- Timesaving: It would save time for both drivers and the administration to search for the available space for the car park.
- Cost-effective: The system does not cost any hardware as it computes the availability of parking slots using visual feeds from already deployed CCTV cameras.
- Fully automated. It is a very efficient way to handle car parking issues rather than human monitoring

Timesaving means it would save the time of the drivers to park their cars. Many times faculty and as well as students are getting late for the class. They are in a hurry to park their car. They immediately enter into a parking area to search for every possible slot, but most of the time, they cannot find one. It often gets disappointing and frustrating.

It is a cost-effective product. It does not require any hardware and sensors. Most of the parking systems are based on motion sensors and parking meters. This hardware detects the car movements and then it calculates the free parking slot. It increases the overall cost of the product. The maintenance of this hardware would cost more money. Using the already deployed CCTV cameras is a very efficient method to develop a product.

Fully automated means it should not require human monitoring. In most scenarios in our university, guards are helping the drivers to find a place to park the cars. This system will be free from human interaction. The system will update the interface based on live visual feeds, which will be done as soon as a car leaves the parking. It would decrease the headache of admin as well as guards to help the drivers find the free parking slot.

3.4 Use cases

Use cases are a list of actions or steps that a system performs to reach a specific goal. The steps are performed by interacting between different components of a use case model.

The use case diagram for SPARKAU is drawn below;

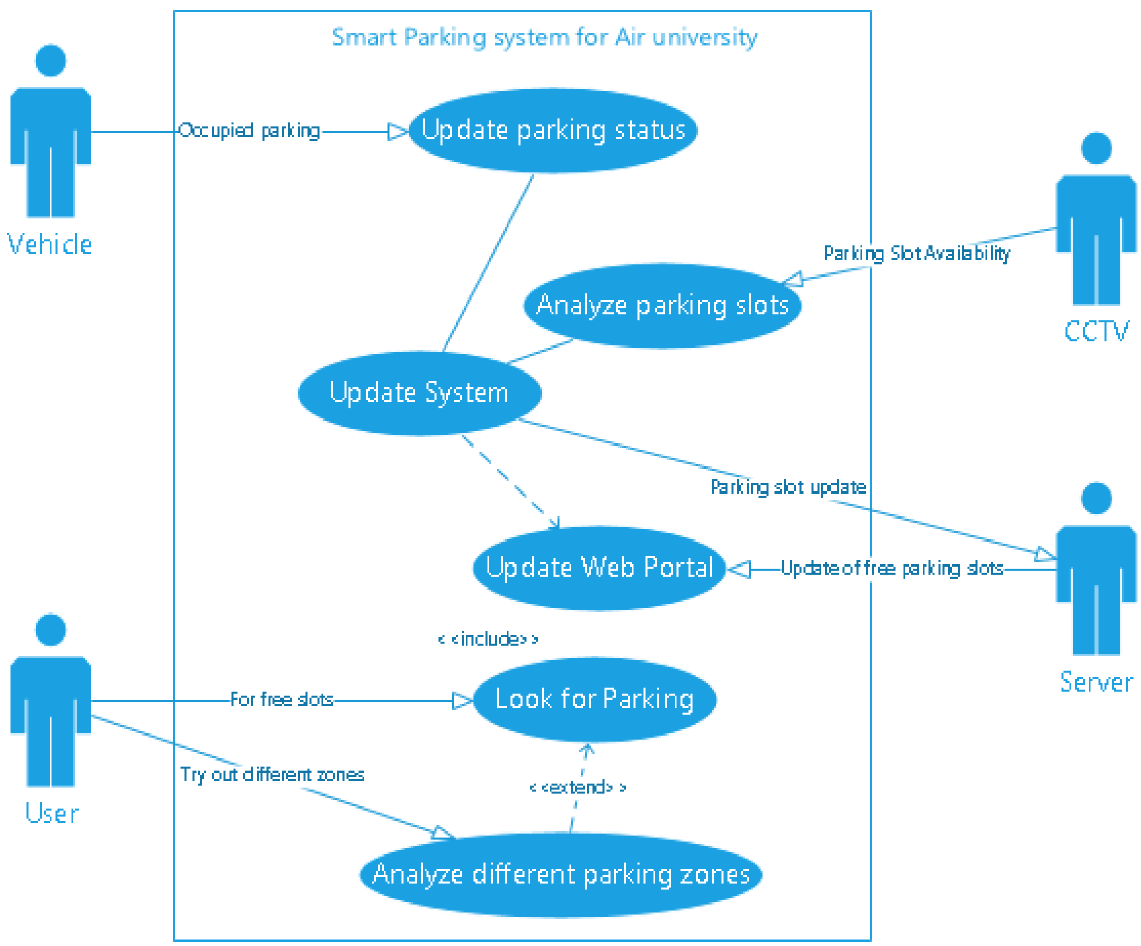


Figure 9 Use Case Model of SPARKAU

There are four different actors involved in this use case diagram user, vehicle, server, and CCTV. The vehicle will occupy the parking slot and CCTV will update the system, the server will continuously look for the new information to update the web portal. The user will analyze the different parking zones searching for vacant space. The CCTV camera will record the parking zone and update the system

Use Case ID:	UC-01
Use Case Name:	Update parking status
Actors:	vehicle
Description:	Car/vehicle will enter into the parking changing the state of parking status.
Trigger:	When the car enters the parking
Preconditions:	None
Normal Flow:	The car enters the parking area It will change the parking status from free to occupied

Table 18 Use Case 1

Use Case ID:	UC-02
Use Case Name:	Analyzing the parking zone
Actors:	CCTV
Description:	CCTV will be analyzing the car slots in the parking zone and processing the information about the slots occupied and free slots

Trigger:	Turning CCTV cameras on
Preconditions:	CCTV in running state
Normal Flow:	CCTV will record the video information from the parking area

Table 19 Use Case 2

Use Case ID:	UC-03
Use Case Name:	Update the system
Actors:	Server
Description:	When the car enters the parking, the server will update the system about the free parking slot.
Trigger:	When the car enters the parking
Preconditions:	At least one parking space available for car parking
Normal Flow:	The server will be updated, the system will forward the information to server

Use Case ID:	UC-04
Use Case Name:	Update web portal
Actors:	Server
Description:	The servers would update the web portal about free parking space.

Trigger:	When a car leaves the parking
Preconditions:	The car should have occupied the space.
Normal Flow:	The server would process the data. It will update the web portal about free parking space

Table 20 Use Case 3

Use Case ID:	UC-05
Use Case Name:	Look for parking
Actors:	User
Description:	The user would analyze the overall parking slots and search for free parking slots
Trigger:	When the user accesses the website
Normal Flow:	User will look for the free parking slot User will get information about where to park his car

Table 21 Use Case 4

Use Case ID:	UC-06
Use Case Name:	Analyze different parking zones
Actors:	User
Description:	Users will be able to look through the various parking zones.

Trigger:	When the user taps the different zone button on a website or mobile web view
Normal Flow:	The user taps different parking zones. Users would get to see the different free slots available in different zones.

Table 22 Use Case 5

This chapter gives a brief overview of the best Smart Parking System (SPS) based on accuracy and performance. It is the Smart Parking System For the university of Kufa. This chapter explains a basic methodology of the Smart Parking System for the University of Kufa. The drawback and the limitations of the current best system are considered. Then the proposed solution as compared with the best existing system is proposed. All the limitations and drawbacks of the existing system have been cut off in the proposed solution. Then all the functional and non-functional requirements are given in the chapter. In the end, the use case diagram of the SPARKAU is given and each use case is also explained.

←************************CHAPTER 3 END*******************************→**

CHAPTER 4

DESIGN

After requirement specifications, the next step is to use these requirements to design the product. This chapter explains the basic architecture of SPARKAU. It has all the designs, methodologies, constraints, low-level diagrams, and high-level diagrams. It also explains the design interface of SPARKAU.

4.1 System Architecture

SPARKAU is a very simple architecture. It has many small components just like any other software. You give input, the software process that input, and then it displays the result. Input is transferred to the internal processing from the CCTV cameras. The input will be any form of image or video. Internal processing will process the information and it will output the data. The website will display that data in a human-understandable form

The initial phase was to collect the data from the admin of Air University. A legal document was developed because of security issues. A non-disclosure agreement (NDA) was signed between both parties. The higher authorities of the Computer Science Department also signed this NDA. Then Data was acquired from the security office.

The next step was to select a suitable model for our specific situation of computer vision. The situation is critical in such a way that the cars are parked sidewise and the camera's view is tilted. To get the object detection correctly, the algorithm has to be chosen very carefully with testing. We tested several algorithms such as support vector machine (SVM), single-shot detector (SSD), regional convolutional neural network(R-CNN) and, Mask-RCNN, and YOLO. The difference between mask-RCNN and RCNN is that mask-RCNN overlays a mask on the object being detected and it is more accurate.

After the selection of the Algorithm was completed, the next phase was to tune the parameters. The algorithm was run on several images from the parking videos and was tested on different threshold and confidence. After a series of experiments, threshold and confidence were decided. Then the original data were tested to analyze the working of the algorithm. After that website was designed for both laptop and mobile/tablet users.API was created along with database and live connections were set up to run everything smoothly. The high-level design diagram of the SPARKAU is given below;

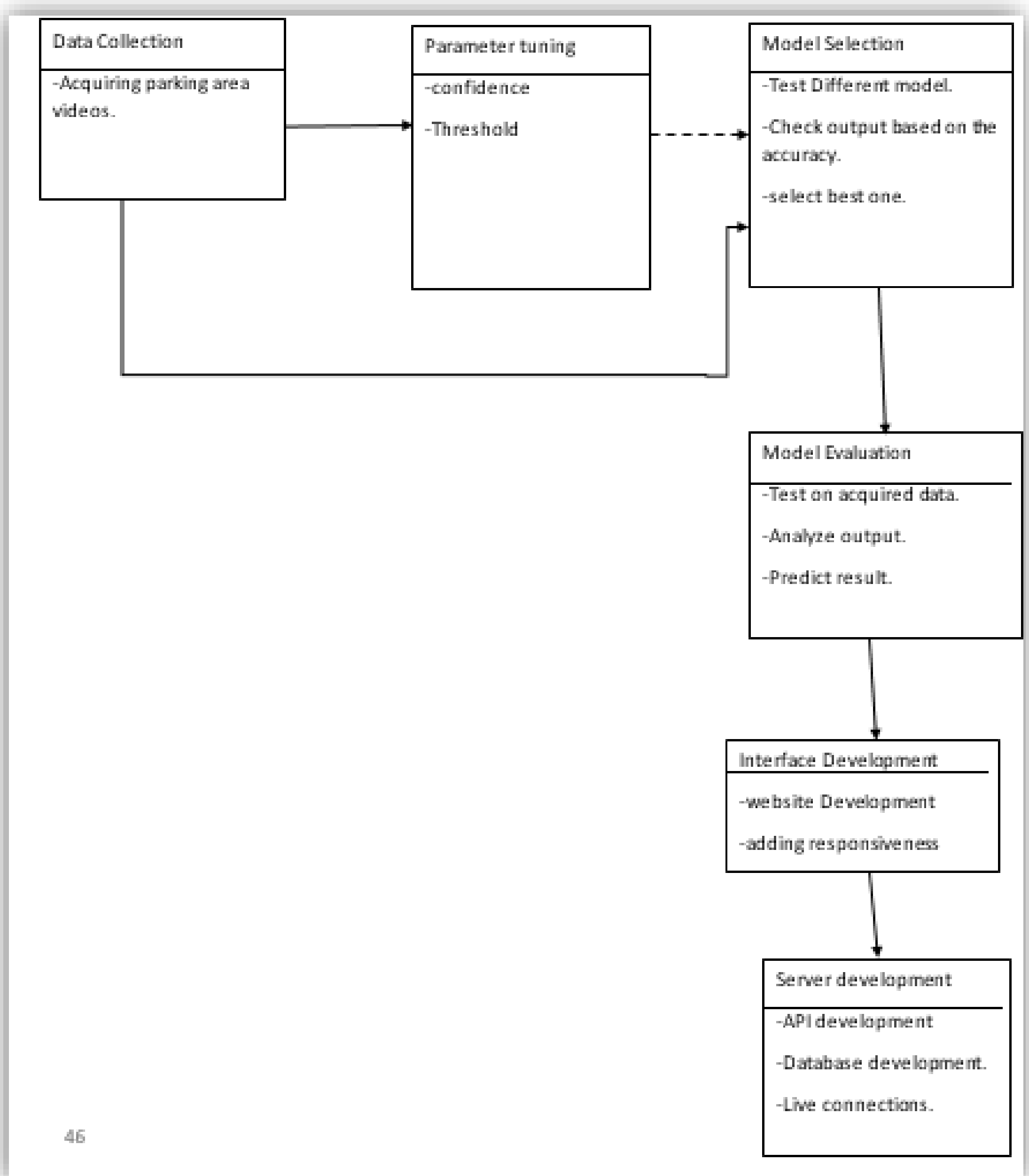


Figure 10 High level System Architecture

4.2 Design Constrains

Constraints are the limitations of the project. In the design phase, several constraints were faced when the system was designed. The major constrains of the SPARKAU were

- Detection Constraints
- Training Constrain
- Annotation Constrains
- Data Collection

Detection Constrain was the limitation of the YOLO algorithm. When YOLO was run, it only detected those objects whose bounding boxes could be drawn. It does not detect those objects, which are a little bit hidden behind the car. As the parking area of our university is tilted. The cameras are also harnessed sidewise. Detecting the cars behind cars is a major constrain of this project.

Training Constrain was also a hurdle in the design phase because of the two things, first because of short of resources for training the data model, secondly, the data collection constraints which will be explained later. for training a YOLO model, it was required to have almost 1000 images/video datasets which is a big constrain.

Annotation Constrain means we had to annotate those training datasets, which is dependent on data collection. for any classification algorithm to work, we have to feed it different images with annotations on it about the class. The algorithm will start training and will try to recognize the features of the image from the annotation as its class.

Data Collection is the basic step of any project. For this purpose, we visited the admin of Air University several times but due to security reasons, they did not allow us to collect the data. We visited them several times submitting applications to allow us to collect the data. In the end, we managed to get some of the chunks of videos because of Non-Disclosure Agreement was signed. These videos were not enough to train the model or annotate the data for the testing or classification phase.

4.3 Design Methodology

The methodology is the systematic set of methods applied to a particular system to get a resultant product. These sets of methods define what would be the outcome of the effort. The design methodology is the set of methods followed to get a working design. The Design methodology diagram explains how the methods have been implemented.

Many people consider the waterfall method to be the most traditional software development method. The waterfall method is a rigid linear model that consists of sequential phases (requirements, design, implementation, verification, maintenance) focusing on distinct goals. Each phase must be 100% complete before the next phase can start. There's usually no process for going back to modify the project or direction

SPARKAU has been developed according to the waterfall methodology. The steps included are the Requirement gathering phase, Designing phase, Implementation phase, Testing, and verification phase, and the last phase is the maintenance phase. In the requirement specification phase, all the requirements of the SPARKAU were specified. Many research papers were gathered related to the smart parking system. Other various papers include different types of machine learning algorithms research papers. After that, a list of requirements was written. This list specifically includes the input that the system will accept and the output which it will produce after processing. The next step was to design the SPARKAU architecture along with the subparts and modules. In the design phase, requirement specifications were studied and a bunch of ideas was given for the design. The architecture of SPARKAU was designed.

The next phase is implementation. In the implementation phase, small chunks of code were developed and these units were tested individually. Then in the next phase, these chunk of code were integrated and a full fledge software unit was developed. The software was tested to be free from any errors. Then the system was maintained to keep the code running and free from any type of errors.

4.4 High-level Design

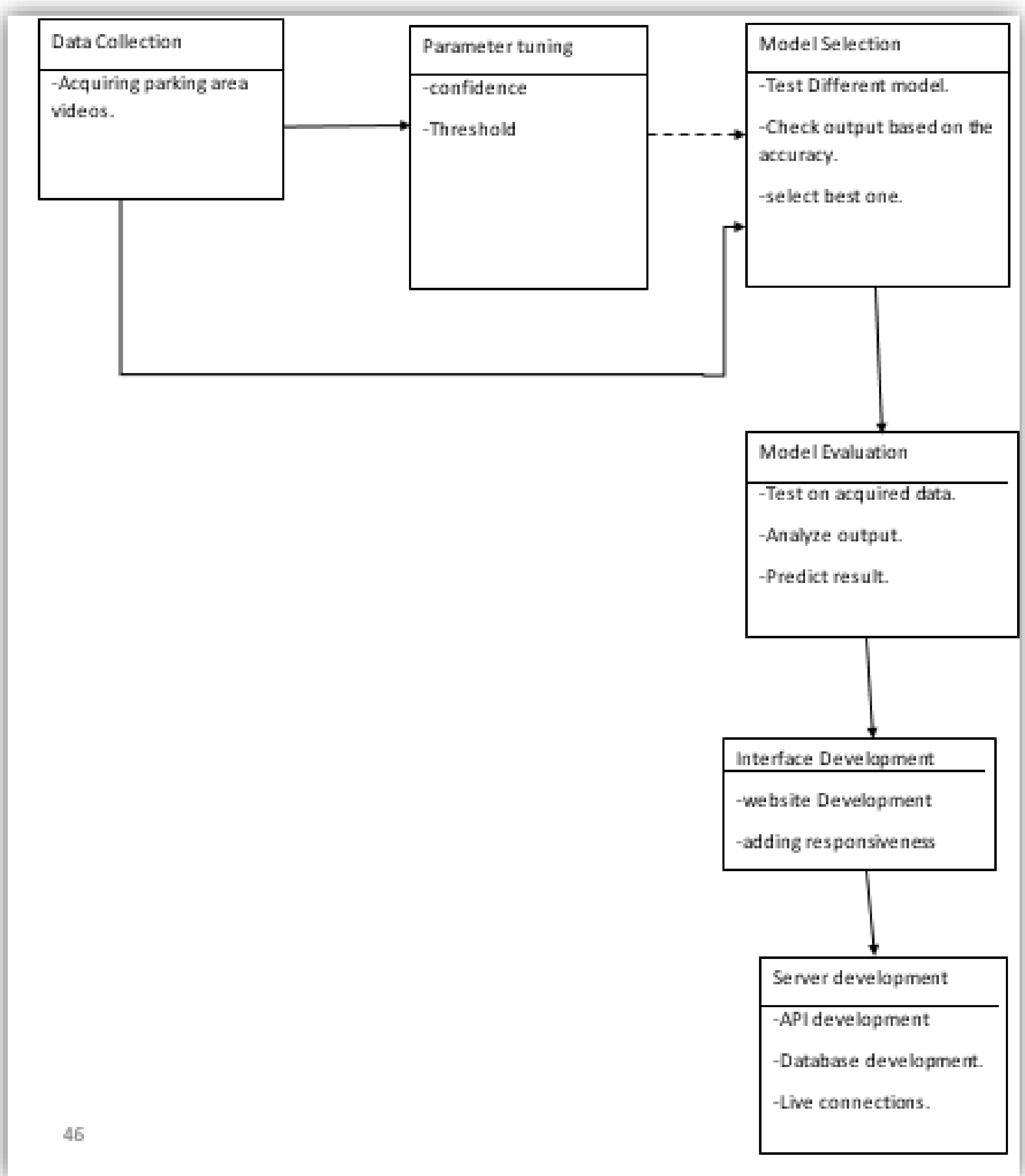


Figure 11 High level design

The high-level design architecture of SPARKAU is given above. It has all the modules that are necessary to build a smart parking system. In the first module, it has a data acquiring step in which the data is gathered. Data gathering is the basic starting point for any product to be accurate. Due to security reasons, Air university did not allow anyone to access the parking videos without permission from AD security. After many application submissions, They decided to give us the videos but they restrict us to write a non-disclosure agreement. It was signed by Departments head and security office's focal person.

The subsequent step was the model selection. In the model selection phase, we first studied the best computer vision algorithms around the globe. We run those models on some specific data sets. The output of each algorithm was stored for comparison. Several algorithms were tested and compared based on speed and accuracy. Finally, one of the algorithms called YOLO[2] outperformed every other one.

The parameters of the algorithm were tuned based on accuracy. Two parameters of YOLO needs to be tuned, Confidence, and threshold. Confidence is the percentage of the object belonging to a class e.g. YOLO tells that a car in an image has 70% confidence that means YOLO is 70% sure that the object belongs to car class. While threshold means YOLO tells how sure it is for that part of the image is an object. After the parameter tuning, the model was evaluated. It was run on the dataset of the university parking area. The output of the algorithm was collected and the results were predicted. YOLO performed with much accuracy on our data.

The next phase started designing the interface. The interface is compatible with android users, ios users, tablet users, and pc users. It is a responsive website that responds based on screen size. After developing the website, the next step was hosting the website. For students, many people prefer going for minimum resource use, so we uploaded the website on **"**000webhost**"**, which provides free hosting and domain for one year. API and database were created for live connections between the website and the backend code. the database and API were created to send the output from the YOLO code to the website.

4.5 Low-level Design

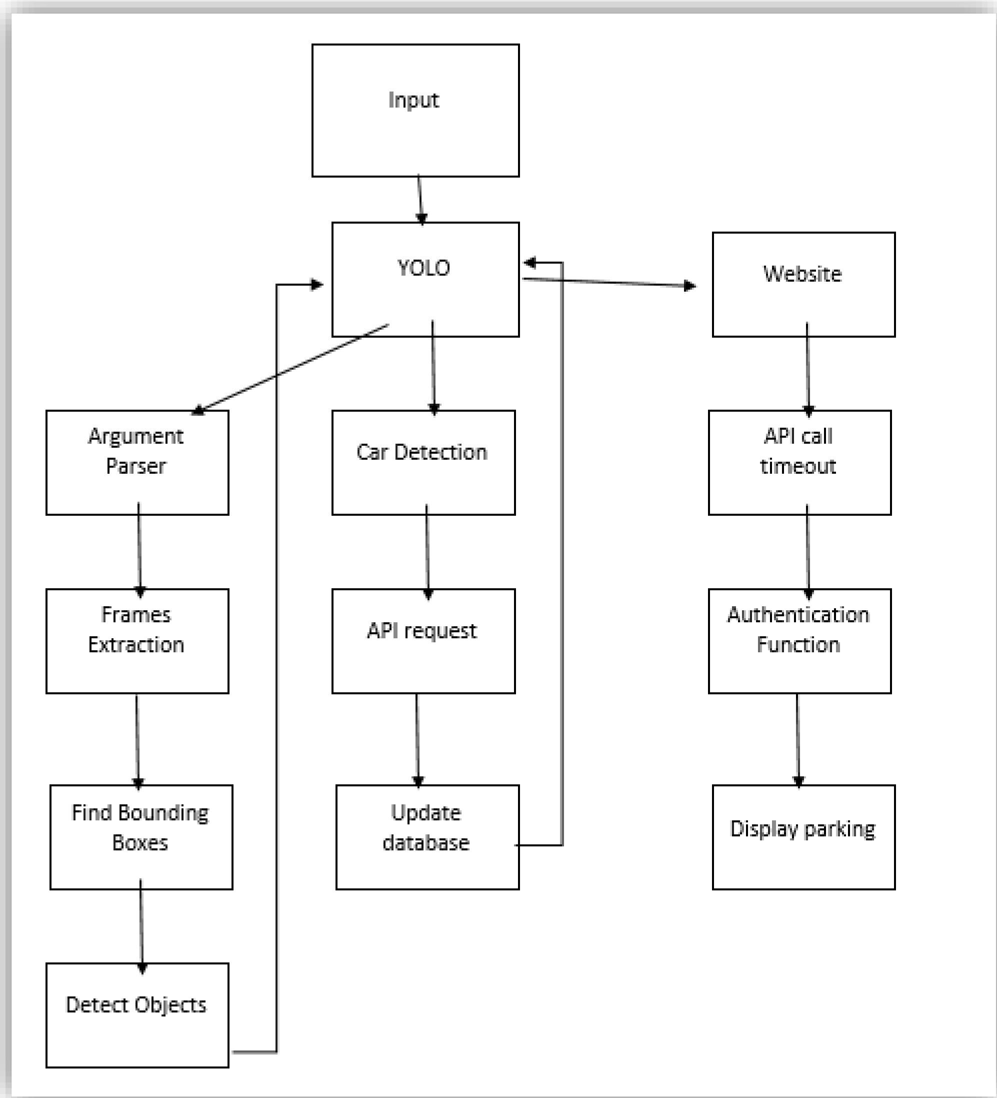


Figure 12 Low level design

The low-level diagram of SPARKAU is drawn above. It explains the step by step low-level modules of SPARKAU. Input is given to the YOLO algorithm in the code. The code first analyzes the arguments passed to the code. These arguments are like run-time program input. Argument parser extracts the image path, confidence value for the execution, threshold value, and the trained weight's path. The code identifies from the path whether the given path is image or video. Then the frames are extracted if the path has a video file stored in it. Then it detects the bounding box of the objects. YOLO stars detecting objects based on the arguments for confidence and threshold. Yolo displays only those objects whose value is below the values of the arguments set by the user.

Our algorithm running alongside YOLO gets those output and performs some processing. It detects the free slots in the input and makes an API request. The data is updated in the database. While on the other hand, the website continuously makes an API call after every 30 seconds out. The database authenticates the API call with API-key. If authenticated, the database allows API to access the data, and the website is updated.

4.6 GUI design

4.6.1 Web View

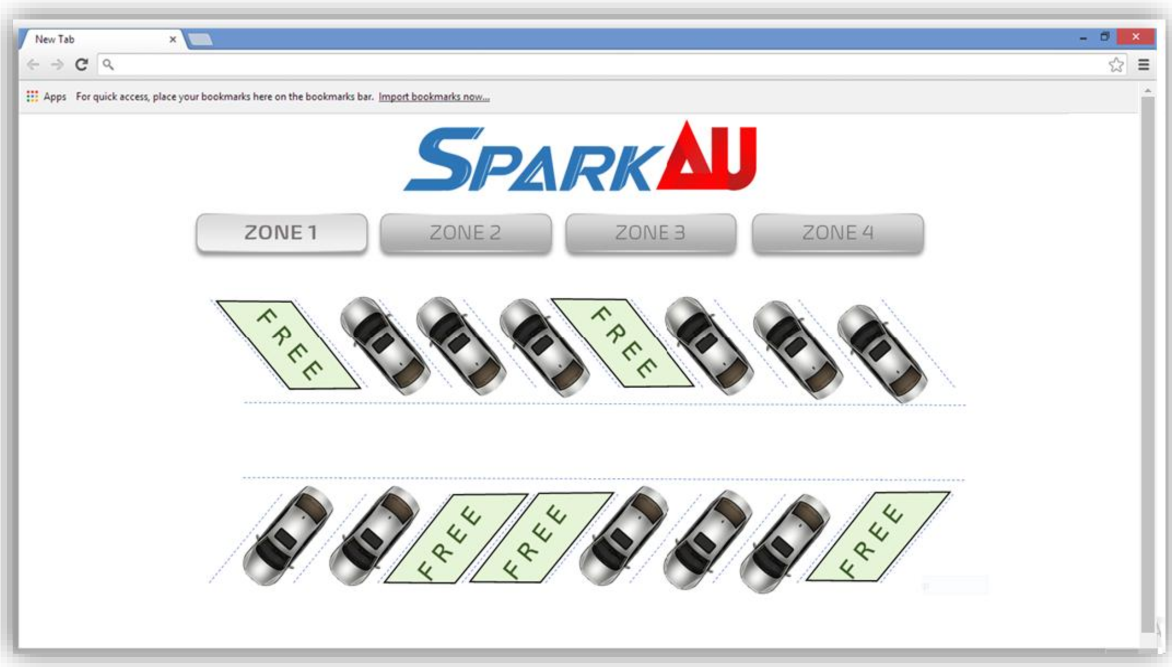


Figure 13 Web layout

Gui is made user friendly and easily understandable. The user can interact with the system using the GUI. The following points are necessary to make a good GUI.

- GUI should be User friendly
- GUIs should be according to the target audience of the product.
- There should be no error while User interacts with GUI
- GUI should be responsive

The front-end website design of SPARKAU is shown above. The topmost part is the logo of our project. It will be a simple image. These buttons will display different parking zones. Each zone will consist of different parking slots. These zones represent the different CCTV cameras in the parking area. Each zone consists of different slots representing the vacant or engaged parking slots

4.6.2 Mobile View

Figure 14 Mobie layout

The mobile interface is shown in the above picture. It is like the web view but except that it is vertical layout The mobile view is aligned vertically because of the small size of the screen. The zone buttons can be displayed in the pop-down menu or they can be displayed just like the interface. The Parking slots are necessary to be oriented in a vertical direction.

This chapter concludes all the design phases of SPARKAU. All the previous requirement specifications are used in the design phase.it has the basic system architecture of SPARKAU. All the design methodology diagrams and interfaces are a part of this chapter. High-level diagram, low-level diagram, design constraints, design methodology, system architecture, and GUI have been explained with details.

←*********************Chapter 4 End**************************→**

Chapter 5

System Implementation

This chapter includes an explanation of the system implementation of SPARKAU. It has diagrams, figures, and explanations of tools for the Smart Parking System for Air University. The diagrams include the Class diagram, Sequence diagram, Component diagram, and Deployment diagram. The diagrams explain the sequence of events, the classes in the project, the components, and the overall package of the deployment diagram. The final part of this chapter has the coding environment, libraries, and coding languages used in his project.

5.1 System Architecture (Three-tier architecture)

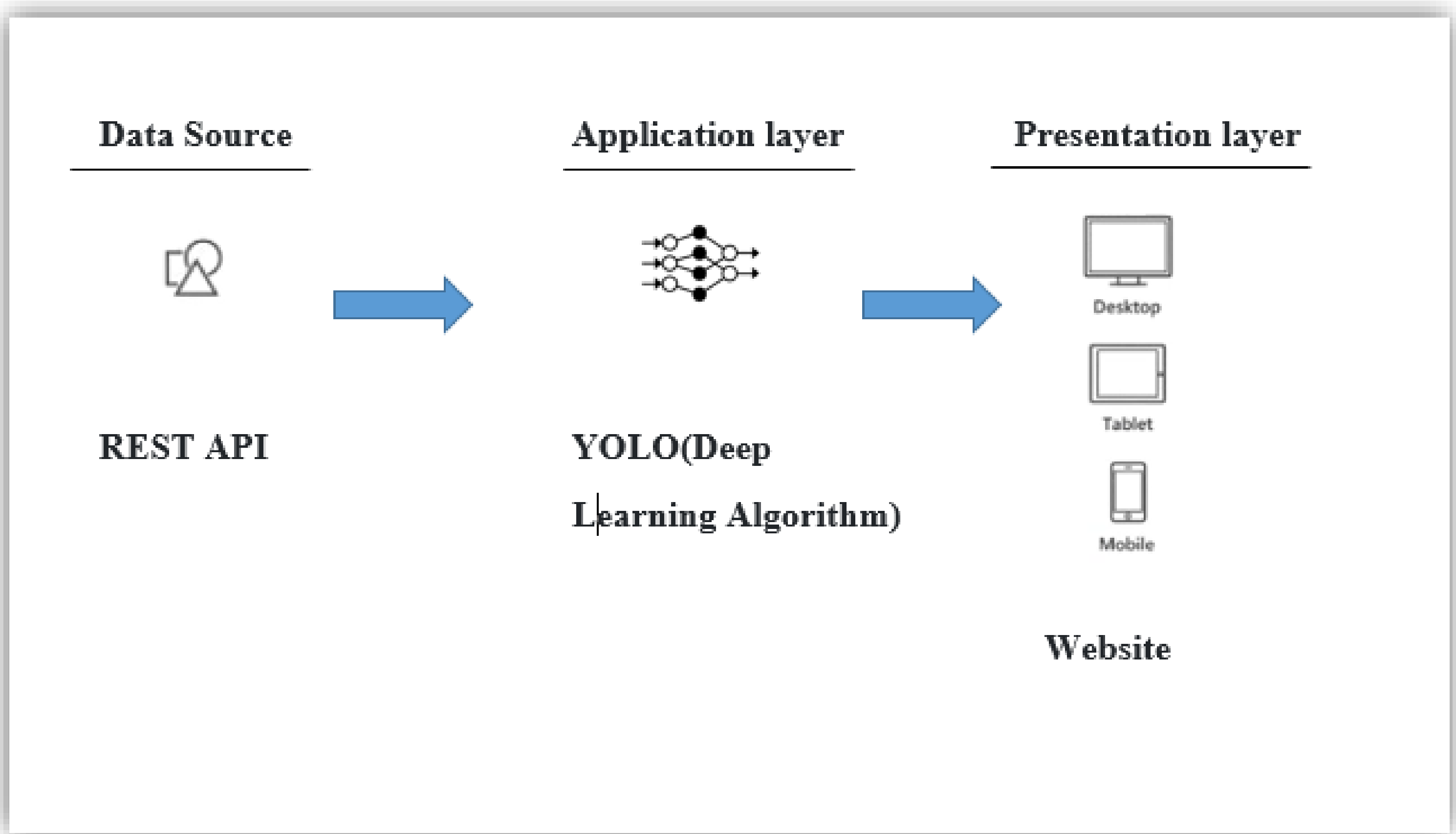


Figure 15 Three-tier Architecture

5.2 System Sequence Diagrams

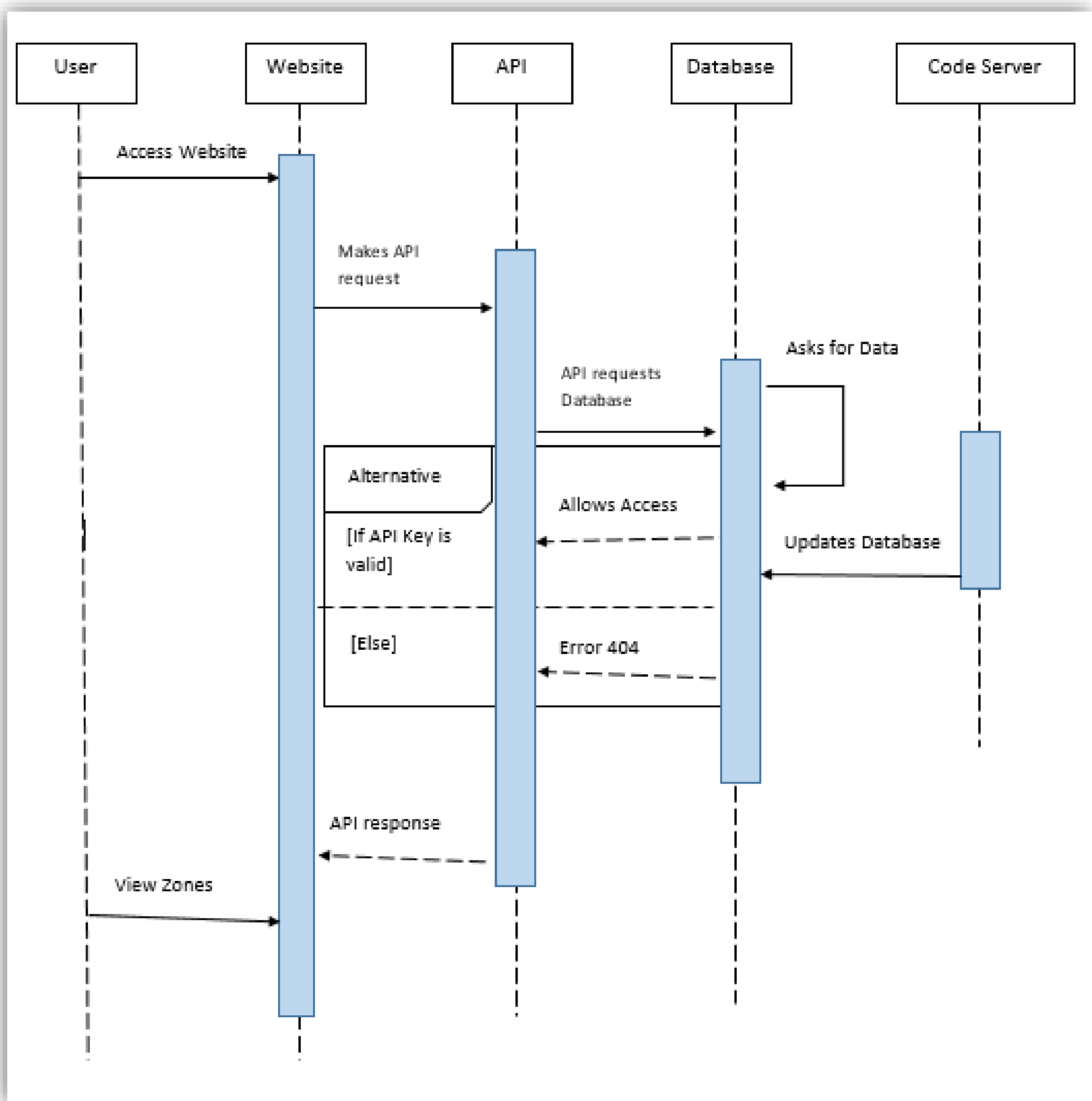


Figure 16 Sequence diagram

5.3 Component Diagram

The Component Diagram explains the fundamental parts of the Application. In SPARKAU, Code Server is the backbone of the whole application, and communication between different components is possible because of API service. All the components of SPAKAU explain through the diagram.

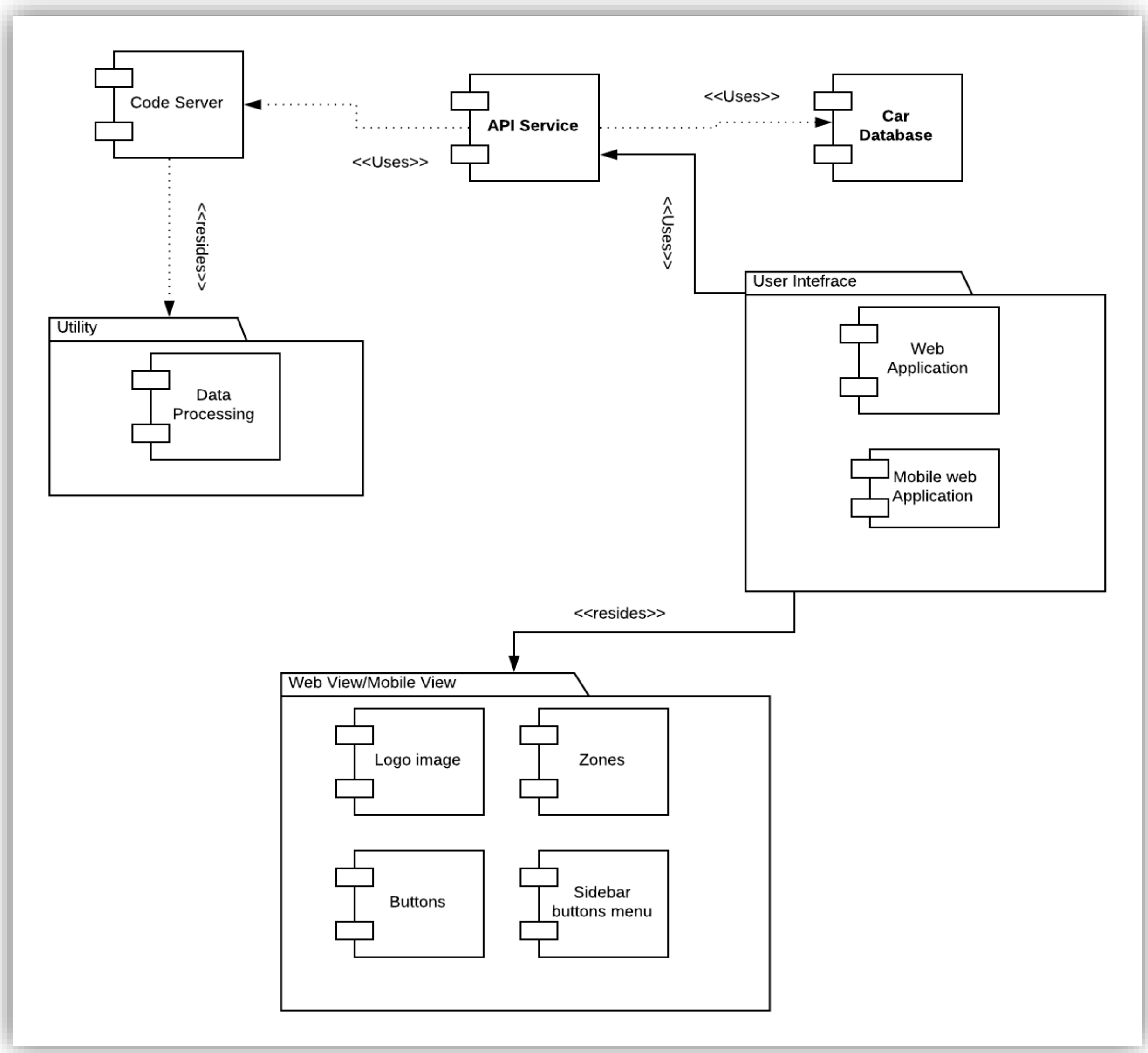


Figure 17 Component diagram

5.4 Deployment Diagram

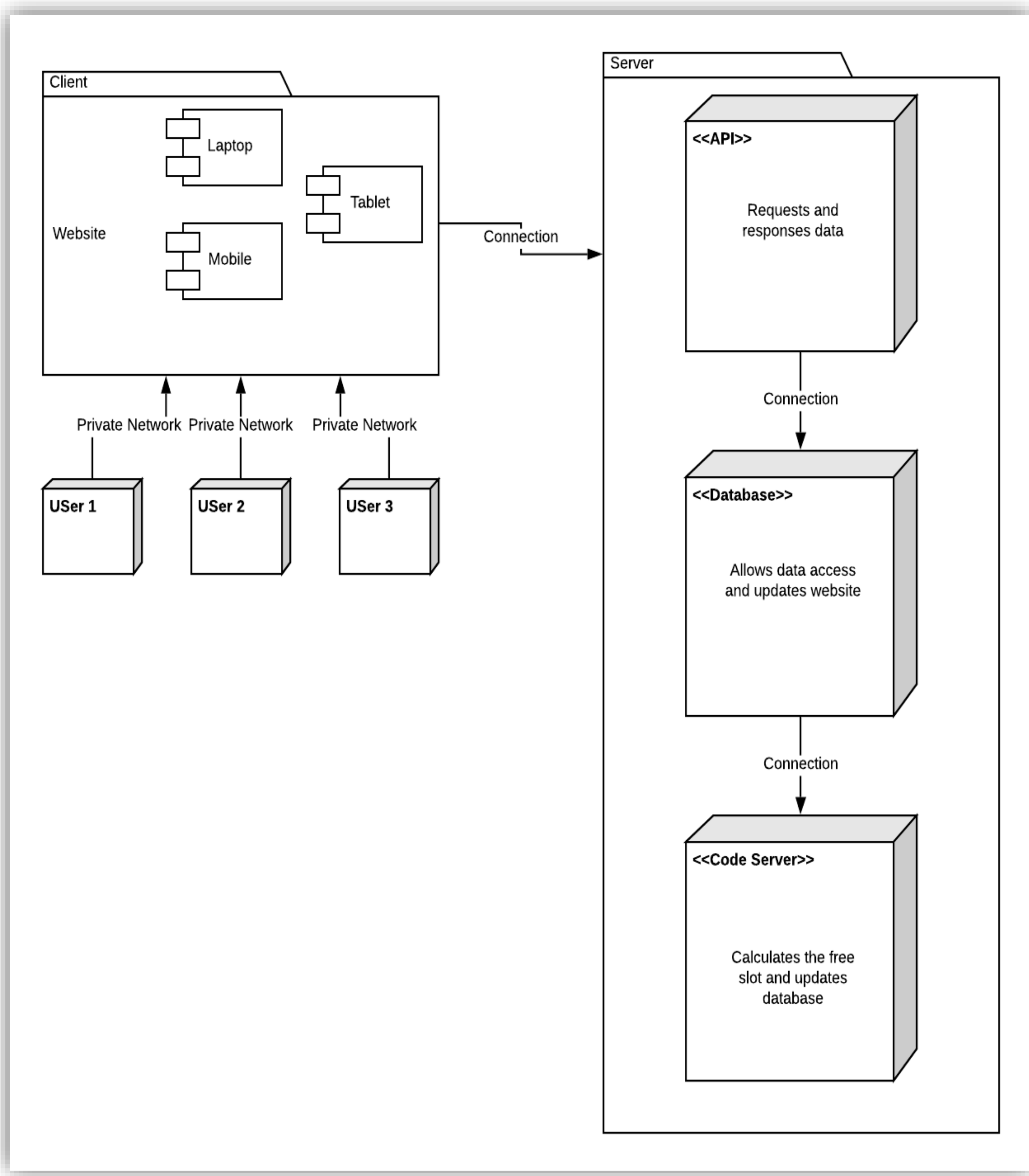


Figure 18 Deployment diagram

5.5 Tools and Technologies

1. Programming language

The programming languages used in this project are python, angular, and bootstrap. The frontend side is developed in angular and bootstrap while all the backend algorithm process is in python

2. Programming APIs

The API used for data transfer between different components of the product is a RESTFULL API. it will travel the data from the database to the hosted website of SPARKAU.

3.Programming Libraries

OpenCV,NumPy,Imutils,ArgParse

4.Programming Environment

The environment for the project is python 3 with anaconda, while code is written in pycharm, while the front end is developed in the CLI environment for the angular and coding environment is NodejS with visual studio code as a code editor.

These diagrams explain the basic structure of the product and the events occurring in this product.

SPARKAU has been developed using three-tier architecture. The component diagram explains the components of the product. The deployment diagram has overall components that are packaged to make a big unit. The class diagram explains the relation of classes among each other and their functions. .It explains the over-all components and packages of the SPARKAU. This chapter also has an explanation of languages and the environment used for development.

←*********************Chapter 5 End***********************→**

Chapter 6

System Testing and Evaluation

After the implementation of the product. The next step is its testing and evaluation. This chapter has all the basic testing and evaluation of SPARKAU. GUI testing, usability testing, compatibility testing, load testing, and exception handling have been included in this chapter. Different images have been generated to present in this chapter. These images provide information about the SPARKAU. This chapter explains the working of our application when the load is bombarded on the product.

6.1 Graphical User Interface testing

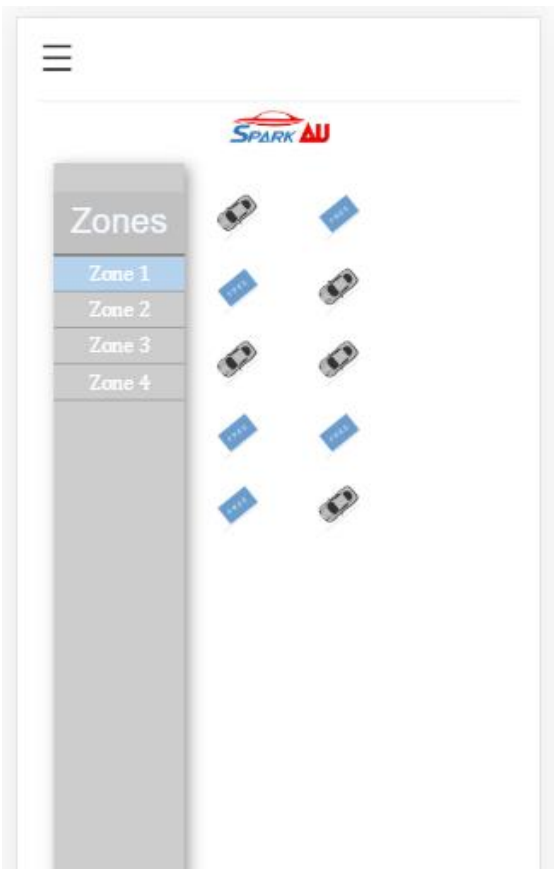
Gui testing is a type of system check that evaluates its presentation when its functionality is performed. GUI testing includes button size check, image size, and all the other functionalities of the product. GUI test checks whether the product is distorted when tested on different views. The GUI testing of SPARKAU is given below along with images.

GUI Test 1

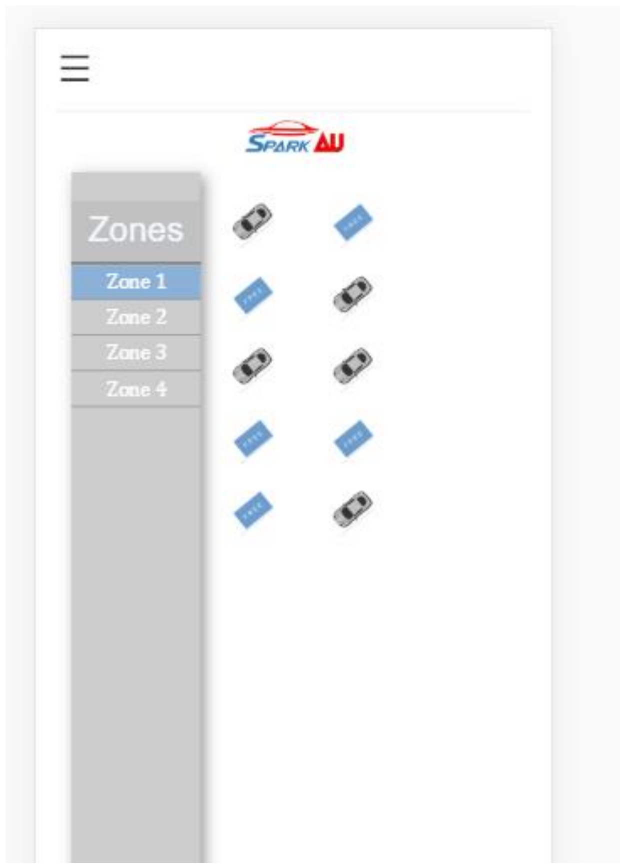
This is the first display of the website. This display is of resolution 1000*663. Width is 1000 pixels while height is 663 pixels. The images and buttons are working perfectly.

GUI Test 2

This display is of resolution 700*625. Width is 700 pixels while height is 625 pixels. The website display is working fine.



GUI Test 3

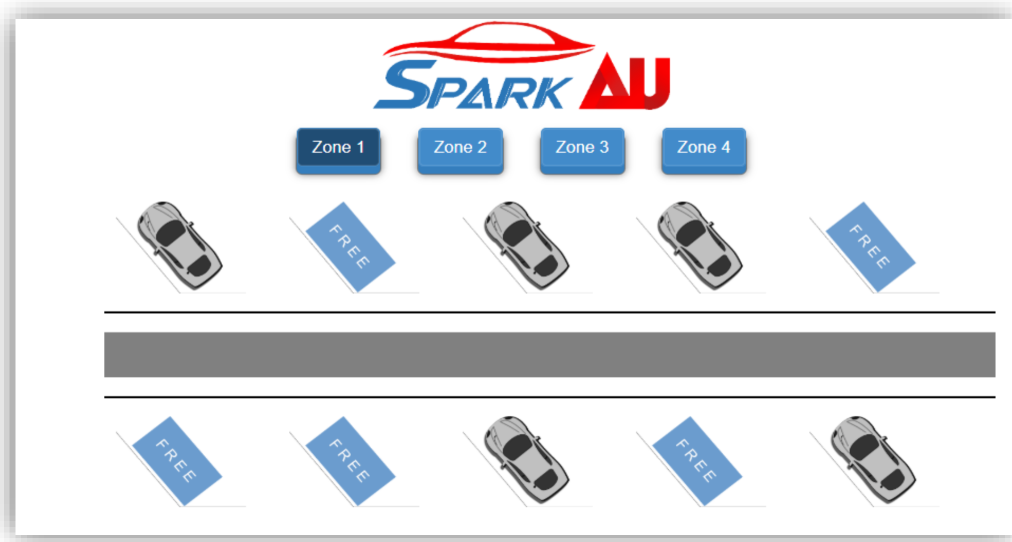


GUI Test 4

The application looks fine when it is tested on different sizes of display. GUI Test. 3 and GUI Test.4 have been taken for the mobile interfaces.

6.2 Usability Testing

Usability Testing means checking the buttons, menu and displays are functioning as required. The test is shown below for every button along with its working functionality.

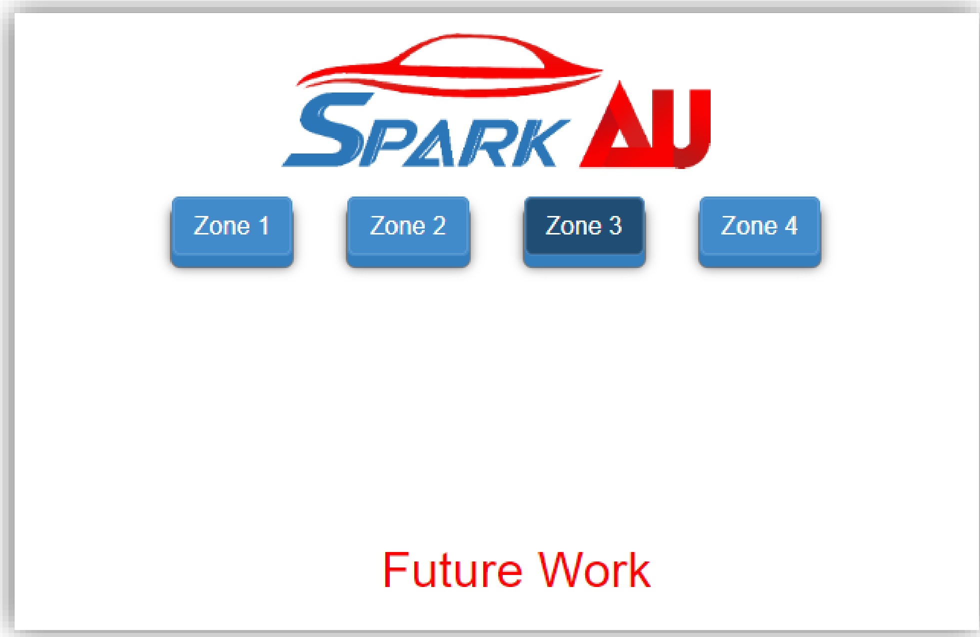


Usability Test 1

The display will look like this when the user clicks on a button called 'Zone 1'.The occupied space is represented by cars and Free slots are represented by pictures of free.

Usability Test 2

Zone 2 and the remaining zones are left for future work. These pictures represent the working condition of this project. The remaining images are given below

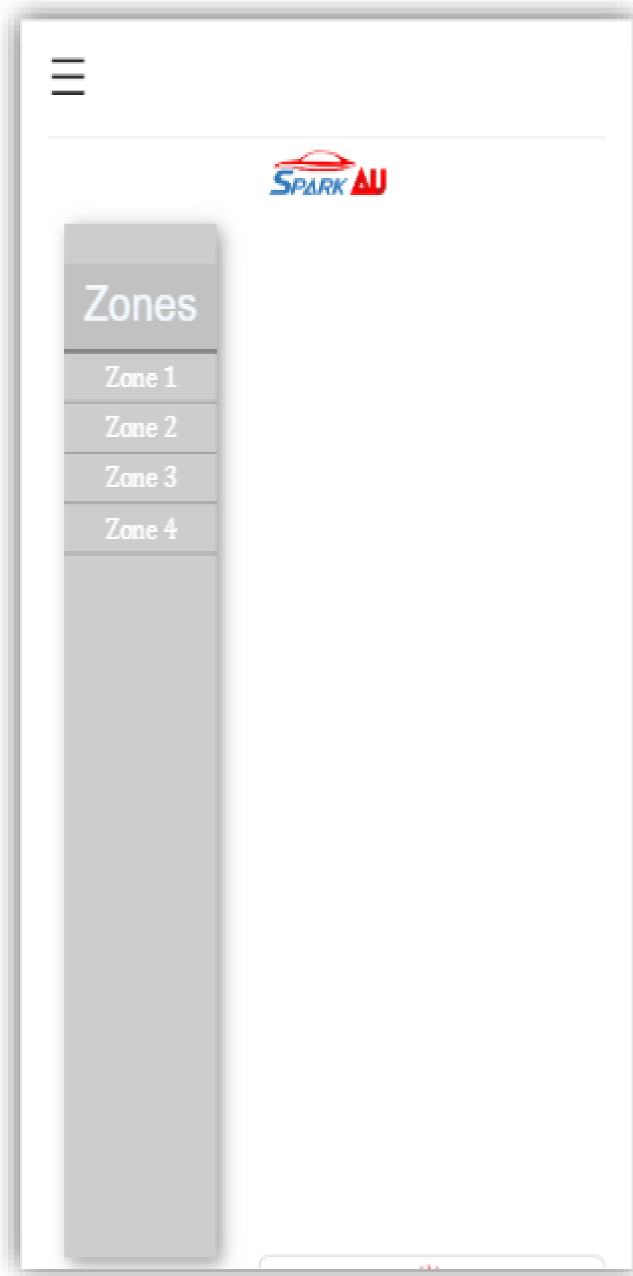


Usability Test 3

Usability Test 4

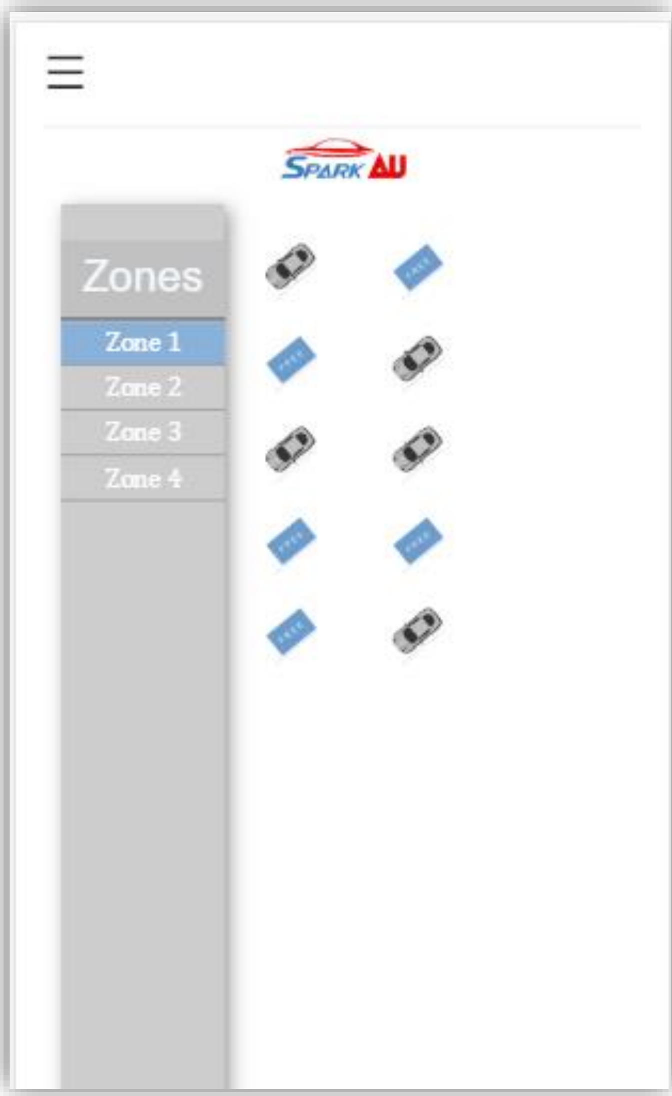
The above-given images are the interfaces for Personal Computer like laptops or tablets. The Usability testing of Interface for mobile is given below

Usability Test 5

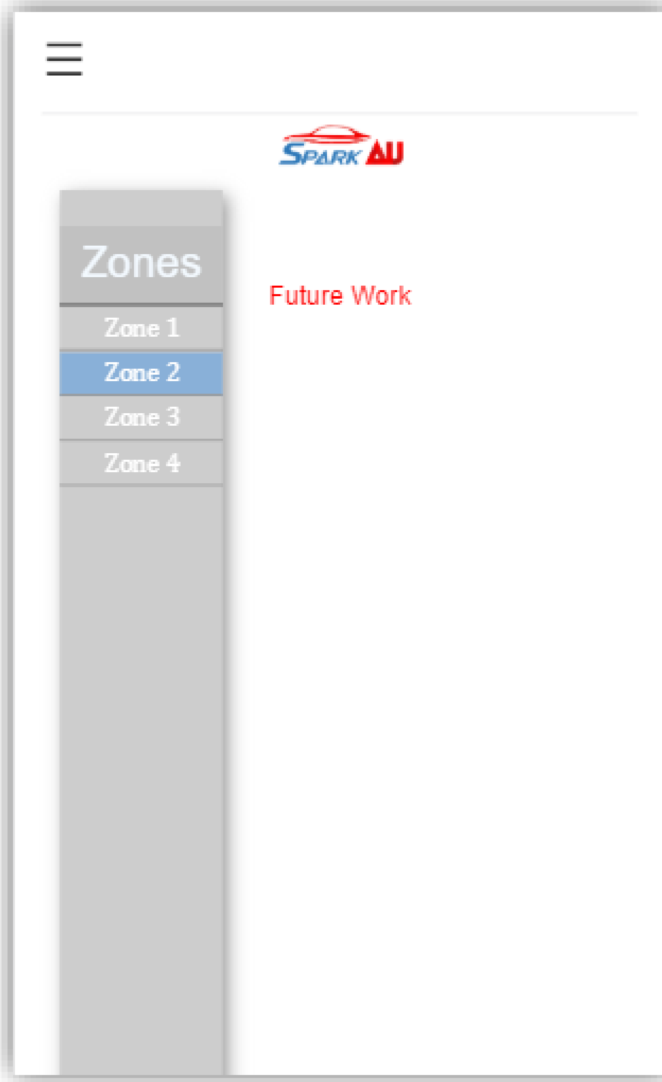


Usability Test 6

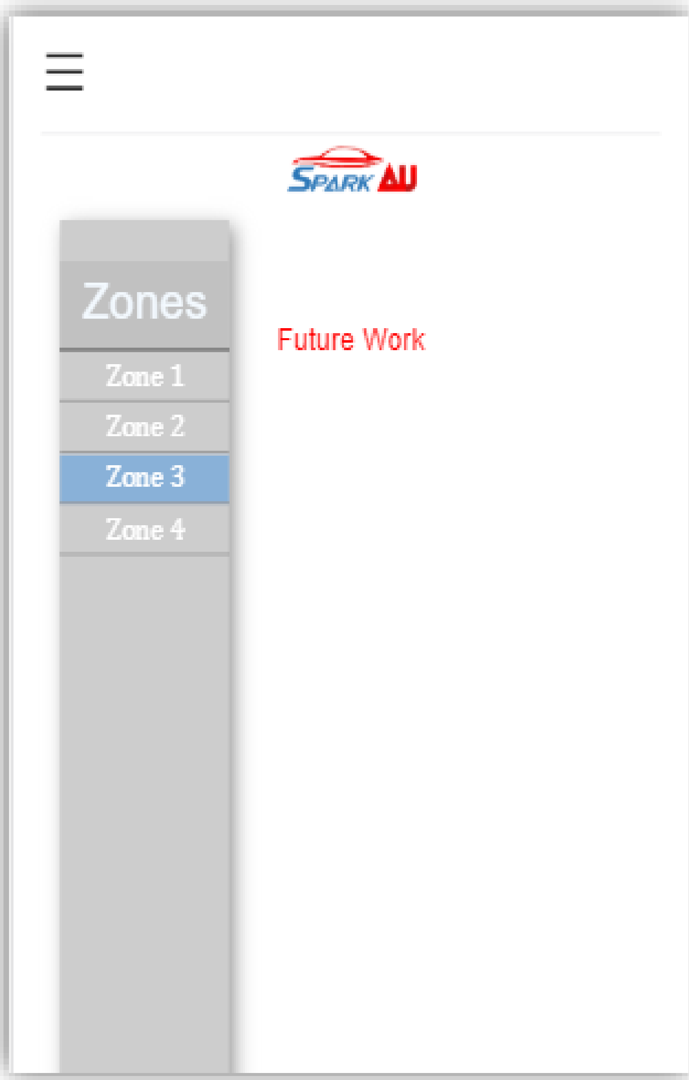
The left interface displays the first page when the website is accessed from the mobile phone. It has the left sidebar toggler and a logo for the SPARKAU. When the user taps on this toggler, a menu pops from the left side as shown in the picture on the right



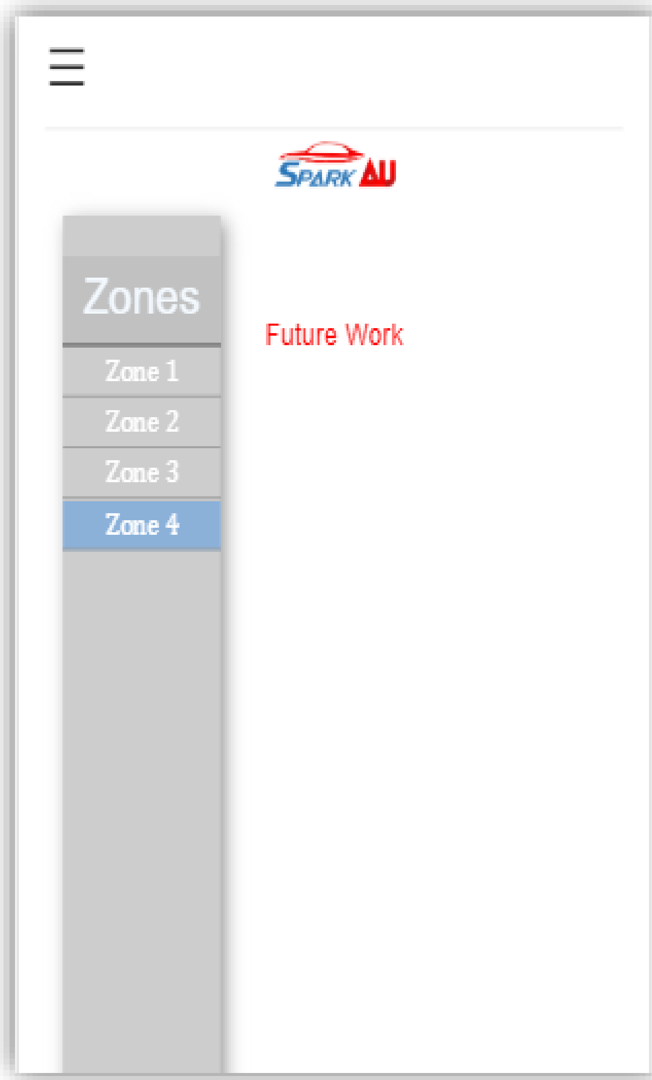
Usability Test 7



Usability Test 8



Usability Test 9



Usability Test 10

6.3 Compatibility Testing

In compatibility testing, we test our product on different types of browsers and check the functionality of the product. We have performed the following tests as given.

Google Chrome

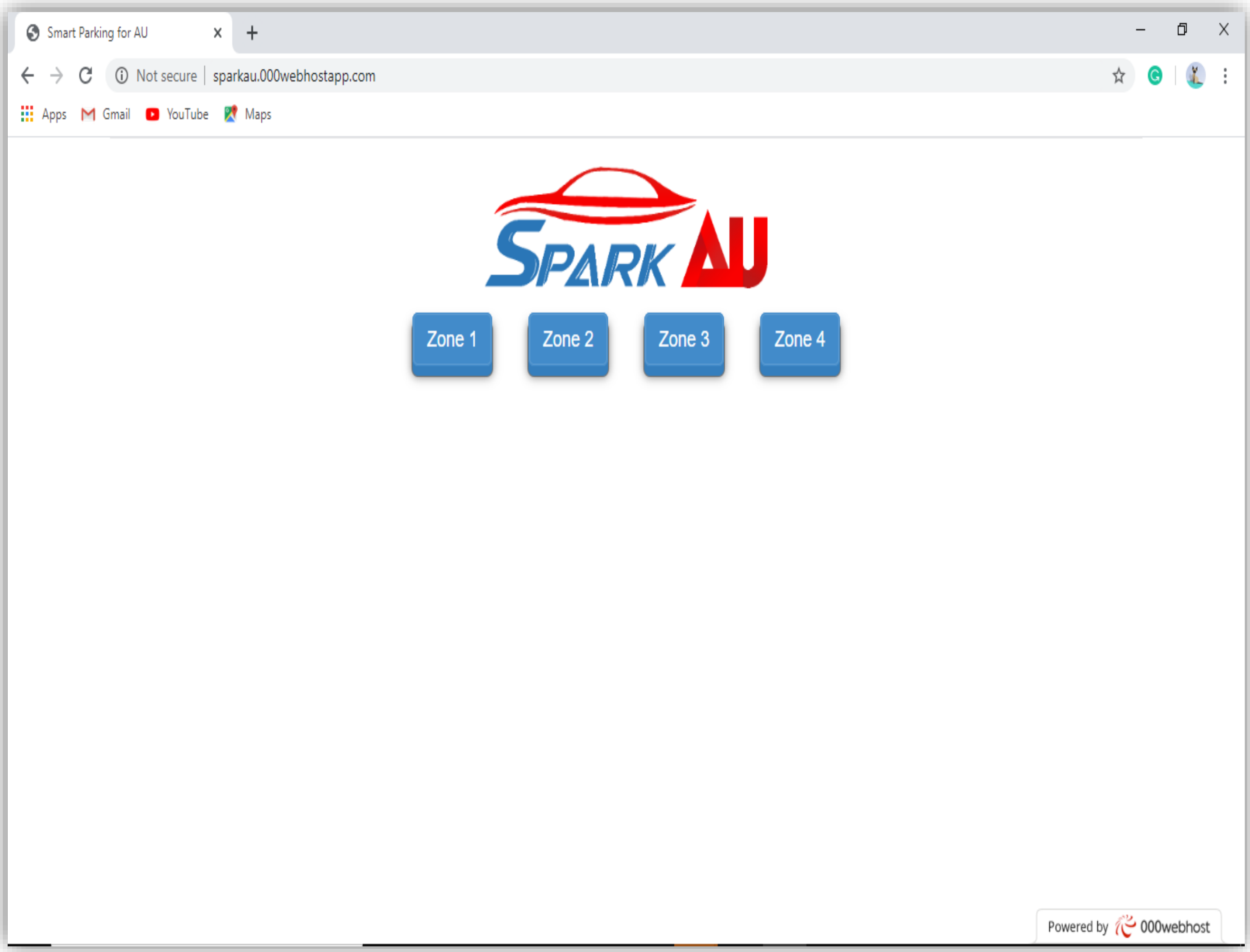


Figure 19 Google Chrome Compatibility

Firefox

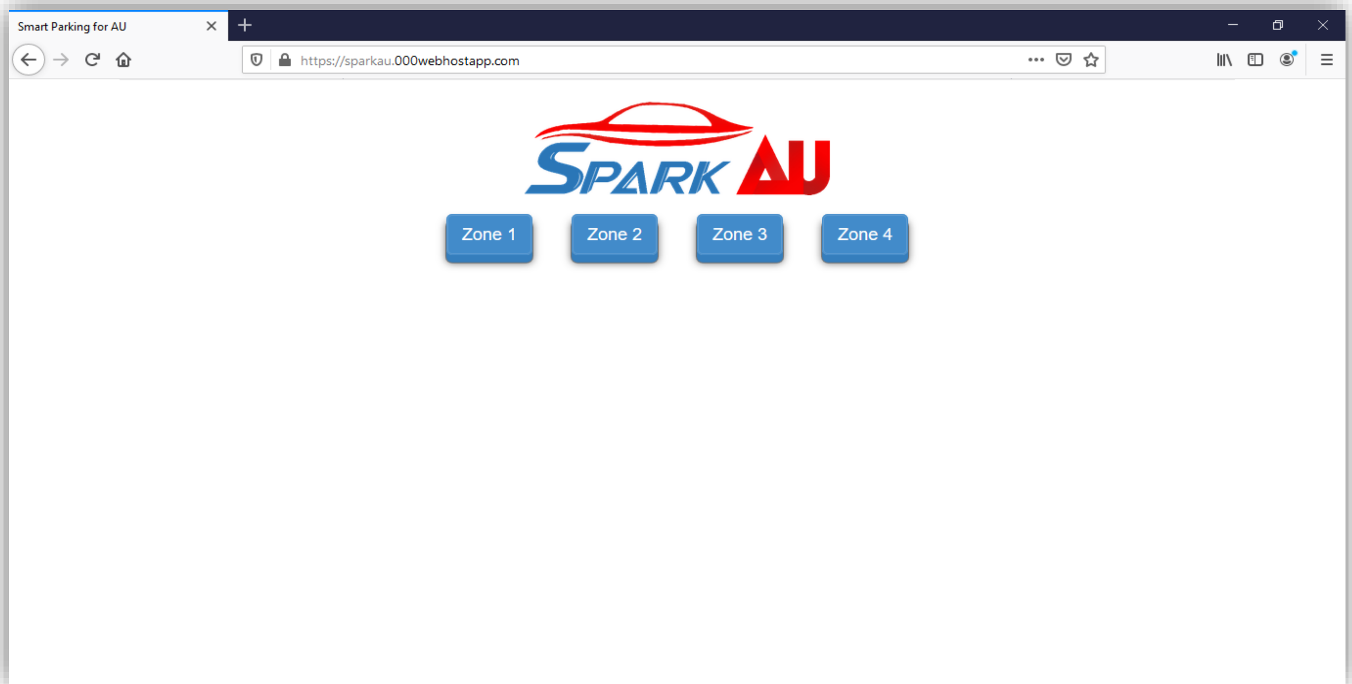


Figure 20 Firefox Compatibility

Microsoft Edge

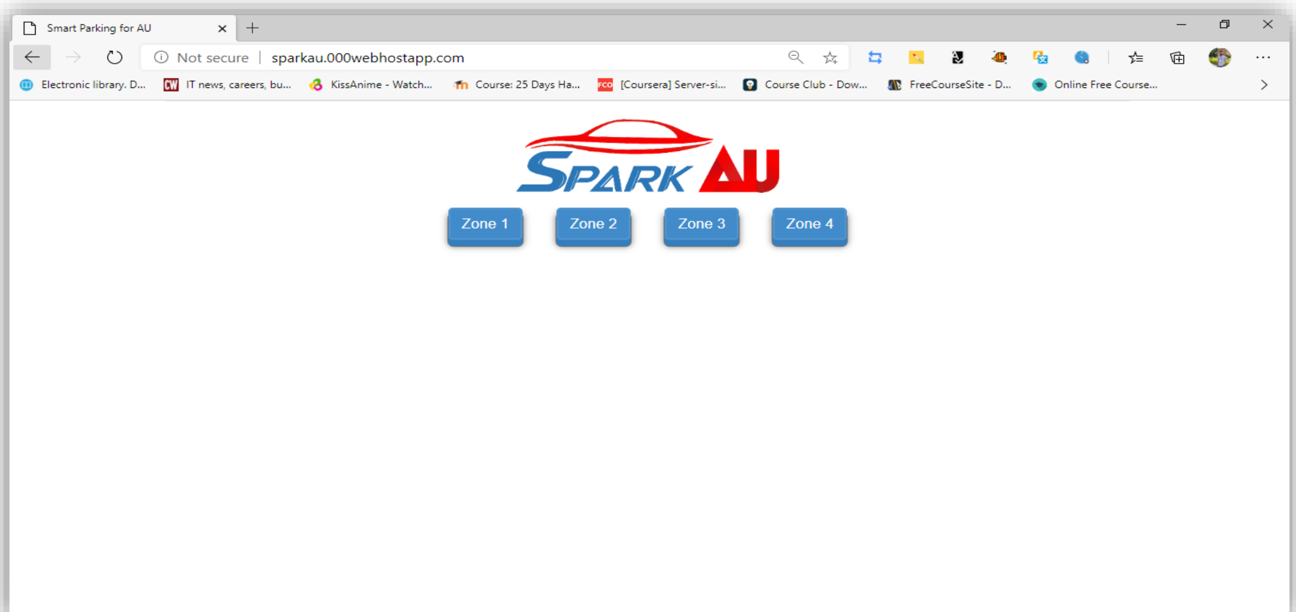


Figure 21 Microsoft Edge Compatibility

Safari

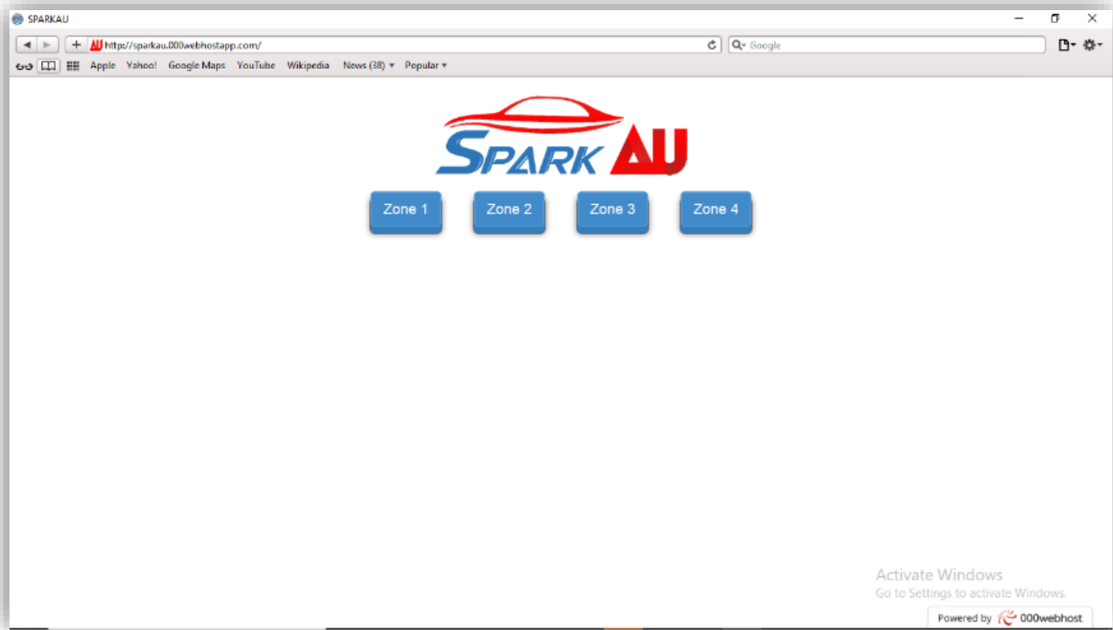


Figure 22 Safari Compatibility

Every browser was tested to run the application. The application performed accurately in all of the four browsers. The buttons were working fine and the cars were updated based on the API request.

6.4 Exception Handling

The code for car detection and free space calculation is written in python. It includes conditional statements, loops, and exceptional handling code. Some of the try-catch and exceptions are given below;

```python
# try to determine the total number of frames in the video file
try:
    prop = cv2.cv.CV_CAP_PROP_FRAME_COUNT if imutils.is_cv2() \
        else cv2.CAP_PROP_FRAME_COUNT
    total = int(vs.get(prop))
    print("[INFO] {} total frames in video".format(total))

# an error occurred while trying to determine the total
# number of frames in the video file
except:
    print("[INFO] could not determine # of frames in video")
    print("[INFO] no approx. completion time can be provided")
    total = -1
```

Exception Handling 1

In the try section. We are using the open CV (computer vision) library for calculating the video frames. We will call a function from Open CV, which calculates the number of frames in the video. Try section will run when input is in video format and it will output the total count of the number of frames in the 'total' variable. However, if the input is corrupted or simply an image. The program is expected to run on video format. So it will output the error with the 'total' as a negative one. Negative one indicates that there is an error in the program or video is corrupted or not working properly.

6.5 Load Testing

6.5.1 NeoLoad

NeoLoad is an automated performance-testing platform for enterprise organizations continuously testing from APIs to applications. It provides testers and developers automatic test design and maintenance. NeoLoad works by simulating traffic (up to millions of users) to determine application performance under load, analyze response times, and pinpoint the number of the simultaneous users which the Internet, intranet, or mobile application can handle.

6.5.2 Load Testing

NeoLoad is a license online tool for software performance testing, load testing, and stress testing. We tested our application for load testing. The number of virtual users who queried the website was sixty. Sixty users were used because the tool has a limit for free users. The results and the output of the testing are given below

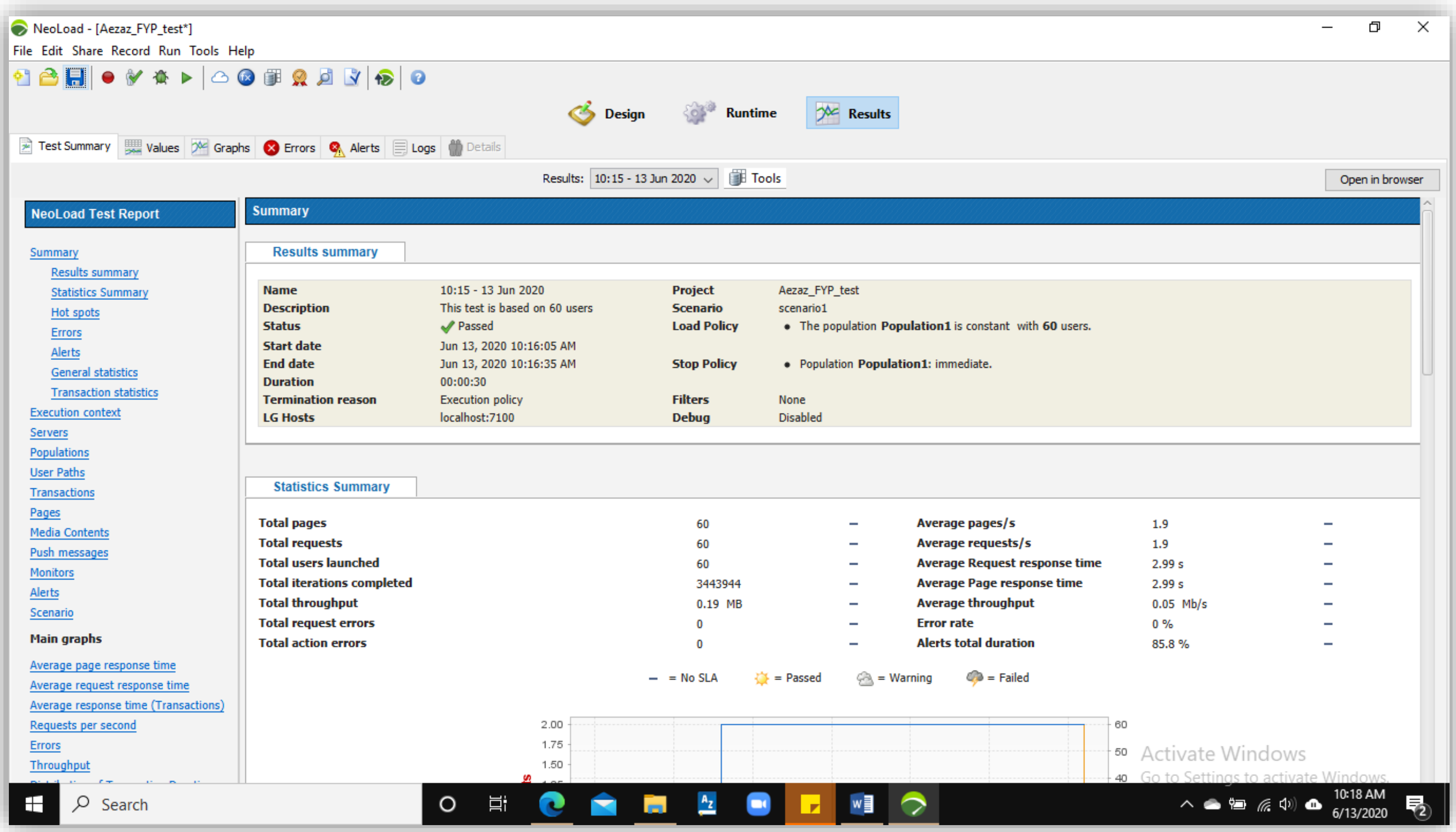


Figure 23 Load Testing on Neoload

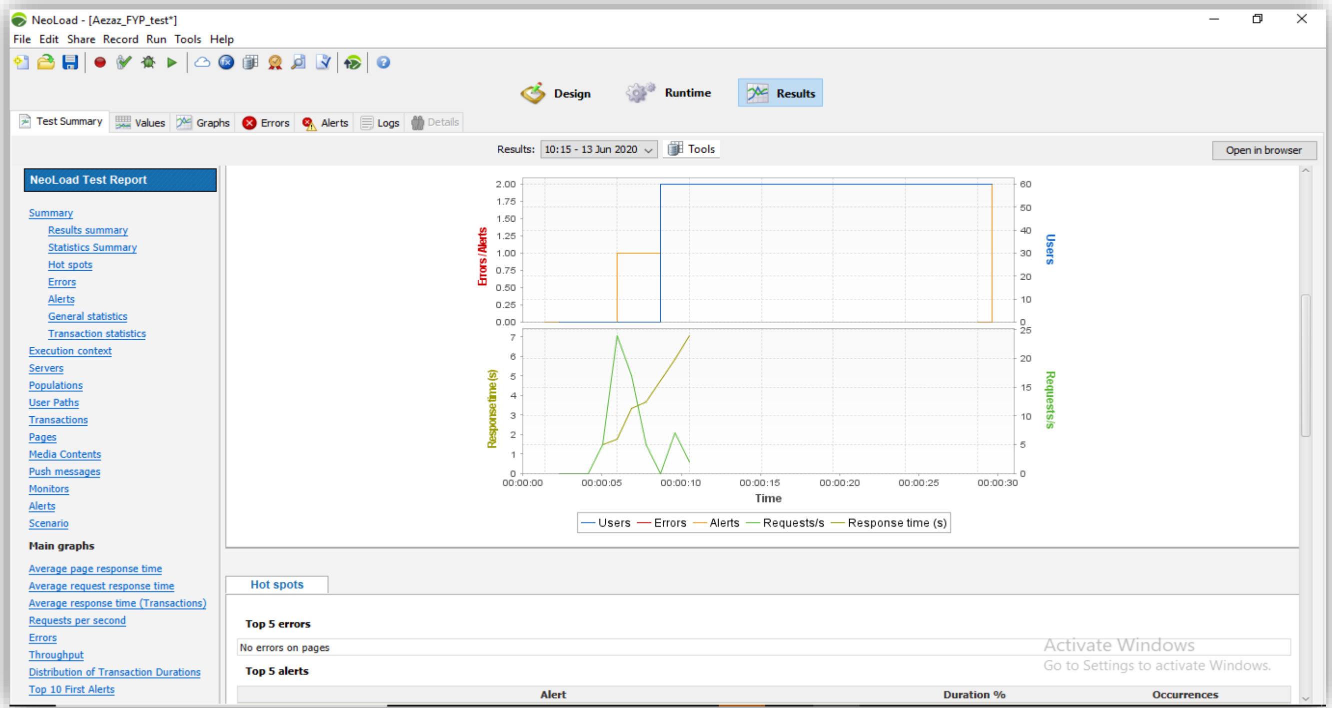


Figure 24 Load Testing on Neoload

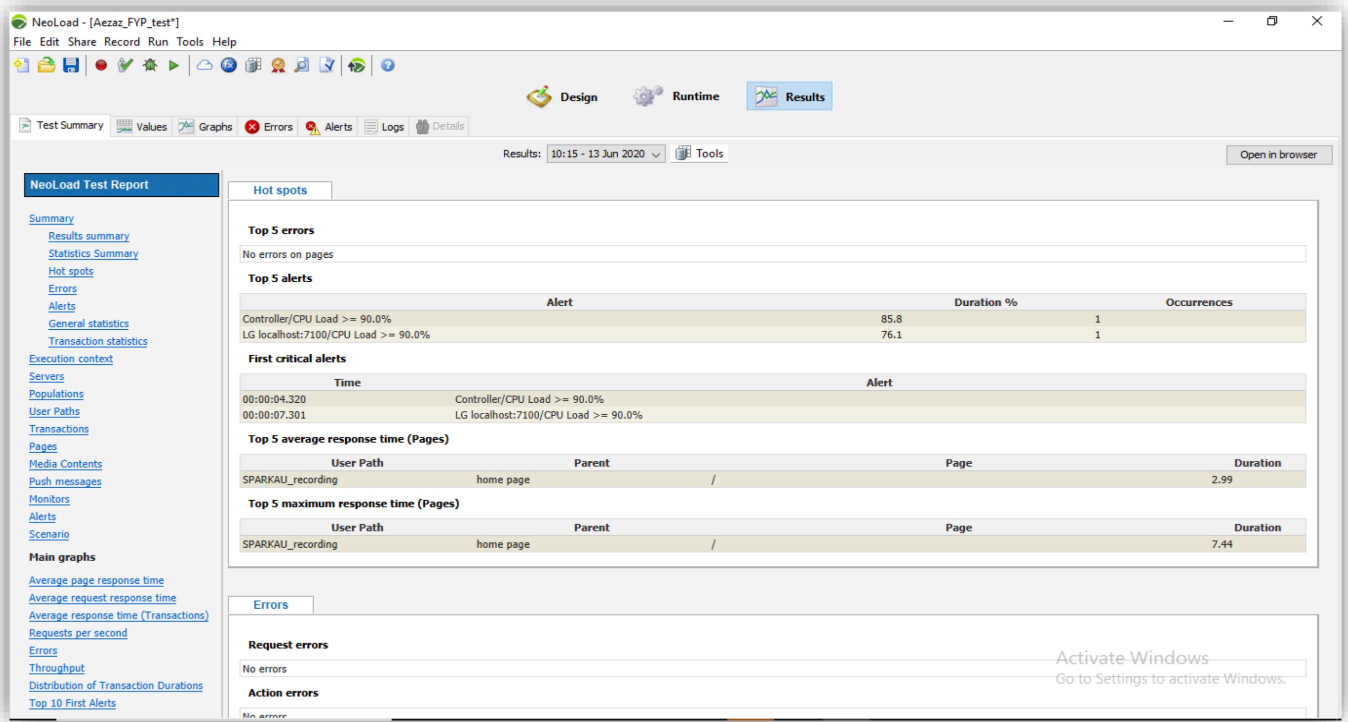


Figure 25 Load Testing on Neoload

The graph on the above images shows that there were no errors when the request was being made on the website. The summary of this tool also shows the errors in the application. In the ‘top 5 error’ section, we can see that no errors were there during the test. The ‘top 5 max response time’ is 2.99 seconds, which is quite good based on the free web hosting and without any specific domain. As a result, it can be said that SPARKAU can handle the load of our University members.

This Chapter contains the testing and performance evaluation of the application. It contains the basic GUI testing, the usability of the application and its testing, compatibility of the application, exception handling in the code, and load testing. The GUI is tested with various experiments and changes to look for the loopholes in the design. The application works fine on heavy load. Its functionality is tested in usability testing while compatibility tests check whether the application runs on other browsers. Then In the final part. Load testing is explained along with pictures. The pictures represent the errors and graphical representation of SPARKAU on load burden.

←**********************Chapter 6 End*************************→**

Chapter 7

Conclusion

7.1 Experiment Performed

We have performed multiple unit tests to achieve reasonable results. The experiment starts from the single images to multiply chunks of video and then real-time videos.

7.1.1 Static Images

The algorithm was first analyzed to run on the images, specifically on the parking images of our university. It detected the cars in the parking but some extra detections are not required in our project. So a new approach has to be designed.

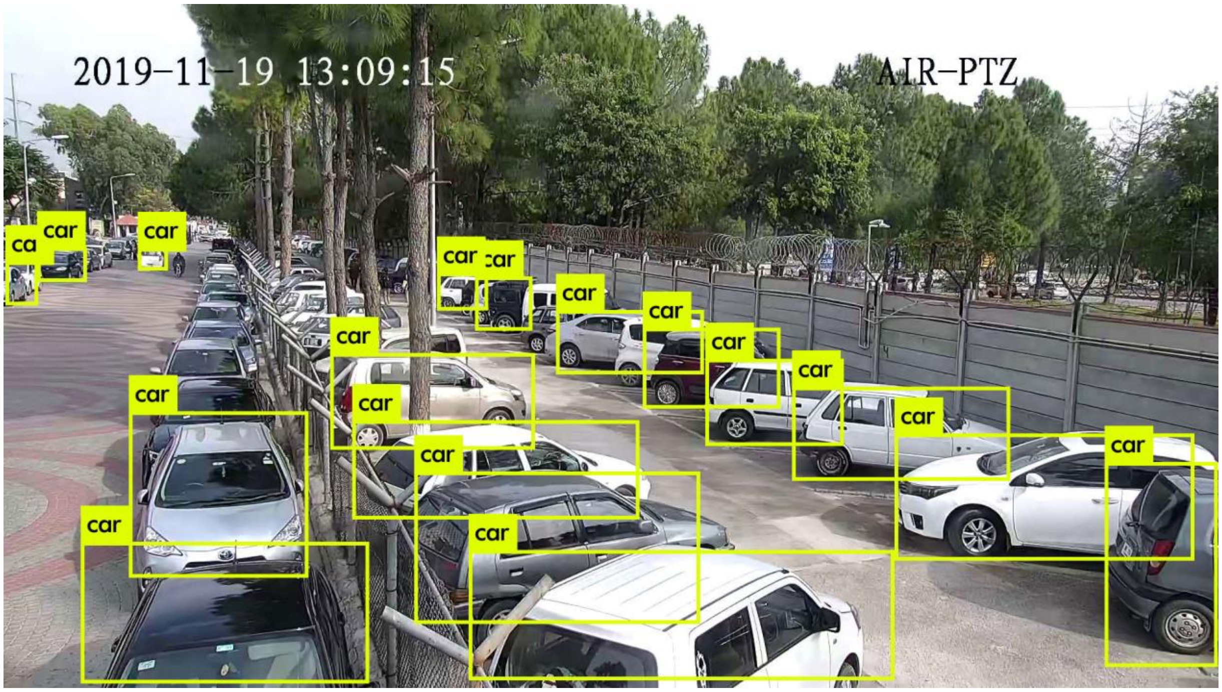


Figure 26 Experiment 1

0

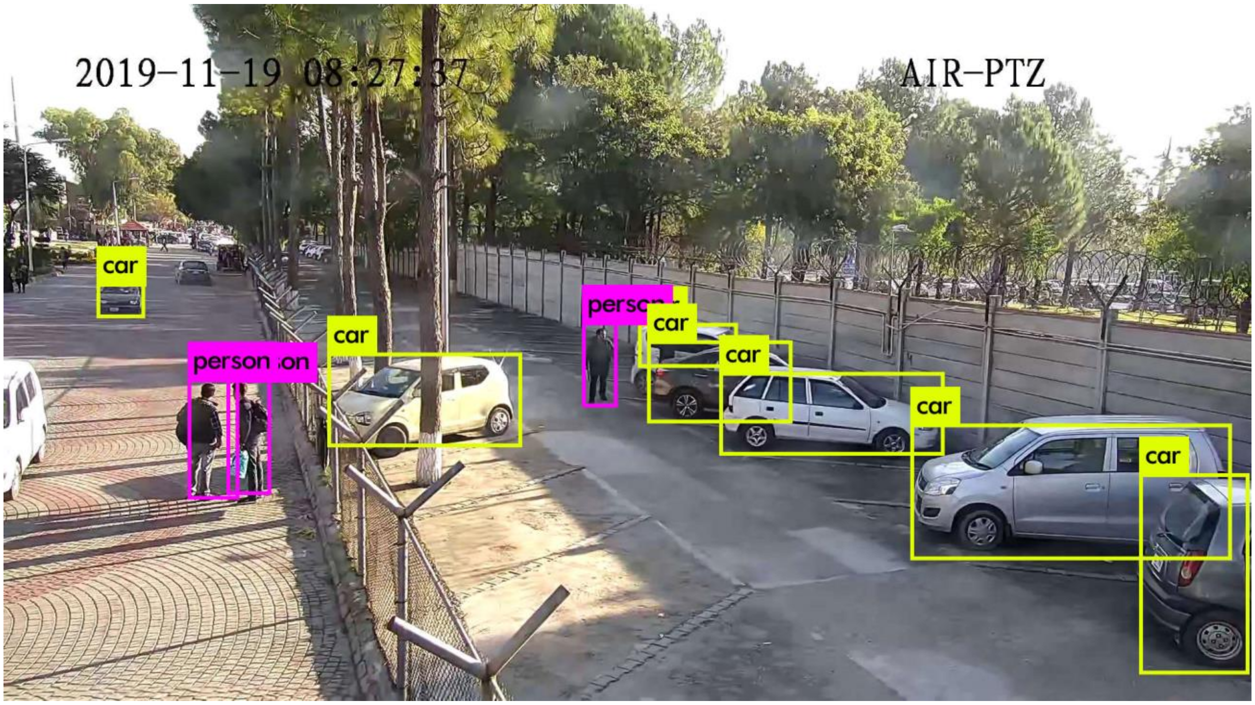


Figure 27 Experiment 2

This is the result of a single image. The algorithm did not count the cars because the edges of some cars are noisy. A new approach was to crop the image into the Region Of Interest(ROI).

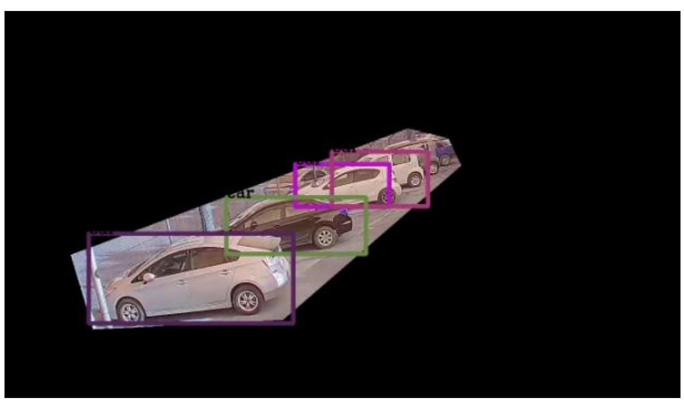


Figure 28 Crop Image

7.1.2 Chunks of Videos

When the results on images were calculated, We moved towards the video which is nothing but a sequence of images. The video was loaded in a small chunk of the whole video, because of the memory limitations of the hardware. Another reason for using the small chunk of the video is the change in the video. In longer videos, the cars are still and there is no change of in or out of the car in the parking. For experimental purposes, we use those chunk of videos that had changing of cars in the parking.

Figure 29 Video 1

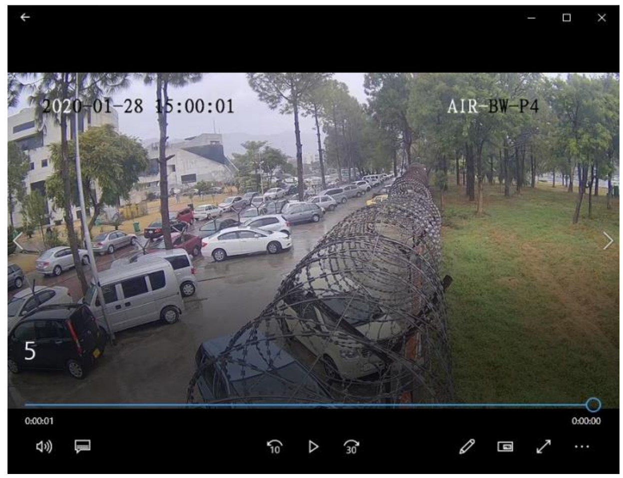


Figure 30 Video 2

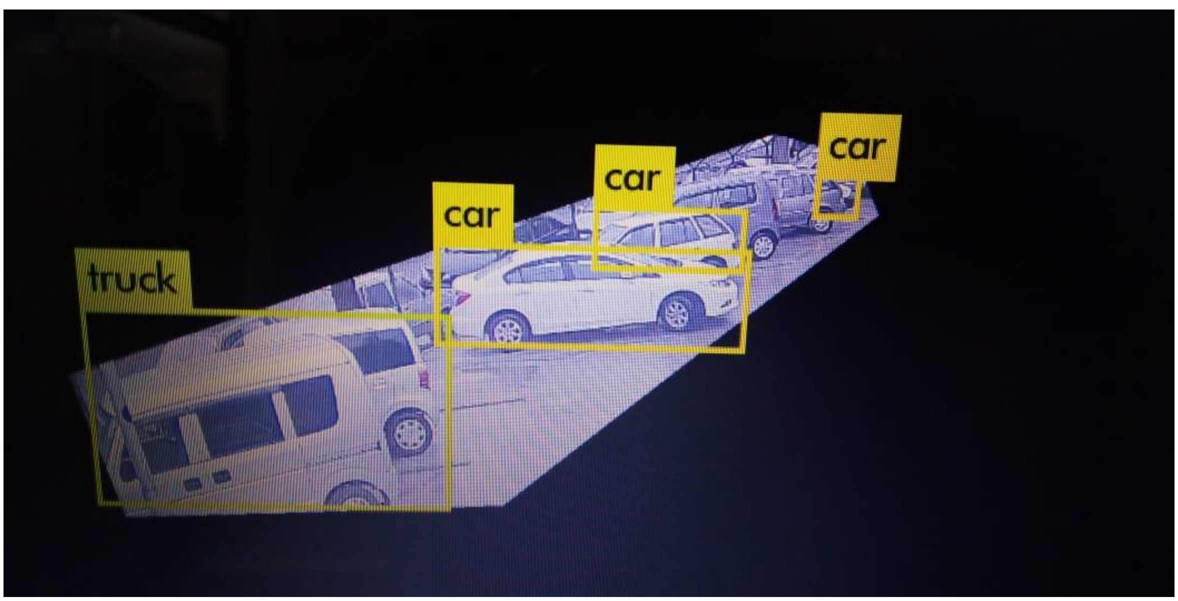


Figure 31 Cropped video

The issues in the experiments are shown in the image. The algorithm does not detect the corner cars or cars hidden behind other cars.

7.1.3 Test on videos

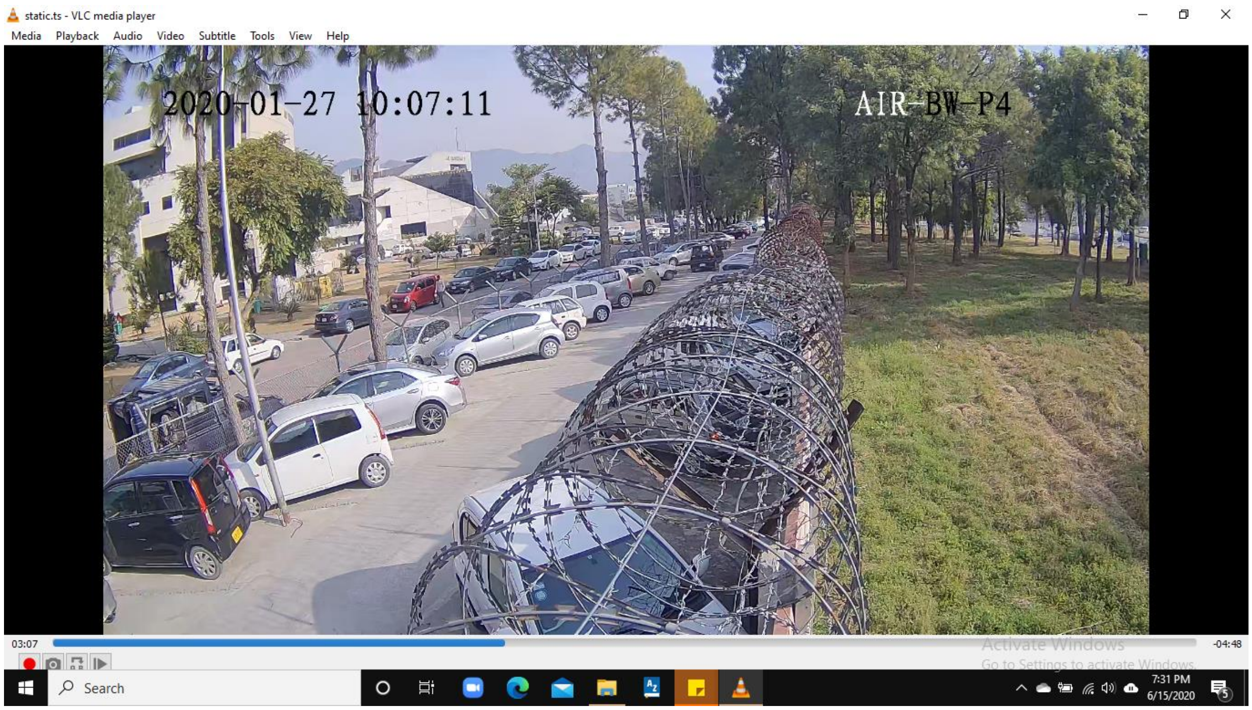


Figure 32 Actual Video

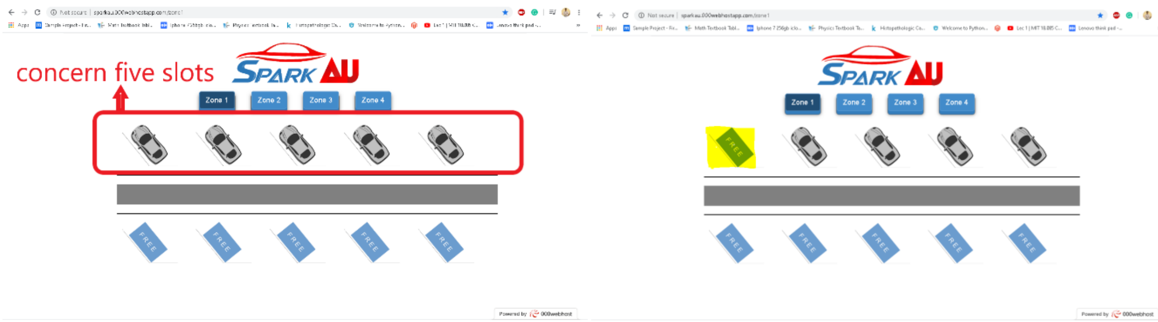
Figure 33One Empty Slot

Figure 34 Slot filled

Code Output

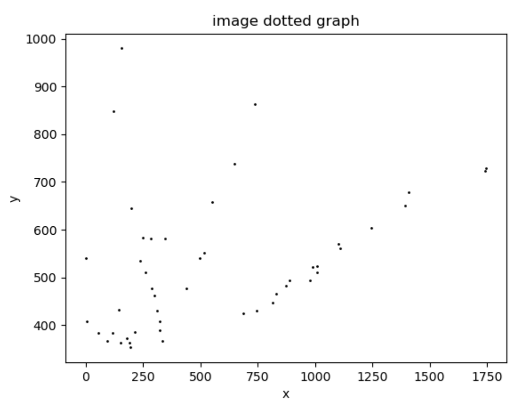
```
starting...
[INFO] loading YOLO from disk...
[INFO] 7897 total frames in video
[0.5622090101242065, 0.8781944513320923, 0.7141857743263245, 0.9832279682159424, 0.9954718351364136, 0.8256444931030273, 0.7664651870727539, 0.6875292062759399, 0.6158134341239929, 0.
[[801, 431, 131, 99], [696, 470, 158, 109], [115, 533, 240, 83], [571, 515, 227, 113], [400, 583, 262, 137], [271, 647, 274, 185], [5, 745, 258, 231], [715, 385, 76, 48], [947, 386, 6
16
[0.5606737732887268, 0.8673650026321411, 0.9844156503677368, 0.9957073330879211, 0.8271974325180054, 0.690746009349823, 0.6376568078994751, 0.6203450560569763, 0.9065262675285339, 0.87
[[801, 431, 131, 99], [697, 470, 158, 110], [570, 515, 229, 113], [400, 583, 261, 138], [270, 648, 273, 186], [5, 746, 256, 231], [716, 384, 76, 49], [946, 386, 63, 32], [626, 404, 111
15
data send to server
[0, 1, 1, 1, 1]
```

Data is sent using restful API and changes are reflected in the website



7.2 Results Calculated

This is the graphical representation of cars in the parking area. The dots represent the central point of the car. Because of hardware limitations, there is no solution for two overlapping points that coincide at the same location. It means two cars parked in overlapping directions cannot be detected accurately.



s

Figure 35 Graphical representation of Mid-points of Cars

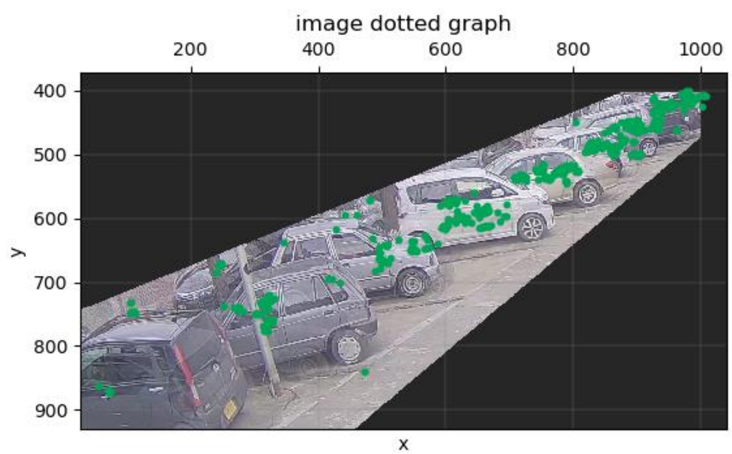


Figure 36 Mid-Points of 100 cars

The algorithm is run on one hundred images of those videos. The images are the cropped images with having specific areas to cover. The image shows the results of the test.

A function was defined to crop the frames in the specific region of interest

```
def cropst1(frame):
    im = frame
    # convert to numpy (for convenience)
    img_array = numpy.asarray(im)
    # create mask
    xy = [(234, 640),
          (915, 385),
          (996, 405),
          (1022, 460),
          (662, 771),
          (279, 790)]
    mask_img = Image.new('1', (img_array.shape[1], img_array.shape[0]), 0)
    ImageDraw.Draw(mask_img).polygon(xy, outline=1, fill=1)
    mask = numpy.array(mask_img)
    # assemble new image (uint8: 0-255)
    new_img_array = numpy.empty(img_array.shape, dtype='uint8')
    # copy color values (RGB)
    new_img_array[:, :, :3] = img_array[:, :, :3]
    # filtering image by mask
    new_img_array[:, :, 0] = new_img_array[:, :, 0] * mask
    new_img_array[:, :, 1] = new_img_array[:, :, 1] * mask
    new_img_array[:, :, 2] = new_img_array[:, :, 2] * mask
    newIm = Image.fromarray(new_img_array, "RGB")
    return new_img_array
```

Figure 37 Code to extract Region of Interest

We analyzed this data and take the average value of all points of the same slots. The extreme value for every single slot was neglected to avoid any overlapping slot. Given below are the detection and the output results of the code;

```
Enter Image Path: C:\yolo\darknet-master\data\1.jpg: Predicted in 22074.096000 milli-seconds.
car: 100%       (left_x:  288   top_y:  612   width:  382   height:  166)
car: 100%       (left_x:  544   top_y:  527   width:  260   height:   99)
car: 89%        (left_x:  686   top_y:  463   width:  214   height:   82)
car: 76%        (left_x:  713   top_y:  420   width:  248   height:  114)
Enter Image Path: C:\yolo\darknet-master\data\2.jpg: Predicted in 22940.816000 milli-seconds.
car: 100%       (left_x:  269   top_y:  604   width:  417   height:  180)
car: 100%       (left_x:  543   top_y:  527   width:  264   height:   99)
car: 91%        (left_x:  651   top_y:  461   width:  260   height:   90)
car: 84%        (left_x:  713   top_y:  422   width:  247   height:  113)
Enter Image Path: C:\yolo\darknet-master\data\3.jpg: Predicted in 26632.621000 milli-seconds.
car: 100%       (left_x:  289   top_y:  614   width:  378   height:  165)
car: 100%       (left_x:  551   top_y:  526   width:  256   height:  100)
car: 91%        (left_x:  691   top_y:  462   width:  213   height:   83)
car: 77%        (left_x:  792   top_y:  426   width:  159   height:   83)
Enter Image Path: C:\yolo\darknet-master\data\4.jpg: Predicted in 23989.482000 milli-seconds.
car: 100%       (left_x:  292   top_y:  615   width:  360   height:  164)
car: 98%        (left_x:  559   top_y:  516   width:  243   height:  111)
car: 71%        (left_x:  659   top_y:  458   width:  203   height:   98)
car: 91%        (left_x:  753   top_y:  457   width:  145   height:   91)
car: 96%        (left_x:  797   top_y:  425   width:  154   height:   86)
Enter Image Path: C:\yolo\darknet-master\data\5.jpg: Predicted in 26588.827000 milli-seconds.
car: 100%       (left_x:  286   top_y:  615   width:  370   height:  163)
car: 99%        (left_x:  559   top_y:  518   width:  237   height:  106)
car: 95%        (left_x:  749   top_y:  456   width:  147   height:   90)
car: 96%        (left_x:  829   top_y:  409   width:  146   height:   79)
Enter Image Path: C:\yolo\darknet-master\data\6.jpg: Predicted in 22301.500000 milli-seconds.
car: 62%        (left_x:    3   top_y:  732   width:  102   height:  240)
car: 100%       (left_x:  288   top_y:  614   width:  373   height:  164)
car: 99%        (left_x:  556   top_y:  519   width:  239   height:  105)
car: 95%        (left_x:  750   top_y:  455   width:  149   height:   95)
car: 88%        (left_x:  833   top_y:  408   width:  143   height:   81)
Enter Image Path: C:\yolo\darknet-master\data\7.jpg: Predicted in 21949.607000 milli-seconds.
car: 60%        (left_x:    4   top_y:  732   width:  103   height:  242)
car: 100%       (left_x:  291   top_y:  614   width:  366   height:  163)
car: 98%        (left_x:  534   top_y:  521   width:  245   height:  104)
car: 57%        (left_x:  703   top_y:  464   width:  151   height:  102)
car: 93%        (left_x:  756   top_y:  454   width:  143   height:   96)
car: 86%        (left_x:  830   top_y:  408   width:  145   height:   81)
Enter Image Path: C:\yolo\darknet-master\data\8.jpg: Predicted in 31033.994000 milli-seconds.
```

Figure 38 Output of Code

7.3 Achievements

Our primary goal was to detect the filled and empty. We can claim to have achieved almost 70% accuracy. Whenever a car leaves the parking, the live video is fed into the code, it detects the new slots and updates the database, The Website asks the database to send data and the website is updated. Another achievement is the real-time updating of parking slots. whenever a car leaves the parking slot, the website is updated as soon as it leaves the slot.

7.4 Future Directions

SPARKAU is a very helpful tool for Air University. It will help the members of Air University to park their cars without wasting any time. The Application has been developed in python and angular. It solely performs the basic task of providing information about free slots. The only zone that is working in this application is zone 1. The remaining zones that are zone 2, zone3, and zone 4 are left for future work. This application can be developed further to enhance the parking zones. Our university has also developed new parking zones for cars. The software can be deployed as a single entity that will manage the whole university. It can cover all the zones of the university.

User Manual

Programmer's perspective

YOLO version

There are three versions of YOLO. Every version has its pros and cons.

- YOLOv1
- YOLOv2
- YOLOv3

YOLO 3 is considered the fastest and most accurate Algorithm in computer vision. So the Algorithm used in the SPARKAU is YOLO v3.

Framework and language selection

YOLO is implemented in python and C++ programming languages. Its popularity is in C++ with a convolution network running on Darknet. It is popular for one reason that it is impressively fast. However, C++ language is considered as a low-level language because of its syntax and mnemonics code. Therefore, in terms of simplicity and modification, we use YOLO's implementation in python 3.6. Pycharm is used for programming and modification in YOLO.

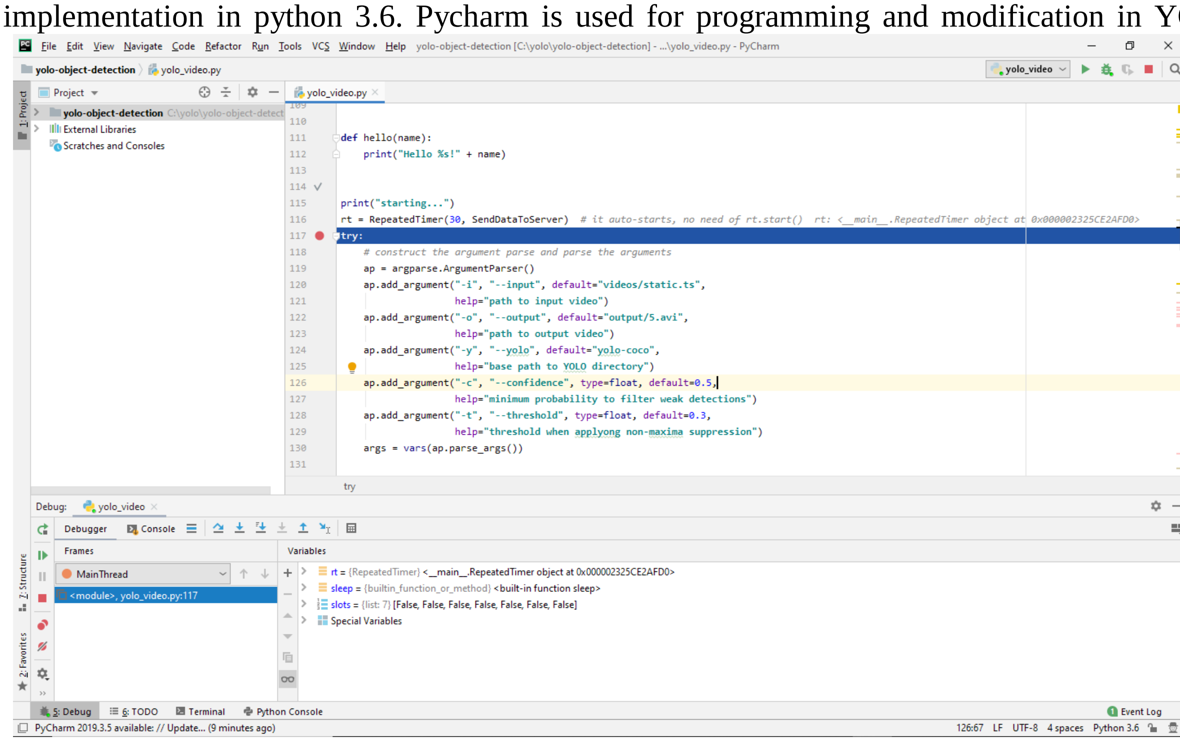
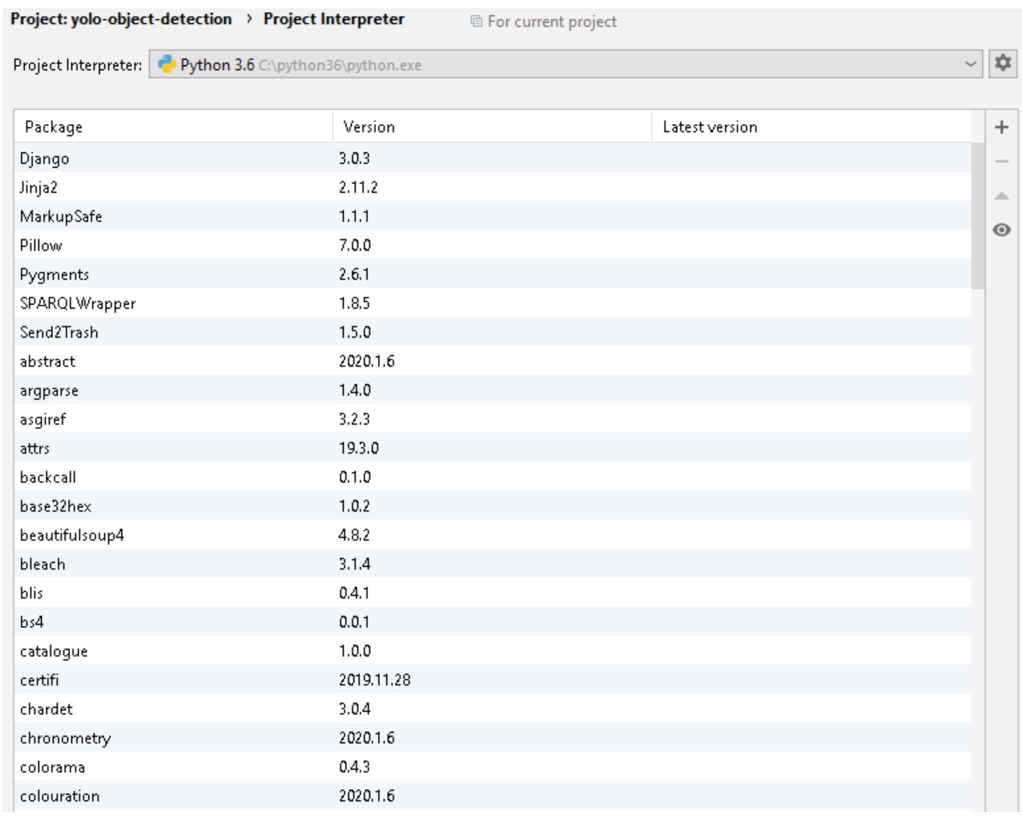


Figure 39 Interface of Pycharm

Dependencies

Import NumPy
Import argparse
Import imutils
import time
import cv2
import json
import os
from PIL import Image, ImageDraw
from threading import Thread
import requests
from threading import Timer



Project: yolo-object-detection › Project Interpreter For current project

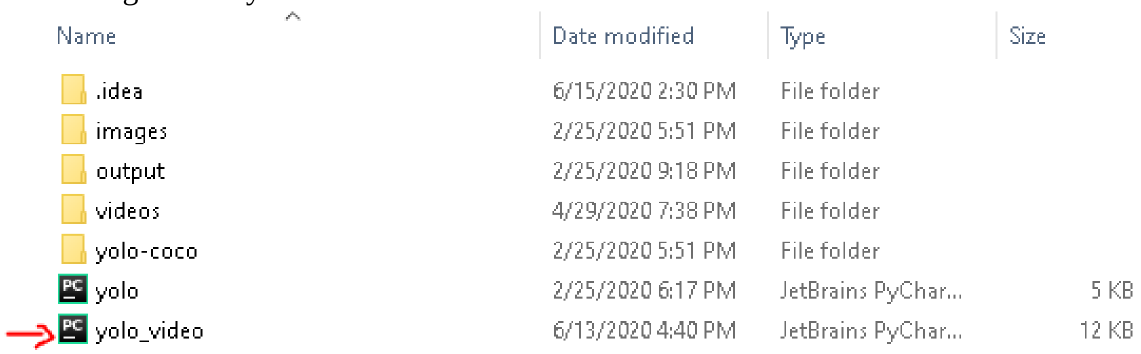
Project Interpreter: Python 3.6 C:\python36\python.exe

Package	Version	Latest version
Django	3.0.3	
Jinja2	2.11.2	
MarkupSafe	1.1.1	
Pillow	7.0.0	
Pygments	2.6.1	
SPARQLWrapper	1.8.5	
Send2Trash	1.5.0	
abstract	2020.1.6	
argparse	1.4.0	
asgiref	3.2.3	
attrs	19.3.0	
backcall	0.1.0	
base32hex	1.0.2	
beautifulsoup4	4.8.2	
bleach	3.1.4	
blis	0.4.1	
bs4	0.0.1	
catalogue	1.0.0	
certifi	2019.11.28	
chardet	3.0.4	
chronometry	2020.1.6	
colorama	0.4.3	
colouration	2020.1.6	

Figure 40Packages to install in the Pycharm

Running (SPARKAU)

Go to the working directory of SPARKAU



double-clicking the yolo_video.py file. Pycharm loading will appear

After

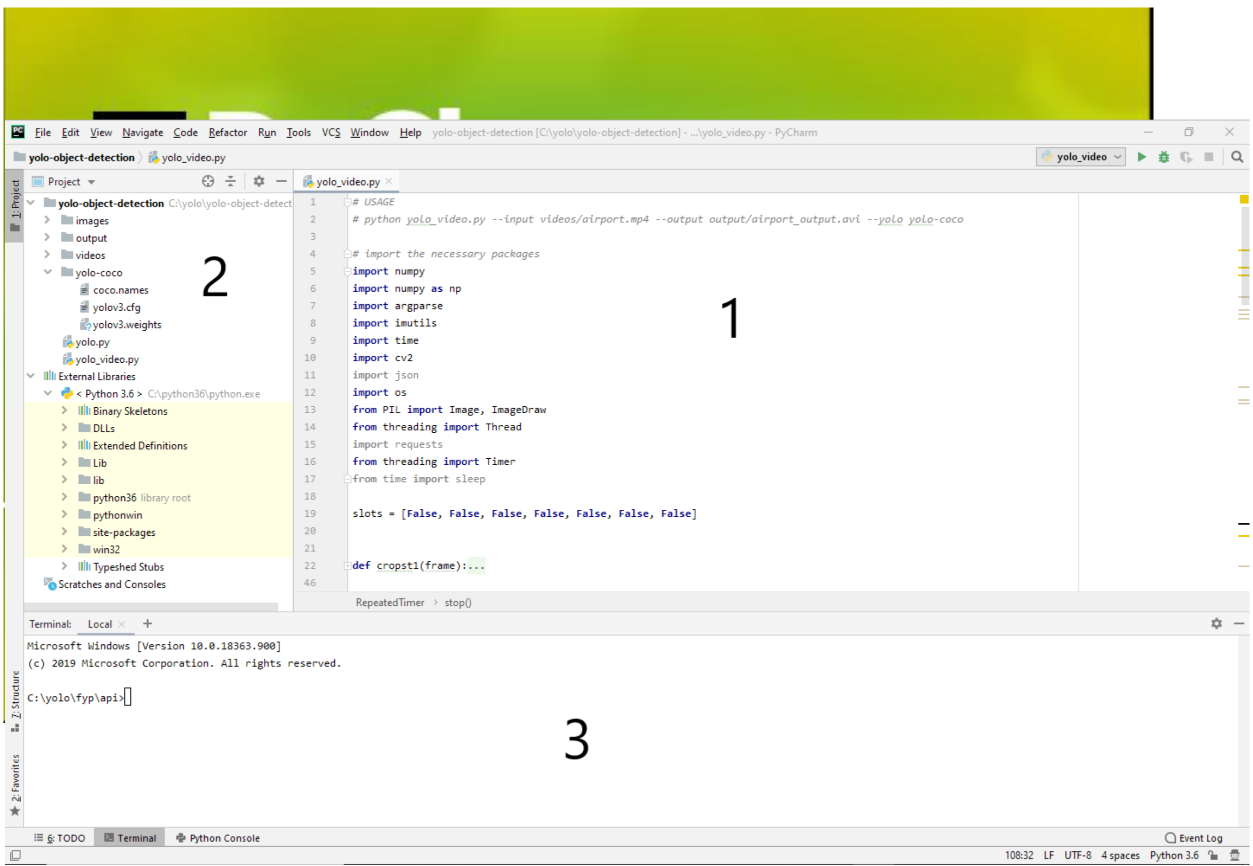


Figure 42 Landing page of Pycharm

loading, the landing screen will look like this

It has three main panels each with its specific domain

1)- code is displayed from where we can edit, modify, or work on our project.

yolo_video.py

```python
rt = RepeatedTimer(30, SendDataToServer)  # it auto-starts, no need of rt.start()
try:
    # construct the argument parse and parse the arguments
    ap = argparse.ArgumentParser()
    ap.add_argument("-i", "--input", default="videos/static.ts",
                    help="path to input video")
    ap.add_argument("-o", "--output", default="output/5.avi",
                    help="path to output video")
    ap.add_argument("-y", "--yolo", default="yolo-coco",
                    help="base path to YOLO directory")
    ap.add_argument("-c", "--confidence", type=float, default=0.5,
                    help="minimum probability to filter weak detections")
    ap.add_argument("-t", "--threshold", type=float, default=0.3,
                    help="threshold when applyong non-maxima suppression")
    args = vars(ap.parse_args())

    # load the COCO class labels our YOLO model was trained on
    labelsPath = os.path.sep.join([args["yolo"], "coco.names"])
    LABELS = open(labelsPath).read().strip().split("\n")

    # initialize a list of colors to represent each possible class label
    np.random.seed(42)
```

Figure 43 Code editor

2)-It shows the hierarchy of our project. All the different components of the project are listed here.

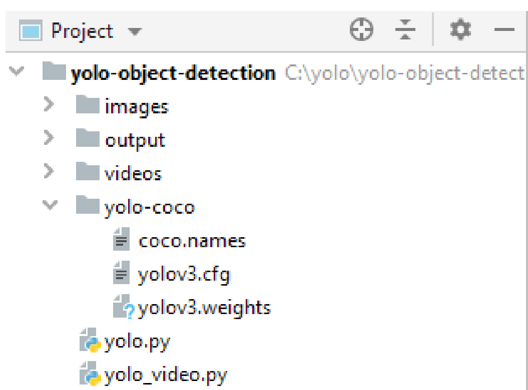


Figure 44Project Files and hierarchy

3)- It shows the terminal python console and other debugging facilities

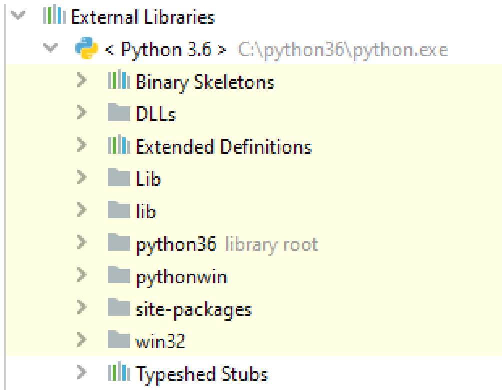
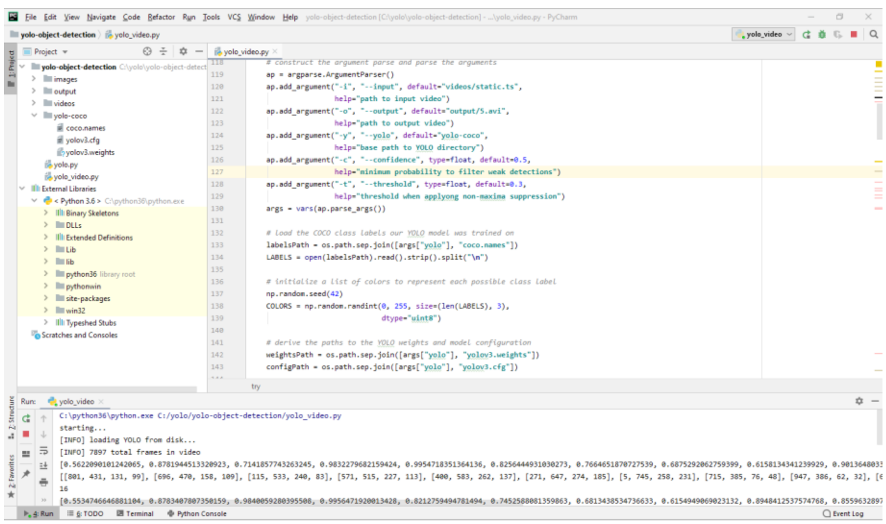


Figure 45 External libraries

On the top right corner, it has two buttons, the play icon is to run the project.



The bug icon represents debugging mode, which can run the code with the facility to provide breakpoints. Red dots are the breakpoints as shown in the picture below.

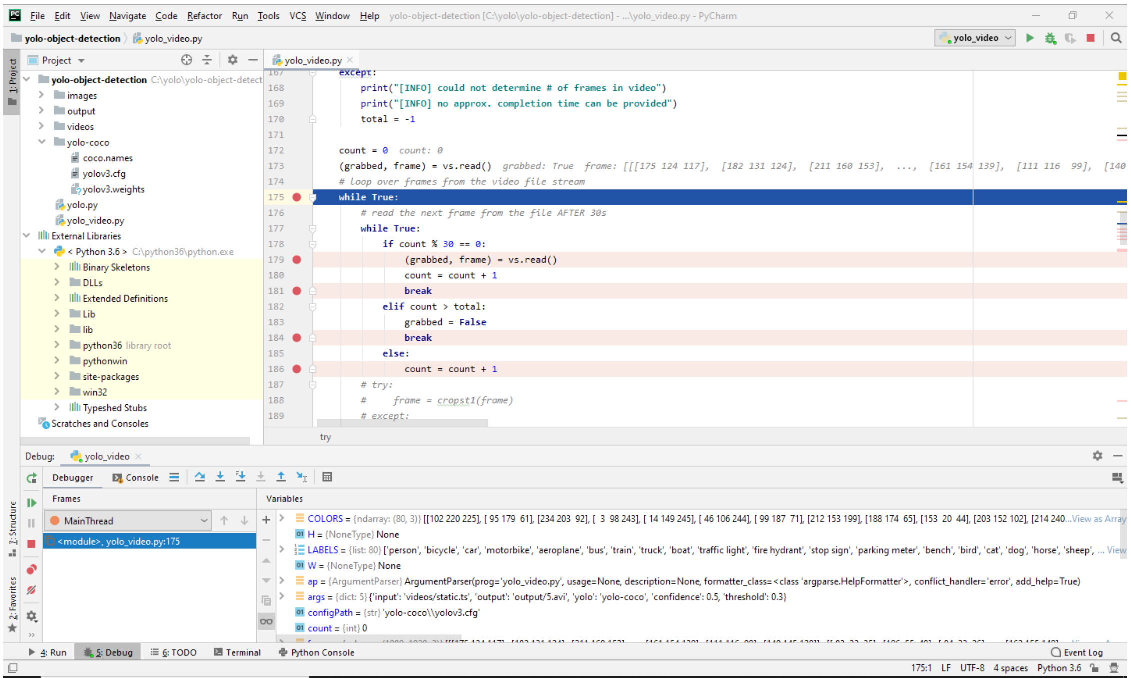


Figure 46 Defining Breaking Points

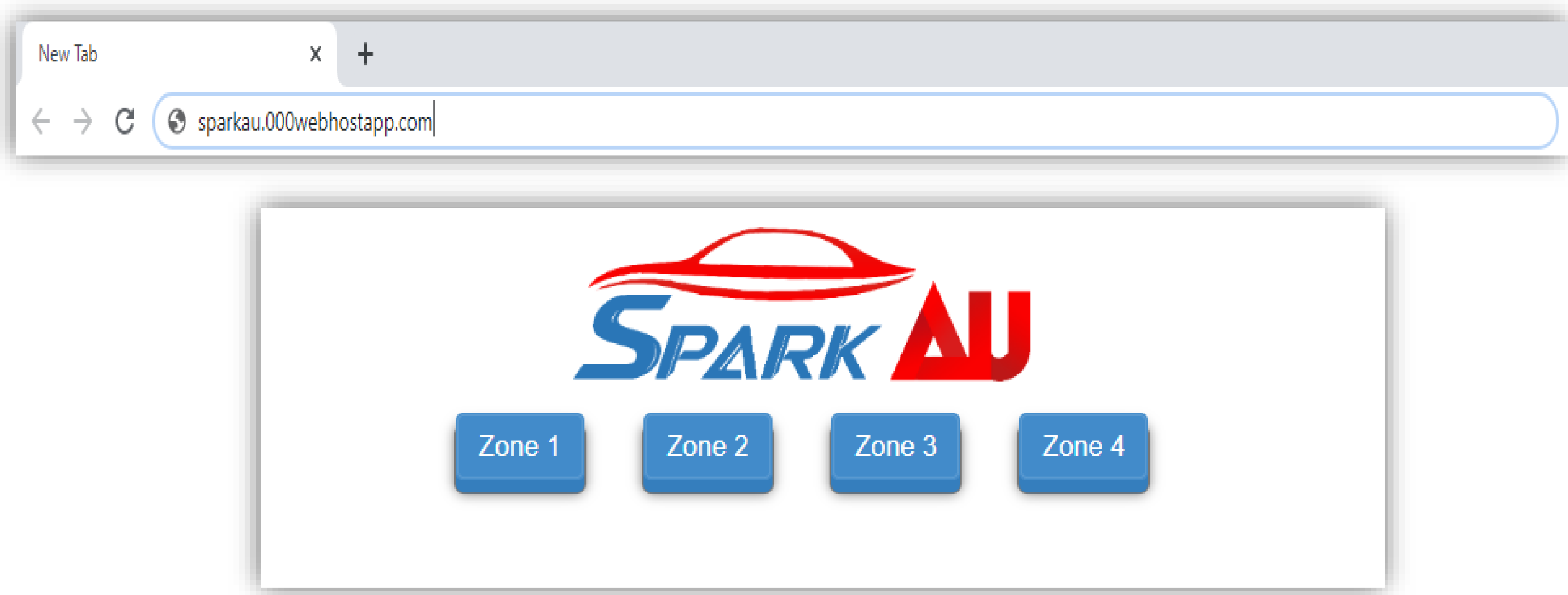
User’s perspective

SPARKAU is a smart application that will be used by the students, faculty, and admin of the air University. The system will help them park their cars without wasting any time and money. The usage for the user of the GUI is explained in with pictures.

Web Interface

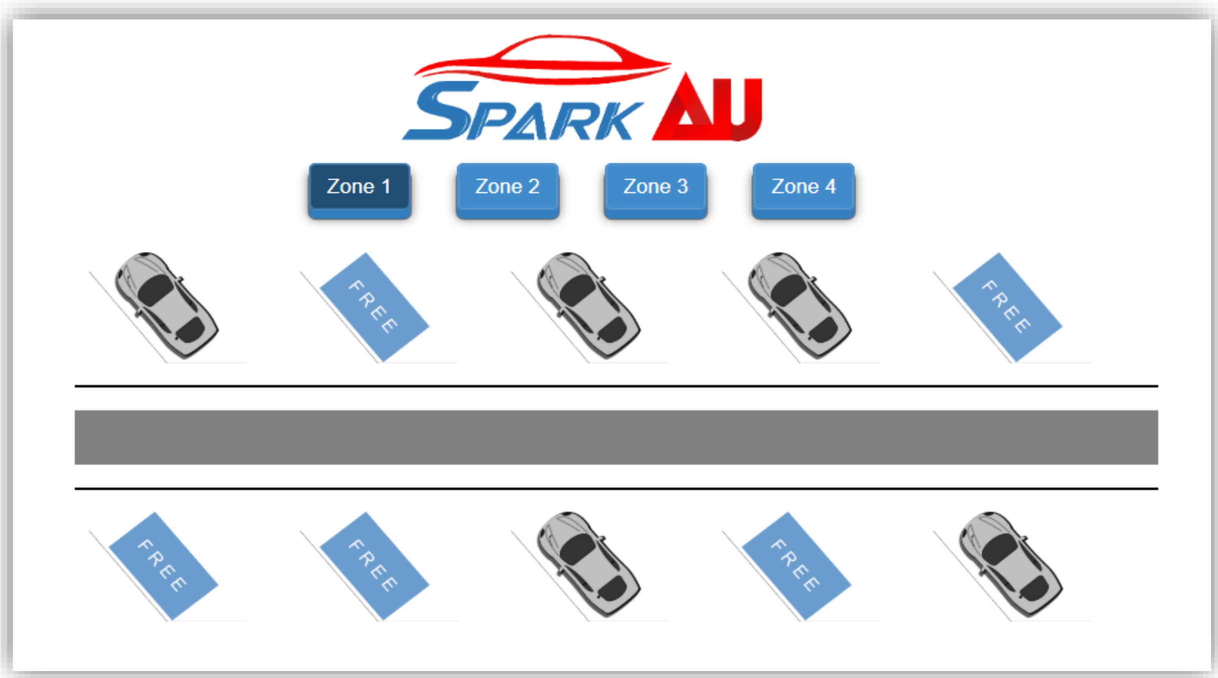
To access the web User Interface of the Smart Parking System for Air University. The user will type the URL on his tablet or laptop to access the website of the SPARKAU. The website is deployed on the free web hosting site. Everything on this website works fine. The URL is

http://sparkau.000webhostapp.com



How to use 1

This image is the main home screen for the website of SPARKAU. It has the logo of the SPARKAU. Below it has four buttons for different zones. Each zone represents the different parking zones of Air University. Each zone can be used to look for free parking slots. Every zone has will consist of 10 different parking slots.



How to use 2

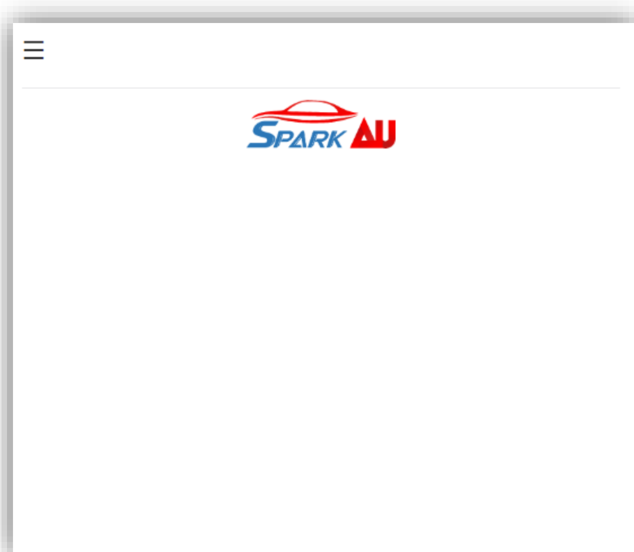
When the user clicks on Zone 1, It will display all the slots. The parking slots are represented horizontally to have the same representation as to the original parking. The parking slots in the university are build tilted that is why these free slots and car parks are also shown tilted. Free slots represent available slots for parking while occupied parking is represented by cars.

The slots and the backend server code are working on zone 1. The remaining zones i.e. zone 2, zone 3 and zone 4 are left for future work.

How to use 3

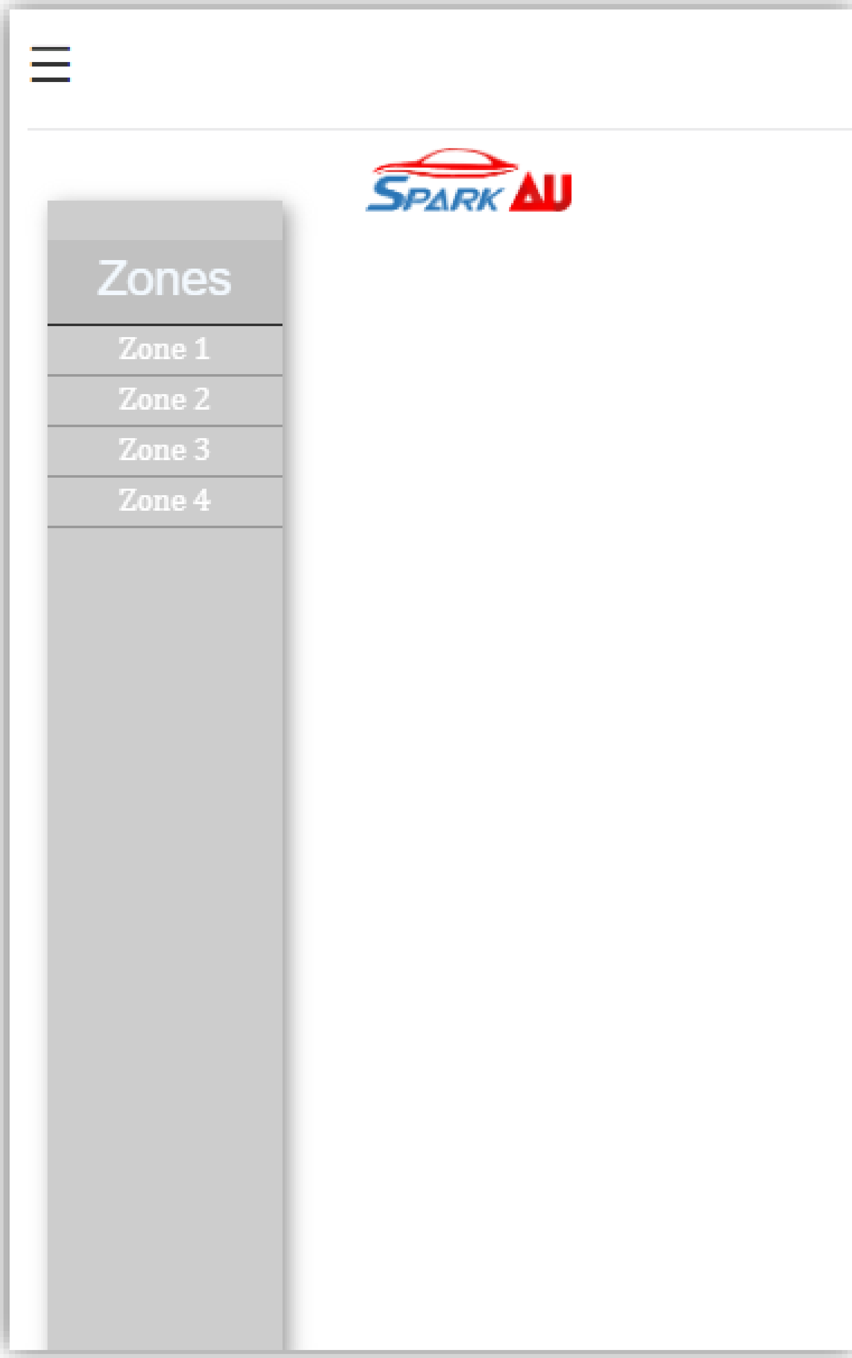
Mobile Interface

The mobile interface is also the same except the display is represented vertically. The buttons are shown on the left menu side of the application. The URL is the same URL: http://sparkau.000webhostapp.com/



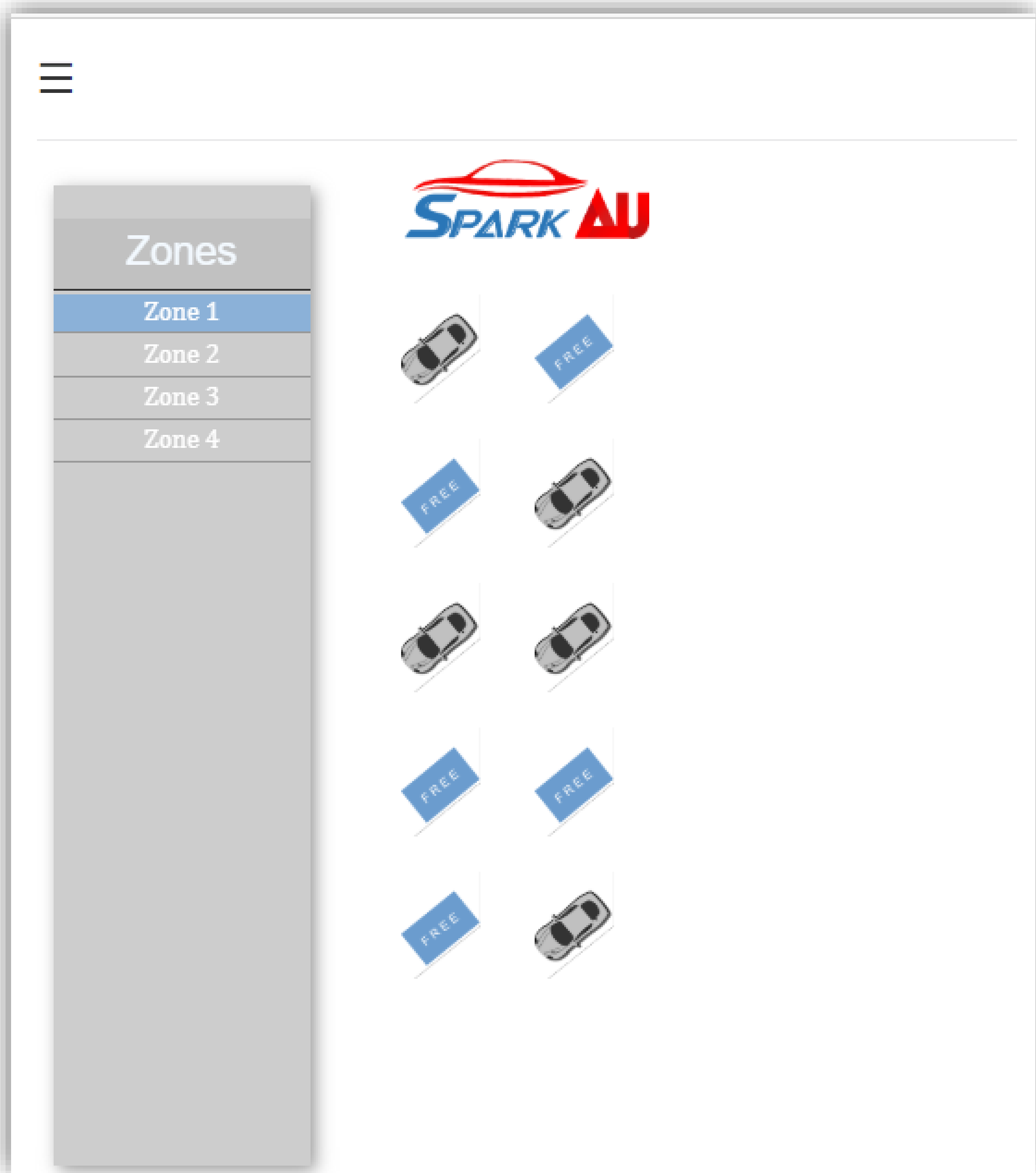
How to use 4

The mobile interface will look like the above-given image, It will only have a logo and sidebar menu. When the user taps this menu. A sidebar pops from left displaying different zones as shown in below picture



How to use 5

These Zones are clickable buttons with every zone connected to the corresponding original parking zone of Air University. When User taps on Zone 1, it will display the free slots as shown below



How to use 6

Zone 1 is highlighted which will tell the user about the zone in which he is searching for the free slot.

References

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