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91

IT 497: Graduation Project Report
Product Release-2

Prepared by
Afnan Alotaibi, 442202653
Rahaf Alnassrallah, 442201397
Futoon Alsalami, 442201864
Sarah Alqahtani, 442200435
Shahad Alqahtani, 442202316

Supervised by
Dr.Hailah Alballaa

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Table of Contents

List of figures:

List of tables:

91

Afnan Alotaibi [1], Rahaf Alnassrallah [2], Futoon Alsalami [3], Sarah Alqahtani [4] and Shahad Alqahtani [5]

[1]Information Technology Department, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia; 442202653@student.ksu.edu.sa
[2]Information Technology Department, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia; 442201397@student.ksu.edu.sa
[3]Information Technology Department, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia; 442201864@student.ksu.edu.sa
[4]Information Technology Department, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia; 442200435@student.ksu.edu.sa
[5]Information Technology Department, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia; 442202316@student.ksu.edu.sa

Abstract (English):

Gas is crucial for our daily transportation needs, yet the unpredictable consumption and the crowds in gas stations can disrupt plans and consume valuable resources. In response, the "91" mobile application enables users to calculate consumption and expenses through their bills and assist them make informed decisions by utilizing AI technology to detect and report gas station occupancy in real-time and recognize car plates. Utilizing the YOLO (You Only Look Once) object detection algorithm, the app processes streams of entrance and exit footage to determine current occupancy and recognize users via their car plates. Implemented in Python, the YOLO model integrates seamlessly with Firestore database, where occupancy, car plates and bills information is stored and accessed by the user-facing Flutter application. Following an Agile development methodology, the project emphasizes iterative improvement and user feedback integration. Evaluation demonstrates the app's efficacy in providing accurate occupancy and consumption insights. "91" offers a practical solution to the challenges of gas station congestion and calculating gas consumption, facilitating smoother travel experiences and optimized planning for users.

ملخص (العربية): في حين يُعد الوقود ضرورة أساسية لتنقلاتنا اليومية، إلا أن استهلاكه غير المتوقع والازدحام في محطات الوقود يمكن أن يعطل خطط الفرد ويستنفد الموارد الثمينة. وبهدف التغلب على ذلك، يوفر تطبيق الجوال "91" للمستخدمين إمكانية حساب استهلاك الوقود والنفقات من خلال فواتيرهم، ويساعدهم على اتخاذ قرارات مدروسة باستخدام الذكاء الاصطناعي الذي يعمل على حساب مستوى الازدحام في المحطات في الوقت الحالي.

يعمل التطبيق على تحليل مقاطع دخول وخروج السيارات من محطات الوقود باستخدام خوارزمية "YOLO" لتحديد عدد السيارات المتواجدة حاليًا والتعرف على المستخدمين من خلال لوحات سياراتهم. تم تطوير الخوارزمية بلغة البايثون ودمجها مع قاعد البيانات "Firestore"، حيث يتم تخزين معلومات مستوى الازدحام و لوحات السيارات والفواتير. ومن ثم تسترجع هذه المعلومات وتعرض للمستخدم عن طريق التطبيق. لقد تم اتباع منهجية "Agile" في تطوير هذا المشروع، التي تركز على التحسين المستمر والاهتمام بملاحظات المستخدمين. وقد وضح التقييم فعالية التطبيق في تقديم معلومات صحيحة من ناحية استهلاك الوقود وازدحام المحطات. يقدم تطبيق 91 حلاً عملياً في مواجهة تحديات ازدحام محطات الوقود وحساب استهلاك الوقود. مما يوفر تجارب قيادة وتخطيط افضل للمستخدمين.

Keywords: Computer Vision; Real-time Occupancy Detection; License Plate Recognition; License Plate Extraction; Fuel Consumption Tracking; Artificial Intelligence in Transportation; Gas Station Management; Fuel Economy Database; QR Code Integration.

INTRODUCTION

91 application

1 Introduction

The reported daily oil consumption in Saudi Arabia is approximately 3,876 thousand barrels, with around 539.45 thousand barrels per day allocated for the gas station market [1] [2]. Reports also reveal that approximately 25% of Saudi Arabia's oil consumption is attributed to the automobile sector [2]. These numbers show the substantial size of the gas station market within the country, and even though Saudi Arabia is promoting adopting hydrogen-based engines and electric vehicles to lower carbon emission, the gas stations market is still expected to grow given readily available gas and gas stations provide additional amenities such as electrical cars charging stations and convenience stores. Recognizing the significance of this industry, the 2030 vision includes plans to connect this market and enhance its infrastructure.

In this document, we will provide a background section that covers machine learning, computer vision, and relevant libraries. The report also includes a literature review and competitive product analysis. The system design and development section outline the methodology, system requirements, and design details. It also covers data design, interface design, and implementation. System evaluation evaluates experimental results, user acceptance testing, and quality attributes. The report concludes with findings, conclusions, suggestions for future work, acknowledgments, references, and appendices.

1.1 The problem

Despite the importance of the gas station market, gas station customers face many challenges. In addition, gas stations get overcrowded during different periods of the day which results in a time-consuming experience for customers. Another problem is there is no real-time data on the availability of fuel types for customers before visiting the gas station, which can cause an inconvenience.

1.2 Objectives and scope

To address these challenges, the project aims to connect customers with gas stations by utilizing artificial intelligence's computer vision capabilities. The objectives of the software development project include providing real-time occupancy detection, identifying cars through a license plate recognition process for billing purposes, and allowing gas station managers to provide information about fuel availability and other amenities.

The scope of the project encompasses the development of a mobile application accessible through Android platforms, enabling users to choose gas stations based on occupancy levels, fuel availability, services, and working hours. Additionally, the application will generate fuel expense statistics and consumption based on bill records recorded via car identification, either through license plate recognition or unique QR codes.

The set up requires 2 cameras, a camera representing the entrance and another representing the exit, illustrated in figure 1. However, the scope had limitations and was applied on the campus' gates due to challenges in obtaining permission from gas stations because of security and privacy concerns. And even though we obtained permission from the authorities on campus we still had very limited options for the setup of the cameras because of the instructions we received and the circumstances of the area we were allowed to set up at. The walls we were allowed to install the cameras on were too far from the lanes to recognize car plates, so we considered recognizing the car plates passing through the lane closest to the cameras. Setting up in a real gas station would require more cameras to cover all the lanes in case one camera is not close enough to detect all lanes.

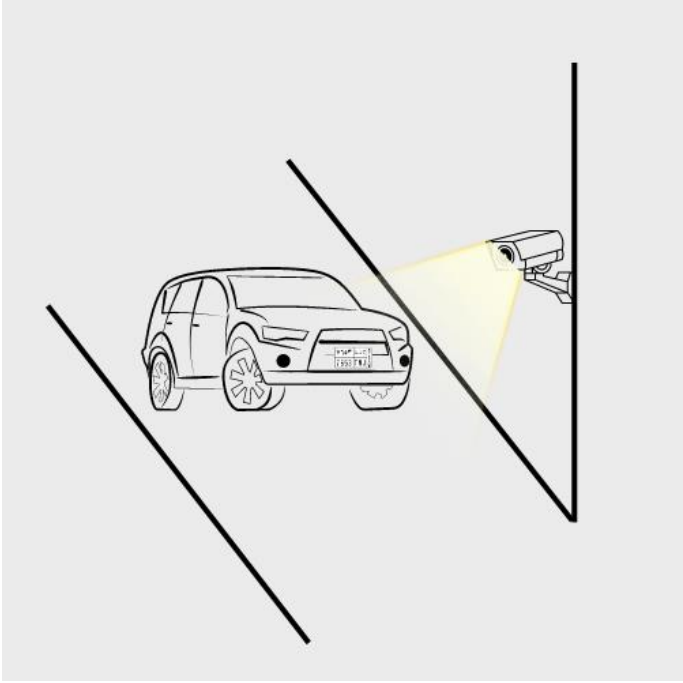

Figure 1- Entrance setup illustration.

1.3 Product vision

The vision of our product is to assist car drivers in finding gas stations with real-time occupancy information. The mobile application utilizes computer vision technology to estimate the occupancy level at the gas station and detect license plate numbers for billing purposes. Unlike other fuel applications, such as "PetroApp" [3], our product offers a unique combination of features, including real-time occupancy detection, fuel availability information, and expense tracking, all powered by AI technology.

1.4 Approach

The overall approach in developing 91 followed the agile methodology, allowing continuous assessment and enhancement of the product. The project began with data collection on the targeted users, which influenced the selection of the main features. The development stage involved continuous reviewing and refining. Various datasets collected, such as a fuel economy database from SASO, and Saudi car plate datasets from Kaggle and another collected through the set-up cameras, which were used for training the car license plate recognition model. Experimental stages were conducted during the camera setup and model development, which will be further explained in this document.

1.5 Main contribution

The main contribution of the project is a running application that provides users with real-time occupancy information at gas stations, as well as fuel consumption and expense tracking. Additionally, the project includes a gas station employee application for billing purposes, a branch manager's website to manage partnered stations, and an admin website to manage applications and branch managers. The utilization of AI technology, specifically computer vision, sets our solution apart from competitors, offering a comprehensive set of features tailored to address the challenges faced by gas station customers. Providing users with these features will allow them to manage their time and plans efficiently, and the insight into their consumption will help them better manage their resources and maybe lower their carbon emissions.

Background

91 application

2 Background

In this chapter, we will provide a comprehensive discussion of the technologies to be utilized in our project. We will begin by explaining the concept of machine learning and its various types, followed by an exploration of computer vision and its functioning. Subsequently, we will delve into the concept of object detection and object tracking, then we will introduce the YOLO framework for computer vision. Additionally, we will provide information on some popular open-source libraries for computer vision, discuss the choice of camera type to be used, clarify the concept of the Real-Time Streaming Protocol (RTSP), and conclude by discussing Saudi license plate number detection.

2.1 Machine Learning

Machine Learning is an AI technique that provides machines the ability to automatically learn from data and past experiences to identify patterns and make predictions with minimal human intervention. It uses a data-driven approach, which means it is trained on historical data and makes predictions on new data. It finds patterns in large datasets faster than humans [4] [5].

2.1.1 Neural networks

Deep learning is a subset of machine learning, which is determined by the number of hidden layers in neural networks. "Traditional neural networks only contain 2-3 hidden layers, while deep networks can have as many as 150" [6]. Neural networks simulate the way the human brain works. It consists of interconnected nodes and three main layers: the input layer, which receives the values, several hidden layers, which perform all the calculations to find hidden features and patterns, and the output layer, which is the final output of neural networks. Its common application is image recognition which what we need in computer vision technology. One of its types is Convolutional neural networks (CNNs) which are usually utilized for image recognition, pattern recognition, and/or computer vision [7]. Figure 2 shows the main structure of the neural networks [7].

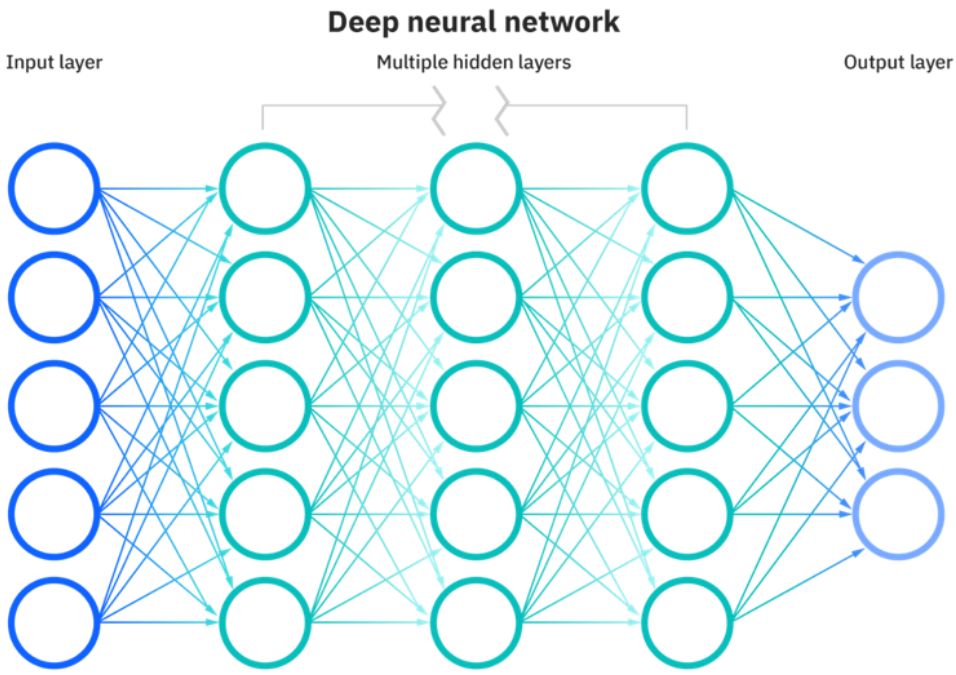

Figure 2 - Neural network main structure.

2.2 Computer vision

Computer vision is one of the artificial intelligence techniques that we will use in our project. It is able to understand images as humans do. It analyzes images pixel by pixel and has several uses, most notably object detection [8].

2.2.1 How computer vision works

Computer vision needs a lot of data. For example, to teach a computer to identify cars, it must see many car images to spot differences. It works in three basic steps: Acquiring an image, it can be acquired in real-time through cameras for videos for analysis. Processing the image, and understanding the image. Figure 3 illustrates a final result of an object detection and classification in computer vision using the YOLO (You Only Look Once) algorithm which is a popular object detection model that will be discussed later [9]. Basically, the model is trained using a vast amount of data that was acquired somehow, comprising images of cars, people, traffic lights, and their respective labels. After the training phase, the model is then tested using validation images, which are accompanied by the correct labels to evaluate the accuracy of its predictions.

Figure 3 - YOLO Multi-Object Detection and Classification

2.2.2 Object detection

Object detection is a computer vision technique for locating instances of objects in images or videos. Its algorithms typically leverage machine learning or deep learning to produce meaningful results. humans can recognize and locate objects of interest within a matter of moments when they look at images or videos. The goal of object detection systems is to emulate this capability using machines [10]. Figure 4 illustrates the process of object detection, representing a high-level overview of how object detection is performed [10].

Figure 4 - Using object detection to identify and locate vehicle.

2.2.3 Object tracking

Object tracking is a valuable computer vision technique that involves identifying and monitoring objects across frames in videos or images. It differs from object detection, which focuses on identifying objects within a single frame without considering their movement over time.

2.2.4 Yolo

You Only Look Once (YOLO) is a popular object detection model known for its speed and accuracy. It looks at the whole picture just once and quickly points out what and where those things are. This makes it useful for situations where we need to identify moving scenes like real-time occupancy detection for gas stations [11].

2.3 Popular Open-Source Libraries for Computer Vision

In this section we will describe a couple of popular open-source libraries for computer vision.

2.3.1 OpenCV

OpenCV is an open-source library that makes computer vision fun and easy to implement and plays a major role in real-time operations. It works with C++, C, Python, and Java and can run on Windows, Linux, Mac OS, iOS, and Android [12].

2.3.2 PyTorch

PyTorch is an open-source machine learning library for creating and training deep learning models based on neural networks. It works with Python and C++. Its main feature is that it uses dynamic computational graphs which provides flexibility in designing complex neural network architectures [13].

2.3.3 IP cameras

IP cameras are a type of surveillance camera that connects to a network or the internet. They use wireless connections, enabling them to communicate with other devices on the network and be accessible over the internet for remote control [14].

2.4 Saudi license plate numbers

There are various challenges associated with ANPR, including variations in license plate formats, especially Saudi plates. There are differences in terms of characters (English and Arabic characters), numbers, symbols, and colors on plates. YOLO needs to be trained on a diverse dataset that includes all possible plate variations, and the model needs to handle a wide range of character designs. There are also challenges related to the lighting conditions and image quality, the model needs to be trained on different lighting conditions and strive to enhance image quality as much as possible. Figure 5 illustrates the different formats of Saudi license plate numbers, which we aim to adapt current pre- trained models for Automatic Number Plate Recognition (ANPR) which is a technology that uses various image processing techniques to automatically read and interpret the license plates of vehicles [15].

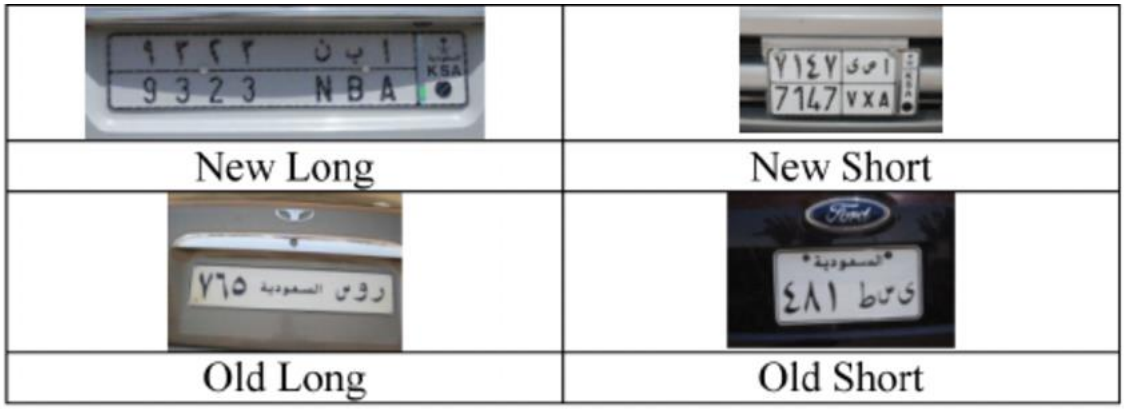

Figure 5- Different formats of Saudi plates.

2.5 Object Detection Performance Measures

Evaluating the performance of an object detection model is crucial for understanding how well it can identify and locate objects within images. This involves using specific metrics that provide insights into the model's accuracy and reliability. Initially, some essential definitions should be clarified [16]:

- **True Positive (TP):** When the model correctly identifies and locates objects, and the IoU score is at or above a certain threshold.
- **False Positive (FP):** When the model wrongly identifies an object that isn't there or the IoU score is below the threshold.
- **False Negative (FN):** When the model misses detecting an object that is actually present.
- **True Negative (TN):** Not applicable in object detection, as it refers to correctly identifying the absence of objects, which isn't the focus in object detection tasks.

1. Precision(P):

It measures the accuracy of the model's positive predictions, indicating how well it distinguishes true objects from false positives. A high precision score means the model is good at avoiding false positives.

$$\text{precision} = \frac{TP}{TP + FP}$$

2. Recall (R):

Also known as sensitivity or true positive rate, measures the model's ability to capture all relevant objects in the image. A high recall score means the model identifies most of the relevant objects.

$$\text{recall} = \frac{TP}{TP + FN}$$

3. Intersection Over Union (IOU)

Intersection over Union (IoU) is a key metric in computer vision, especially for tasks like object detection. It is essential for evaluating the quality and accuracy of these models. The IoU is calculated by taking the intersection area of two bounding boxes and dividing it by the union area of these boxes [16]. Mathematically, the IoU formula is expressed as:

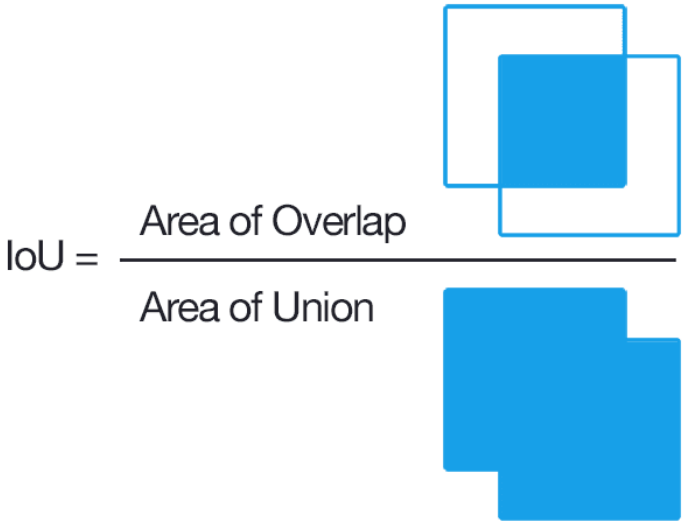

Figure 6 – IoU [17]

This value shows how much the predicted bounding box overlaps with the actual bounding box. A higher IoU score means the model's prediction is more accurate in locating the object.

https://medium.com/@henriquevedoveli/metrics-matter-a-deep-dive-into-object-detection-evaluation-ef01385ec62

Literature Review

91 application

3 Literature Review

In this chapter, we will provide related research and studies on the field of Automatic Number Plate Recognition (ANPR) and a traffic density estimation using convolutional neural networks (CNNs) and computer vision techniques which is related to the use of computer vision in occupancy detection, and we will look over some competitors and a product analysis for them.

3.1 Related research

A detailed survey of relevant algorithms in the field of Automatic Number Plate Recognition (ANPR) conducted and summarized the findings of a study by Laroca, Severo, and 5 others [18]. The study outlined a comprehensive procedure that encompassed object detection using YOLO Detector, character segmentation through Convolutional Neural Networks (CNNs) aided by bounding boxes, and recognition incorporating data augmentation and distant CNNs for letters and digits. Performance metrics revealed high accuracy rates for individual steps of the ANPR process, with the overall recognition rate ranging from 78.33% to 93.53% across two datasets—SSIG and UFPR-ALPR. Notably, the ANPR system was tailored to Brazilian license plate formats, warranting adjustments for other layouts. This data provided valuable insights into the efficacy of the ANPR system, with potential applicability to similar projects focusing on Brazilian license plates. However, adaptability considerations were crucial when addressing different license plate formats or regions.

In this study [19], three modules were developed for traffic density estimation using convolutional neural networks (CNNs) and computer vision techniques. The first module segmented input traffic video clips, eliminating similar adjacent frames. The second module, employing the OpenCV library and image segmentation algorithm, removed non-vehicle objects from traffic images. The third module estimated traffic density based on the output image from the second module. The dataset used consisted of 253 highway traffic video clips with varying traffic densities and weather conditions. It was divided into training and testing datasets, with a 5-fold cross-validation system. The proposed model achieved an overall average correct classification rate of 98.66%. Compared with a previous model, it demonstrated more even traffic density estimation rates and outperformed in the "Medium" and "Heavy" traffic categories. The study showcased the potential of the proposed model for

stable traffic density estimation and highlighted future avenues for improvement and evaluation with different traffic scenarios and environments.

3.2 Competitive product analysis

- **Fuelly:** a mobile application to track vehicles fuel economy using gas mileage calculations and set service reminders for the vehicle [20].
- **PetroApp:** a mobile application that finds gas stations, lists the amenities in the gas station, track fuel consumption and set car services and insurance reminders [21].
- **Sasco:** a mobile application that finds Sasco stations, lists amenities in the gas stations and enables users to order gas deliveries [22].
- **Petrol stations:** a mobile application that locates gas stations, lists the amenities in gas stations and provides the gas station's contact information [23].

Table 1 - Competitive product analysis.

Feature	Fuelly	PetroApp	Sasco	Petrol stations	91
Gas stations' location		√	√	√	√
Fuel availability					√
Fuel types		√			√
Occupancy					√
Fuel consumption	√	√			√
Gas station amenities information		√		√	√
Ordering fuel deliveries			√		
Promotions			√		√
Car services and insurance reminders	√	√			
Gas Station's phone number				√	

3.3 Findings

As seen above, 91 provides the gas stations' locations like many of its competitors, such as: petroApp, Sasco and petrol stations. It also calculates fuel consumption like Fuelly and petroApp, as for the fuel types that the gas stations carry, only 91 and petroApp provide such information. And while 91 doesn't enable users to order fuel deliveries like Sasco or provide Car services and insurance reminders like Fuelly and petroApp, it does provide fuel availability information and utilize computer vision to provide real time occupancy information which is where it differs from its competitors.

System Design and Development

91 application

4 System Design and Development

4.1 Methodology

Agile methodology is a flexible and iterative approach to software development that emphasizes collaboration, adaptability, and customer feedback [24]. Rather than following a rigid plan, Agile teams work in short cycles, or "sprints," to deliver incremental improvements to the software [24]. This allows for quicker response to change and ensures that the product evolves in alignment with customer needs.

The Scrum framework, a cornerstone of Agile methodology, structures our software development process into iterative cycles, or sprints, fostering adaptability and collaboration [25]. Within this framework, roles, events, and artifacts work in harmony to drive progress [25]. Key roles include the Product Owner Afnan, responsible for articulating stakeholder needs and prioritizing tasks, the Scrum Master Dr. Hailah Alballaa, who facilitates the Scrum process and supports the team, and the Development Team, a self-organizing group responsible for delivering increments of work. Events such as Sprint Planning, Daily Standups, Sprint Reviews, and Retrospectives provide cadence to our work, ensuring alignment and continuous improvement. The Product Backlog serves as a dynamic repository of tasks, prioritized by the Product Owner, while the Sprint Backlog outlines the specific goals for each sprint [26]. Ultimately, the Increment represents the tangible outcome of each sprint, embodying the progress made and delivering value to stakeholders [25]. This structured approach empowers our team to respond to change efficiently, collaborate effectively, and deliver high-quality software iteratively.

In our Agile principles in practice, we emphasize weekly meetings with the supervisor to ensure alignment with project goals and receive timely feedback. Within our student group, we hold iterative meetings to discuss progress, address any challenges, and refine our approach. By delivering working software frequently, we keep stakeholders engaged and ensure that our product evolves in line with their needs. Prioritizing customer collaboration, we actively seek feedback and integrate it into our development process promptly. Through regular reflection, we identify areas for improvement and make adjustments to enhance our effectiveness continuously.

Jira served as our primary project management tool, facilitating sprint planning, backlog management, and task tracking. It allowed us to visualize our workflow, assign tasks, and

monitor progress throughout each sprint. GitHub provided version control and collaboration tools for our development team. We utilized Git repositories for code management, issue tracking, and code reviews, enabling seamless collaboration and ensuring code quality. By integrating these tools into our Agile workflow, we maintained transparency, efficiency, and collaboration throughout the software development process.

4.2 System Requirements

The system requirements were selected mainly based on the user needs, which were discovered by conducting interviews and administering questionnaires. Similar systems were also analyzed in the early stages of this project to gather information about user needs and the market.

4.2.1 System Users

91 is a cross platform application designed to serve users of age 18 and above, who either drive cars or employee drivers but still need the services 91 provides. Users should have an intermediate level of education and have basic skills in using mobile phones.

To facilitate all the services 91 there are 3 different types of users other than the main user described above, which are:

- Admin: The admin is responsible for approving the gas station's registration and can monitor the system's performance. The admin's education level should be at least intermediate, and they should have the basic skills of using desktop devices.
- Branch manager: A branch manager is responsible for registering the gas station, adding all the necessary information (fuel types, fuel availability etc..) and keeping this information updated. The branch manager's education level should be at least intermediate, and they should have the basic skills of using desktop devices.
- Station's employee: A station's employee is responsible for reporting the user's bill by either scanning the QR code or using the user's car registration plate. The station's employees' education level should be at least intermediate, and they should have the basic skills of using mobile phones.

4.2.2 Requirements Elicitation and Analysis

The methods used in the requirements elicitation of 91 were both interviews (see Appendix A) and questionnaires (see Appendix B).

The interviews were one on one interviews with different stakeholders to understand their needs, preferences, and expectations. And during the interviews, participants mentioned that having real-time occupancy information for gas stations was highly valued, as it enables them to refuel more efficiently. Participants also emphasized the importance of accessing information about the amenities offered by gas stations and the fuel availability. The topic of fuel consumption was also discussed, and all participants agreed that having insights into their fuel usage would assist them in budgeting effectively. And when interviewing station managers, they explained how they usually schedule refills, but those refills would be delayed sometimes due to many reasons which may result in not serving customers due to the station running out of gas. They also mentioned that 91 would be beneficial because it would facilitate clear communication between gas stations and their customers and that they would like to participate in it if they have the chance in the future. We also discussed using cameras or setting up cameras and they said that it probably would not cause any problems, they also informed us that managers usually use desktops for work related to the gas station so a website might be the way to go but they also clarified that a mobile phone would be good as well.

We also prepared a questionnaire targeting a wider audience to gather quantitative data on preferences and requirements, to which we got 51 replies. Most of the participants were young and females, and the percentage of drivers was higher than others. most of the participants highlighted the importance of occupancy detection as a main feature because 13% of participants have arrived at a gas station only to find it crowded at least once a month whereas 33.3% experienced that at least 2 times a week. According to participants, the crowding causes delays in their plans and work on that day, and the majority do not use Google Maps to check for crowding. There was a percentage that could not be overlooked who did not monitor the car’s fuel expenses, which led to adding that feature to our application to try to address that situation. When we asked the question: What would be the benefit to you if we provided you with monthly statistics for your fuel expenses? The dominant answer was that it would help users with their budget and make them more aware of their fuel consumption and costs. Participants also highlighted the importance of reporting fuel type availability, which encouraged us to include this feature as well. Also, 70% of the participants encouraged the

addition of promotions and discounts and reinforced that in the comments as well. To collect more requirements commenting on any additional ideas was allowed and we received multiple requests regarding showing gas stations' amenities, types of cards accepted (vis, mada etc…), and diesel availability.

The process of conducting interviews and developing a questionnaire has proven to be immensely beneficial in our project. It has allowed us to gain deep insights into our users' needs and preferences, enabling us to create an application that is not only effective but also highly useful for our community.

4.2.3 User Interactions

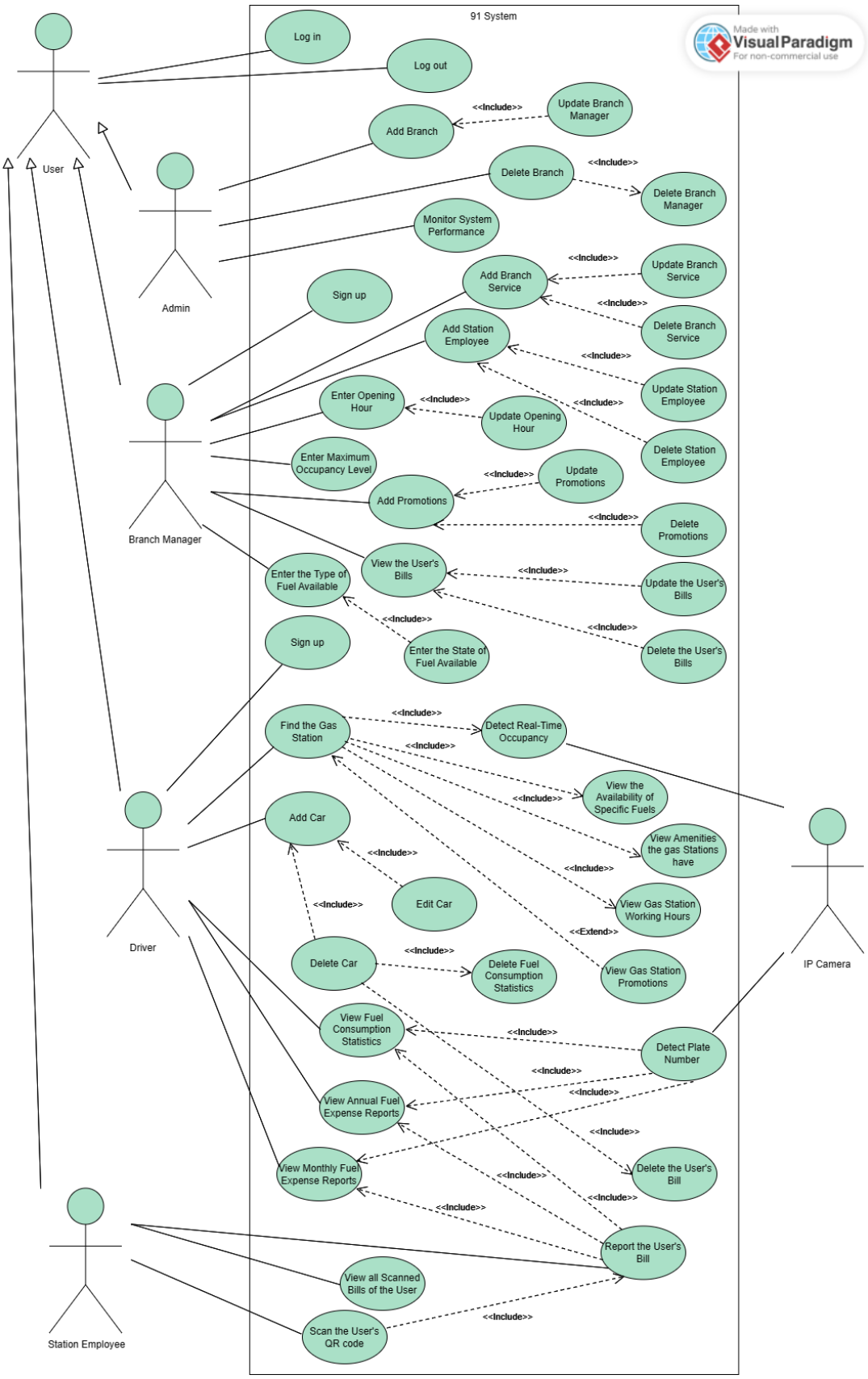

Figure 7- Use case diagram.

4.2.4 Roadmap and Product Backlog

In this section, we will present the roadmap for the 91 application, as depicted in figure 8. A product roadmap is best described as a depiction of the incremental process by which a product will be developed and delivered over time [27]. Sprint 01 prioritizes user authentication and fundamental station functionalities, encompassing login/signup processes for users and branch managers, find gas station, fuel type and availability, working hours management, and station registration. Sprint 02 extends the platform's capabilities by incorporating employee management functionalities, fuel consumption insights, expense tracking, and car management features. Sprint 03 introduces real-time occupancy detection, plate number detection, streamlined billing processes via QR code generation and scanning, and comprehensive user billing management. Sprint 04 enhances the user experience by providing access to station amenities, promotions, and enabling branch managers to manage services and promotions effectively. Finally, Sprint 05 culminates in administrative functionalities, including admin authentication, branch management, and system optimization measures to ensure robust performance and scalability. This roadmap emphasizes a systematic and iterative approach towards building a comprehensive and user-centric gas station management application.

- Roadmap

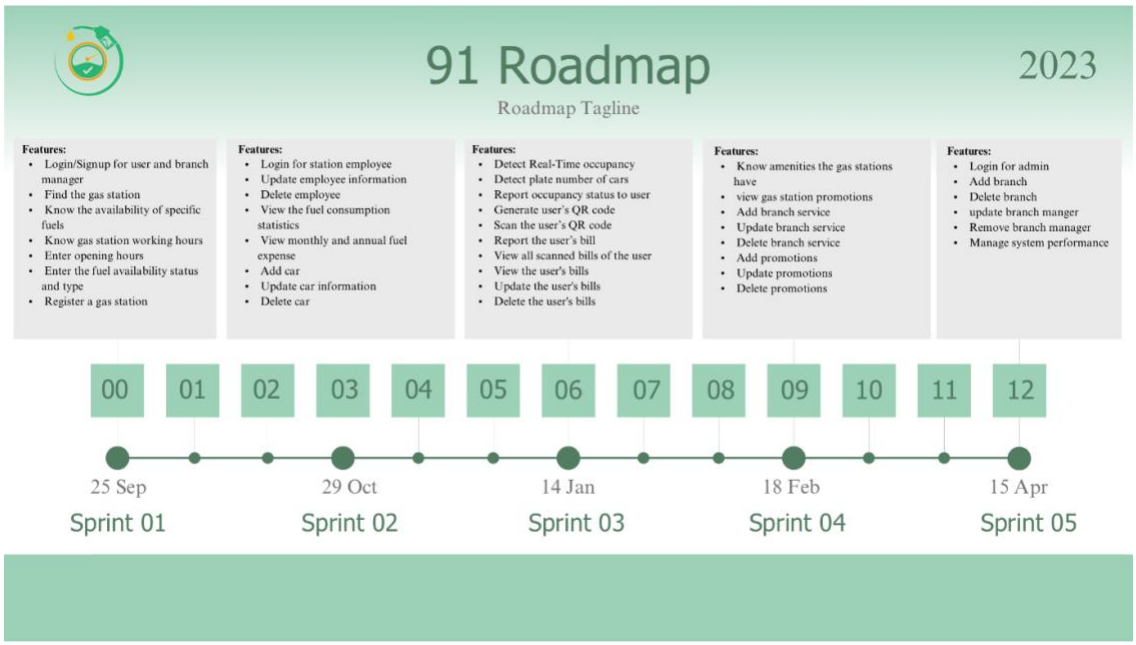

Figure 8- 91 roadmap.

- Product backlog

Table 2- 91 Product backlog

ID	PBIs (User Stories)	Size	Type (Feature, defect, technical work, knowledge acquisition)	Status (To do, in progress, or Done)	Acceptance Criteria The conditions of satisfaction that must be met for that item to be accepted.
1	As a new unregistered driver, I want to be able to create a new account so that I can access and utilize the application and use its features.	1	Feature	Done	As a new unregistered driver, I will select 'USER' on the welcome page and then click on the 'Sign Up' button to go to the sign-up user page. From there, I will enter my name, email, and password, ensuring

					that each input adheres to the correct validation criteria. Finally, I will click on the 'Sign Up' button to complete the registration process and gain access to the app using my email and password.
2	As a registered driver, I want to be able to log in to my account so that I can get my privileges.	1	Feature	Done	As a registered driver, I will select 'USER' on the welcome page and proceed to enter my email and password on the login user page, ensuring that each input matches the email and password I registered previously. I will then click on the 'Log In' button to access my privileges and utilize the features of the app.
3	As a driver, I want to be able to find gas stations easily so that I can choose the most suitable one for my needs, ensuring I can continue my journey without the worry of running out of fuel.	3	Feature	Done	As a driver, if I'm logged in, I should be able to find gas stations by tapping the 'Station' button on the app. This action will take me to the 'Station' page, where I can view all the

					available gas stations listed in the app.
4	As a driver, I want to be able to know the availability of specific fuels in gas stations so that I can go to stations with the available fuel.	2	Feature	Done	As a driver, if I'm logged in, I should be able to check the available fuel types at a gas station. By tapping on any station on the 'Station' page, I will navigate to the details page for that station, allowing me to see the different available fuel types.
5	As a driver, I want to know the gas station’s working hours so that I can plan my refueling stops.	2	Feature	Done	As a driver, if I'm logged in, I should be able to view the working hours of a gas station. By tapping the 'Station' button to navigate to the station page, I can then click on any available station to access its details. This will allow me to see the opening and closing hours of the selected station.
6	As a new branch manager, I want to be able to register an account so that I can apply and manage my station.	1	Feature	Done	As a new branch manager, when opening the website, I should be able to register an account in sign up page

					by providing my name, email, and my password. After entering this information, I will click the 'Sign Up' button to complete the registration process.
7	As a new branch manager, I want to be able to register my station so that it can be added to the 91 app.	1	Feature	Done	As a new branch manager, when opening the website, I should be able to register my station after signing up, through the station registration page by providing my base station information, my station name, and my station location. Then I will click the 'Register' button to complete the registration process and send a request to the 91 app to add my station to it.
8	As a registered branch manager, I want to be able to log in to my account so that I can get my privileges.	1	Feature	Done	As a registered branch manager, upon opening the website, I should be able to log into my existing account. I will enter my email and password. Afterward, I will click on the 'Log In'

					button to access my privileges and utilize the features of the website.
9	As a branch manager, I want to be able to enter the opening/closing hours of the gas station so that the driver can know about it.	2	Feature	Done	As a branch manager, when logged in, I should be able to enter the opening/closing hours of the gas station. This will be done while I am updating or editing the information for my station.
10	As a branch manager, I want to be able to enter the availability of specific fuel types so that drivers easily locate stations with the desired fuels for their cars.	2	Feature	Done	As a branch manager, when logged in, I should be able to enter the availability of specific fuel types. Initially, I will provide information about the types of fuel offered at my station. Subsequently, I will update the availability of these fuel types, ensuring that the data is up to date for users in their app.
11	As a branch manager, I want to be able to register a new account for my station employee. So that they can access their roles efficiently.	1	Feature	Done	As a branch manager, I will select ‘Add’ button in the list of my employee and enter his name, his email and his password then click on

					Register button to add them in Collection Station Employee.
12	As a branch manager, I want to be able to update the information of an existing employee so that their records remain accurate and up to date.	2	Feature	Done	As a branch manager, I can easily update my station employee's info. I just click the 'edit' icon in list employee t, make the changes, and click on 'Update' button to update his information.
13	As a branch manager, I want to delete employees so that I can manage the team efficiently and keep records current.	1	feature	Done	As a branch manager, I can easily delete station employees by clicking the 'Delete' icon in the employee list and confirming my intention to delete the selected employee. After clicking 'OK,' the system will remove the employee from both the employee list and the Station Employee collection. The terminated employee will be notified if they attempt to log in to their account.

14	As a registered station’s employee, I want to be able to log in to my account so that I can access my privileges.	1	Feature	Done	As a registered station employee, I will select 'Employee' on the welcome page and proceed to enter my email and password on the login user page, ensuring that each input matches the email and password I registered previously. I will then click on the 'Log In' button to access my privileges and utilize the features of the app.
15	As a driver, I want to be able to view my fuel consumption statistics so that I can track and manage my car's efficiency.	3	Feature	Done	As a driver, if I'm logged in, I should be able to track my fuel consumption by adding my car then each time I refuel my car, a bill will be saved in the app. By summing up the total cost from these bills, I can easily monitor and assess whether my fuel consumption is within a normal level or not.
16	As a driver, I want to be able to view monthly and annual fuel expenses so that I can better manage my	3	Feature	Done	As a driver, when logged in, I should be able to view my monthly and annual fuel

	budget and track my fuel spending.				expenses through a bar diagram displayed on the home page. This visual representation will provide a clear overview of my fuel expenses over time.
17	As a driver, I want to add my car to the app so that I can benefit from features like fuel consumption reports and fuel expenses.	2	Feature	Done	As a driver, when logged in, I should be able to add my car by tapping on the 'Car' button in the bottom bar. From there, I can enter my car information, including its type, plate number, and other relevant details.
18	As a driver, I want to update my car information so that my car information remains accurate and up to date.	2	Feature	Done	As a driver, when logged in, I should be able to update my car by tapping on the 'Car' button in the bottom bar. From there, I select the car whose information I want to update by clicking on it and then apply and click on the edit button.
19	As a driver, I want to delete my car to ensure that the data provided to me remains relevant and up to date.	2	Feature	Done	As a driver, when logged in, I should be able to delete my car by tapping on the 'Car'

					button in the bottom bar. From there, I select the car I want to delete by clicking on the delete icon and then pressing the 'Delete' button in the confirmation message.
20	As a driver, I want to be able to check the occupancy status of gas stations so that I can plan my refueling stops efficiently and avoid long wait times.	4	Feature	Done	As a driver, when logged in, I should be able to check the occupancy status of gas stations by tapping on the 'Station' button in the bottom bar. This will allow me to see if the station is busy, moderately busy, or not busy.
21	When the computer vision model detects the number of cars in the station exceeds the maximum occupancy level, the station's crowd status will be marked as 'busy'.	4	Technical work	Done	As a system, if I'm detecting the number of cars at the station, I should be able to determine the station's crowd status by counting the cars entering. This involves comparing the count to the predefined occupancy levels for that station—whether it is less than, equal to, or more than the

					designated occupancy level.
22	When the computer vision model detects the plate number of cars in station, it will appear in station employee screen	4	Technical work	Done	As a system, if I'm detecting the plate number of cars inside gas station, I should be able to display this car in station employee screen if the car is registered in the app.
23	When the application detects a new user registration, it will generate a QR by using his information.	3	Technical work	Done	As a system, if I'm detecting a new user registration, I should be able to generate a QR code using the user's information, such as their car's plate number, to create a unique QR code for the user.
24	As a station employee, I want to be able to scan the driver's QR code so that I can report the bill to the driver.	2	Feature	Done	As a station employee, when logged in, I should be able to scan a driver's QR code each time they provide it to me after refueling their car in my station.
25	As a station employee, I want to be able to report the driver's bill so that it will be stored in the record.	2	Feature	Done	As a station employee, when logged in, I should be able to report the driver's bill after scanning their QR code following the refueling

					of their car. The reported bill will then be made available to the driver's account after the scanning process.
26	As a branch manager, I want to be able to add a maximum occupancy level in the station so that the computer vision model can detect maximum occupancy levels.	2	Feature	Done	As a branch manager, when logged in, I should be able to set the maximum occupancy level for the station. While entering the station information, I will specify the level of occupancy, indicating the maximum number of cars allowed in the station.
27	As a driver, I want to know the gas station amenities so that I can identify the station that fits my needs during stops.	2	Feature	Done	As a driver, when logged in, I should be able to know about the gas station amenities by tapping on the “gas station” button on the bottom bar. This will allow me to see what amenities are available at gas stations.
28	As a driver, I want to be able to view gas station promotions related to services offered at the station so that I can make	2	Feature	Done	As a driver, when I log in, I should be able to view gas station promotions. While on the gas station page, I

	informed decisions about where to refuel and take advantage of additional services.				will be able to see the promotions, indicating which gas station is in that promotion.
29	As a branch manager, I want to be able to add station services so that I can offer more options to our customers and better meet their changing needs.	2	Feature	Done	As a branch manager, when logged in, I should be able to add the station's services. When I update the station information, I will add the services, indicating the services provided by that station.
30	As a branch manager, I want to be able to update station services so that I can enhance the offerings available to our customers and meet their evolving needs.	2	Feature	Done	As a branch manager, when logged in, I should be able to update the station's services. When I update the station information, I will update the services, indicating the services provided by that station.
31	As a branch manager, I want to be able to delete branch services so that the drivers are informed about the changes in our offerings.	2	Feature	Done	As a branch manager, when logged in, I should be able to delete branch services. When I update the station information, I will delete the services, indicating which services are no longer offered by that station.

32	As a branch manager, I want to be able to add new promotions so that I can effectively market our station.	2	Feature	Done	As a branch manager, when logged in, I should be able to add new gas station promotions. This will be done when I enter the promotion information for my station on the Add Promotion page.
33	As a branch manager, I want to be able to update promotions so that I can enhance our station's offerings and effectively market it.	2	Feature	Done	As a branch manager, when logged in, I should be able to update gas station promotions. When I update the promotions information, I will update the promotions information, indicating that the information is accurate and up to date.
34	As a branch manager, I want to remove promotions so that I can keep our offers up to date for customers.	2	Feature	Done	As a branch manager, when logged in, I should be able to remove gas station promotions. When I update the promotions information, I will remove the promotions, indicating which promotions are no longer offered by that station.

35	As a branch manager, I want to view the bills of my gas station so that I can track expenses and ensure that our financial records are accurate.	2	Feature	Done	As a branch manager, when logged in, I should be able to view all bills reported at my station by my employees. While on the Bill page, I can view the ID of each bill. By clicking on a specific bill, I should be able to view all information related to it, such as fuel type, amount, and other relevant details.
36	As branch manager, I want to update bills of my gas station so that I can maintain an organized record of expenditures.	2	Feature	Done	As a branch manager, when logged in, I should be able to update all bills reported at my station by my employees. While on the Bill page, I can view the ID of each bill. By clicking on a specific bill, I should be able to access all information related to it and then I can click on the update icon to edit the details of the bill.
37	As branch manager, I want to delete bills of my gas station so that I can maintain	2	Feature	Done	As a branch manager, when logged in, I should be able to delete any

	a streamlined and organized record-keeping system, reducing confusion and improving efficiency in financial management.				bills reported at my station by my employees. While on the Bill page, I can view the ID of each bill. By clicking on a specific bill, I should be able to access all information related to it and then I can click on the delete icon to delete the bill.
38	As a station employee, I want to view all bills I've reported for other cars using the application so that I can ensure accurate records and provide reliable service.	2	Feature	Done	As a station employee, when I'm logged in, I should be able to view all bills I've reported using the app. While on the history bills page, I can see all bills along with some related details about each bill.
39	As a driver, I want to be able to view my bills in the app so that I can easily monitor my expenses and track my spending habits.	2	Feature	Done	As a user, when I'm logged in, I should be able to view all my bills. While on the bills page, I can see all bills along with some related details about each bill , like station name and amount.
40	As an admin, I want to be able to log in to my account	1	Feature	Done	As an admin, I will open the website, enter my email and password, and

	so that I can get my privileges.				then click on the 'Log In' button, then access my privileges and take advantage of the website features.
41	As an admin, I want to add new branches in the application so that I can increase the coverage area and options available to users.	3	Feature	Done	As an admin, when logged in, I should be able to add new branches in the app by clicking on the 'Requests' link in the header bar. From there, a list of all the branches that have sent requests to our app appears with their information. Then I select the branch and I will approve it by clicking the 'Add' button.
42	As an admin, I want to delete branches so that we can maintain an updated and organized branch list.	2	Feature	Done	As an admin, when logged in, I should be able to delete a branch by clicking the 'Branches' link in the header bar. From there, a list of all the branches present in our application is provided with their information. After selecting the branch, I click the

					'DELETE' button. Subsequently, the manager will be either reassigned to another existing branch or deleted permanently, and the branch employees will also be deleted permanently.
43	As an admin, I want to update the branch manager for an existing branch to ensure effective management and oversight of each branch's operations.	2	Feature	Done	As an admin, when logged in, I should be able to update a branch manager by clicking on the Branche i want to update it information. click the 'Update' button to modify its manager and his information.
44	As an admin, I want to be able to remove a branch manager from a gas station so that I can facilitate changes in branch leadership or organizational restructuring when necessary.	2	Feature	Done	As an admin, when logged in, I should be able to remove the branch manager by clicking on station that I want to remove the manager. and click the 'DELETE' button.
45	As an admin, I want to be able to access the dashboard related to system branches, so that I can ensure optimal operation and a positive user experience.	3	Feature	Done	As an admin, when logged in, I should be able to monitor a dashboard. From the home page, view statistics about the

					application and overall system performance.
46	As a user, I want the application to be accessible around the clock so that I can access it at any time that suits me.	3	Feature	Done	As a user, if I open the app, I expect 24/7 uninterrupted availability, with no planned downtime except for ongoing maintenance, ensuring continuous service.
47	As a user, I want a system that works reliably over time, so that I can depend on it for my daily tasks without interruptions.	3	Feature	Done	As a user, if I'm using the app, the app should consistently maintain reliability over time, demonstrating stability and uninterrupted functionality during regular use. Allowing users to perform their daily tasks smoothly without experiencing unexpected downtime or interruptions.
48	As a user, I want the application to show helpful error messages and handle unexpected errors smoothly so that I can easily understand and resolve issues.	3	Feature	Done	As a user, if I'm using the app, the app should display clear, informative error messages when an error occurs, guiding users on how to resolve or mitigate the issue. Error messages should be

					user-friendly, concise, and specific.
49	As a user, I want the interface to be user-friendly and accessible, so that I can use the application easily, no matter what my familiarity level or accessibility needs.	3	Feature	Done	As a user, if I'm using the app, the app should prioritize ease of use and accessibility, meeting the needs of users with different levels of familiarity with the application. Users should be able to interact with the application effortlessly, regardless of their prior experience or technical expertise.

4.3 System Design

4.3.1 Architectural Diagram

91 is designed using the MVC (stands for model-view-controller) architecture model, this model separates the application into three components [28]:

1. Model: It is the part that deals with data and processing it. This part can be used across multiple views.
2. View: This part is majorly associated with the User Interface (UI), and it is used to provide the visual representation of the model's data.
3. Controller: It acts as intermediary between the model and the view. This part can be used with different views.

The model gets input from IP cameras as streamed videos then process it and store the results in the database, then when the view needs the data, the controller will request it from the model and then will forward it to the view. Other inputs can come from the view and the

controller will pass to the model that will be stored in the database. The reason for using this architecture is that it provides clear separation of components which makes it easier to develop and manage the code, it will also provide code reusability. Both reasons are good for cross-platform development.

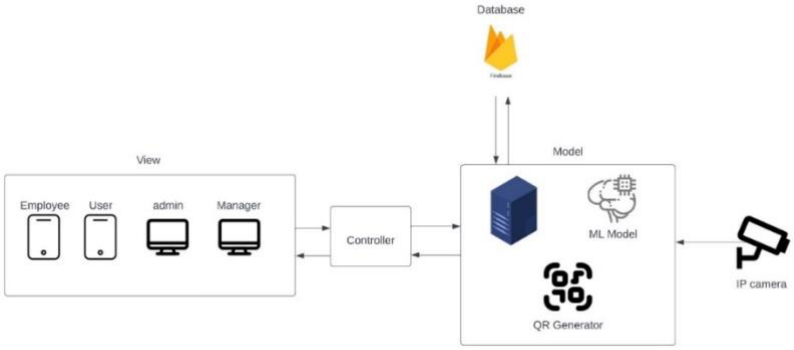

Figure 9- Architectural diagram.

4.3.2 Class Diagram /DFD

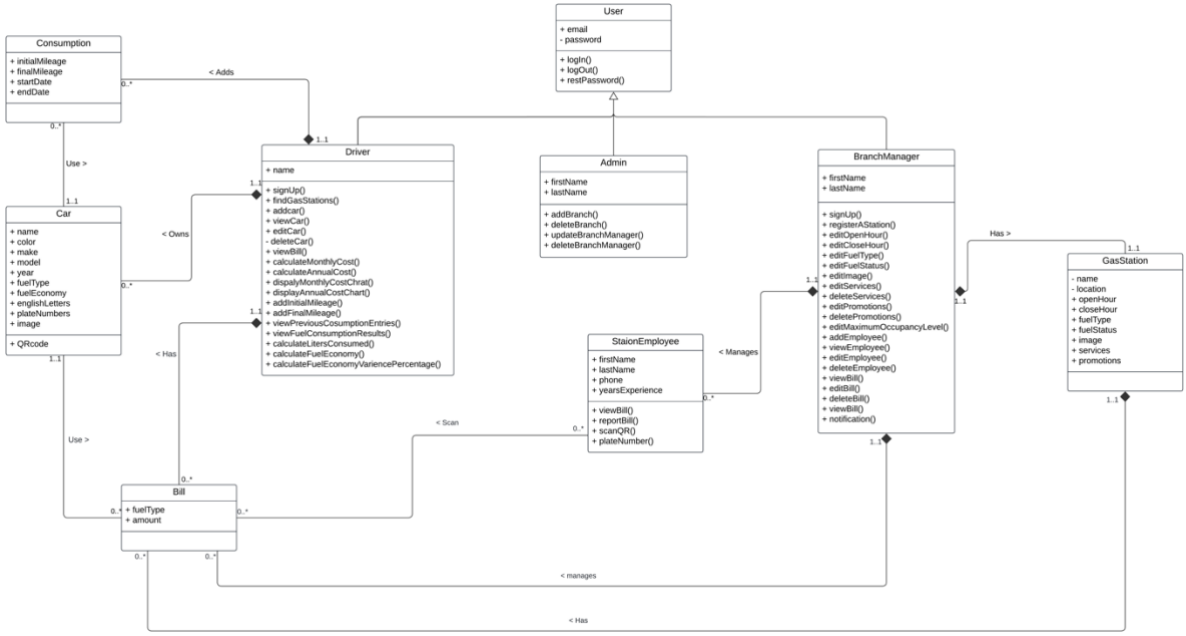

Figure 10- class diagram.

4.3.3 Component Level Design

This section presents a comprehensive design outline for three key features that 91 application provides. Utilizing the flowchart approach to delineate these processes and functionalities. The flowchart method is chosen for its clarity and efficiency in conveying complex procedures. It serves as an effective tool for visually breaking down the main components of the system. It aids in easy comprehension and efficient implementation, making it an ideal choice for detailing processes in a user-centric system.

- Fuel Consumption

In figure 11, the flowchart begins with the user selecting a car and entering mileage data. It then implicitly calculates liters consumed and determines fuel economy, culminating in a display of the results. This visual representation simplifies the understanding of the fuel tracking process.

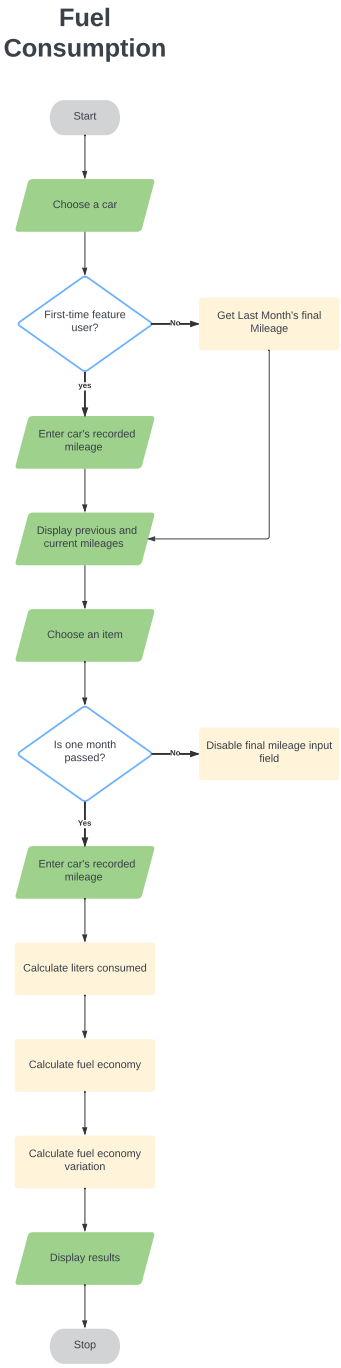

Figure 11- Fuel consumption flowchart.

- Adding a car

In figure 12, the flowchart methodically presents the steps for adding a new car to the system. Starting from entering car details to the submission and display of the vehicle data, the flowchart ensures a user-friendly process, enhancing data management and organization.

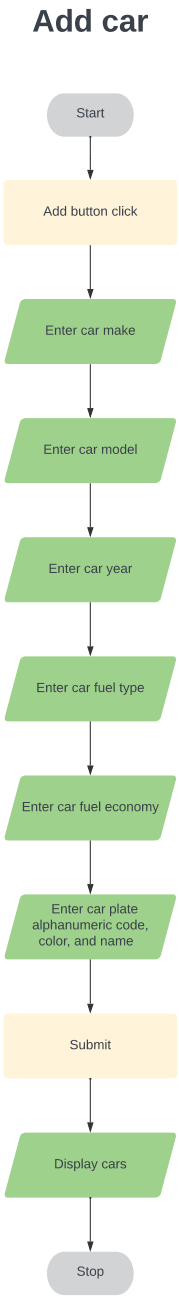

Figure 12- Adding car flowchart.

- Stations' fuel availability

In figure 13, the flowchart here provides a step-by-step guide to checking and updating fuel station availability. It visually represents the process of accessing station information, ensuring that users can easily navigate through the system to find the necessary details.

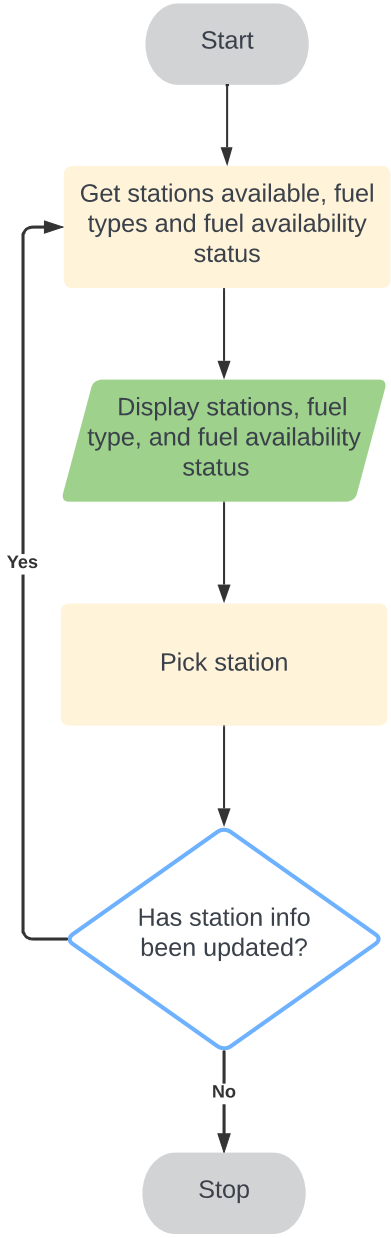

Figure 13- Fuel availability flowchart.

- License Plate Number Recognition

Figure 14 illustrates the process of the license plate recognition system. Initially, a frame from a video is sent to the YOLOv8 model [29], which generates bounding boxes for cars. The image within these bounding boxes is then cropped and fed into a plate position detection model, also trained using YOLOv8. This model identifies the exact positions of the license plates and outputs new bounding boxes. The areas within these new bounding boxes are cropped again, and this cropped image is used to extract the plate numbers [30], resulting in the final output.

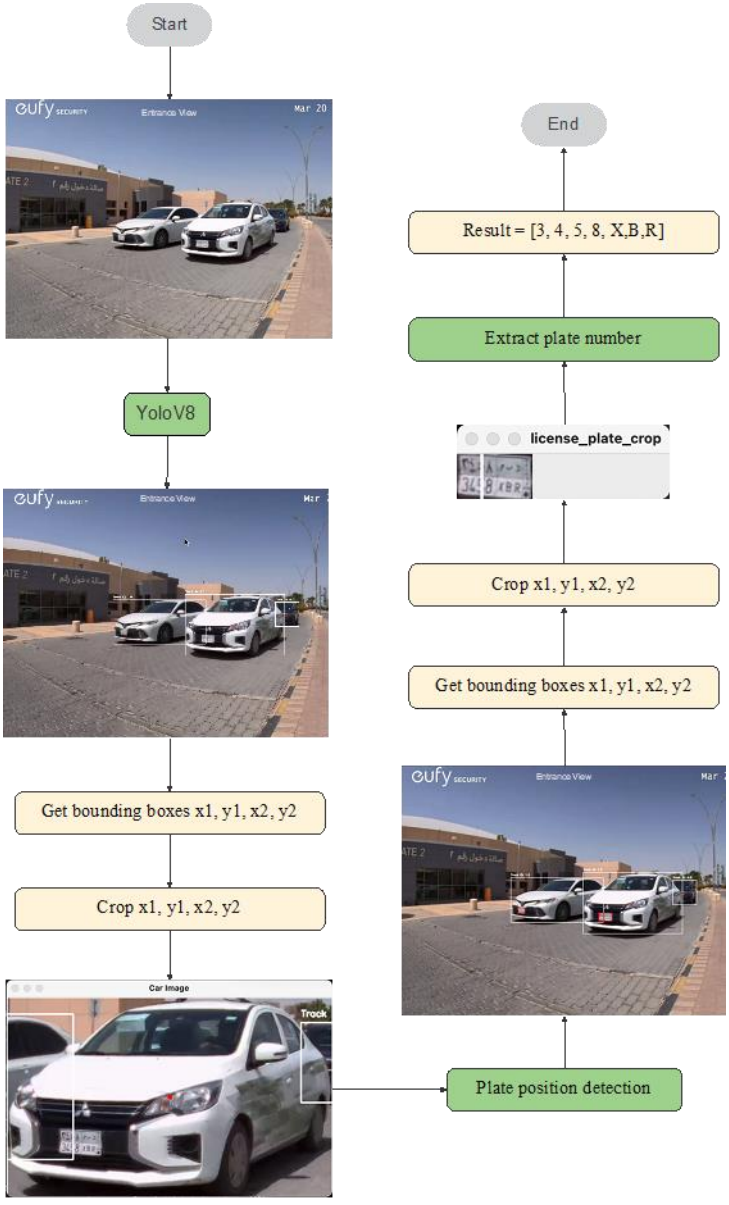

Figure 14- Proposed model structure.

- Occupancy level estimation

Figure 15 illustrates the process of estimating the occupancy level at the fuel station, which begins by loading the necessary libraries and the YOLOv8 model [29]. Video is captured in real-time or from a stored file, and each frame is resized for optimal processing. The YOLOv8 model then detects cars within the predefined entry and exit areas in the frames. As cars pass through these areas, the system counts each entry and exit, updating a counter accordingly. This count, along with other relevant data extracted from the video, is then used to update a database. The process continues this cycle, providing accurate estimates of the occupancy level at the station by tracking the number of cars entering and exiting the designated areas.

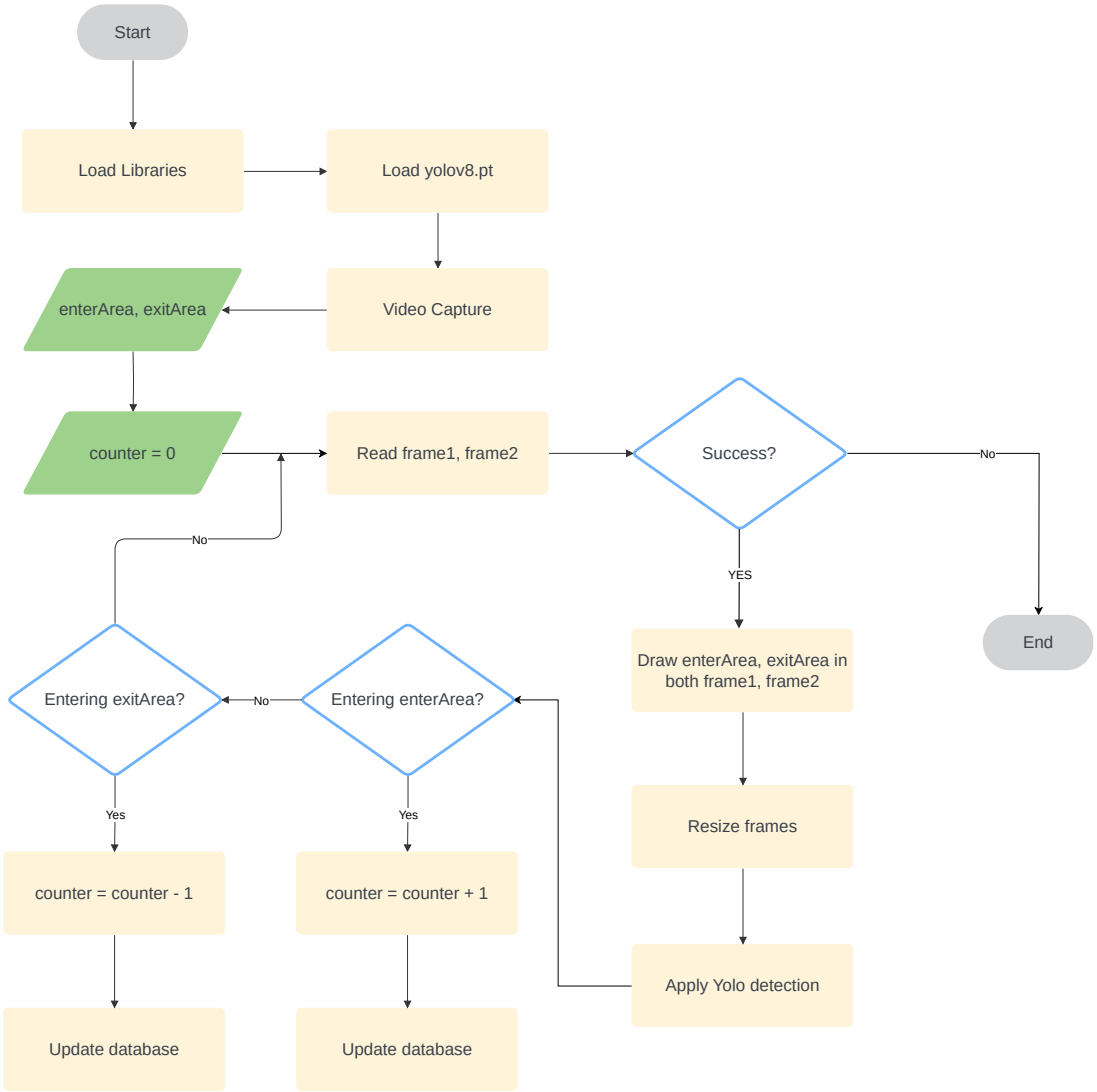

Figure 15- Occupancy level estimation flowchart.

4.4 Data Design

4.4.1 Data Models

- ER diagram.

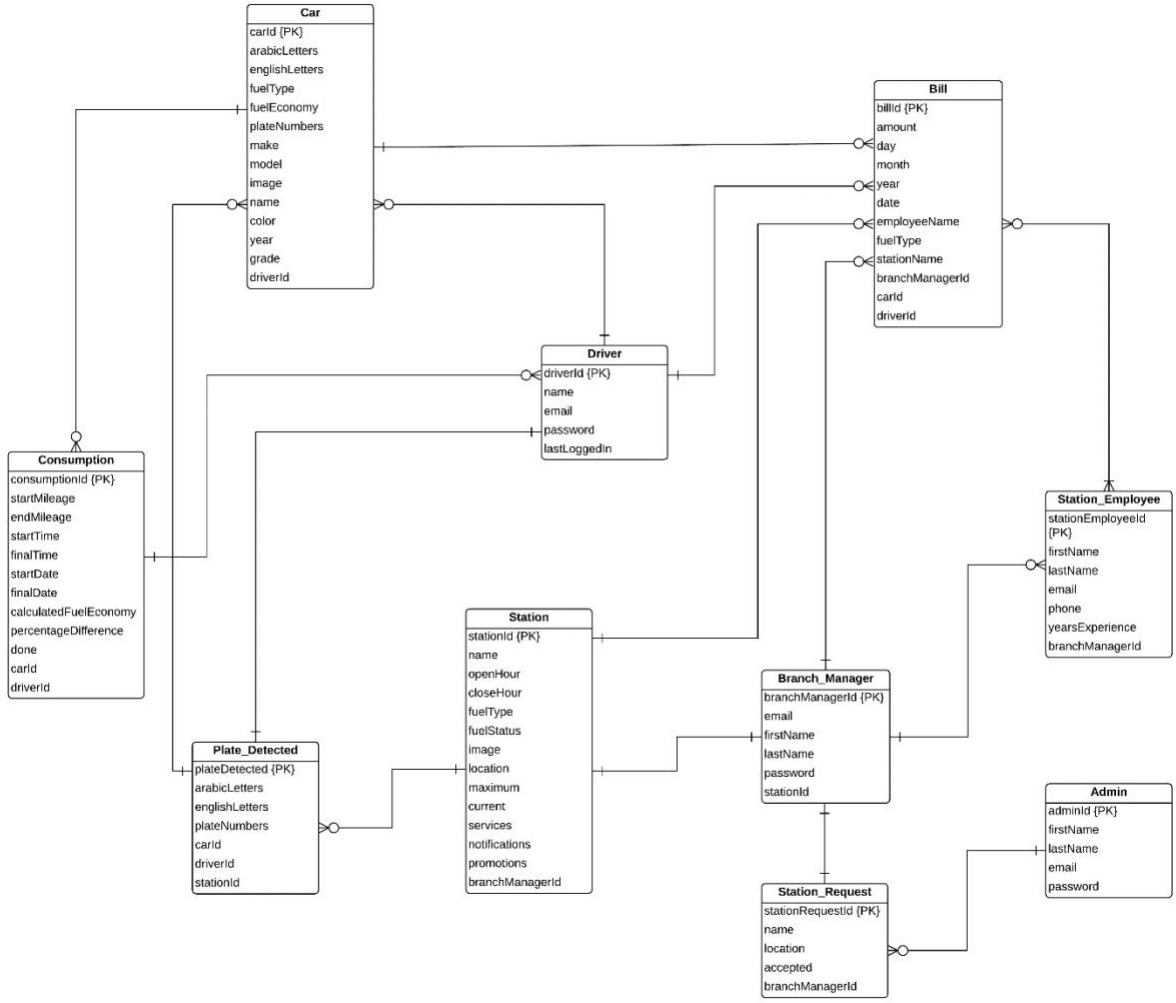

Figure 16- ER diagram.

- Non-relational data model

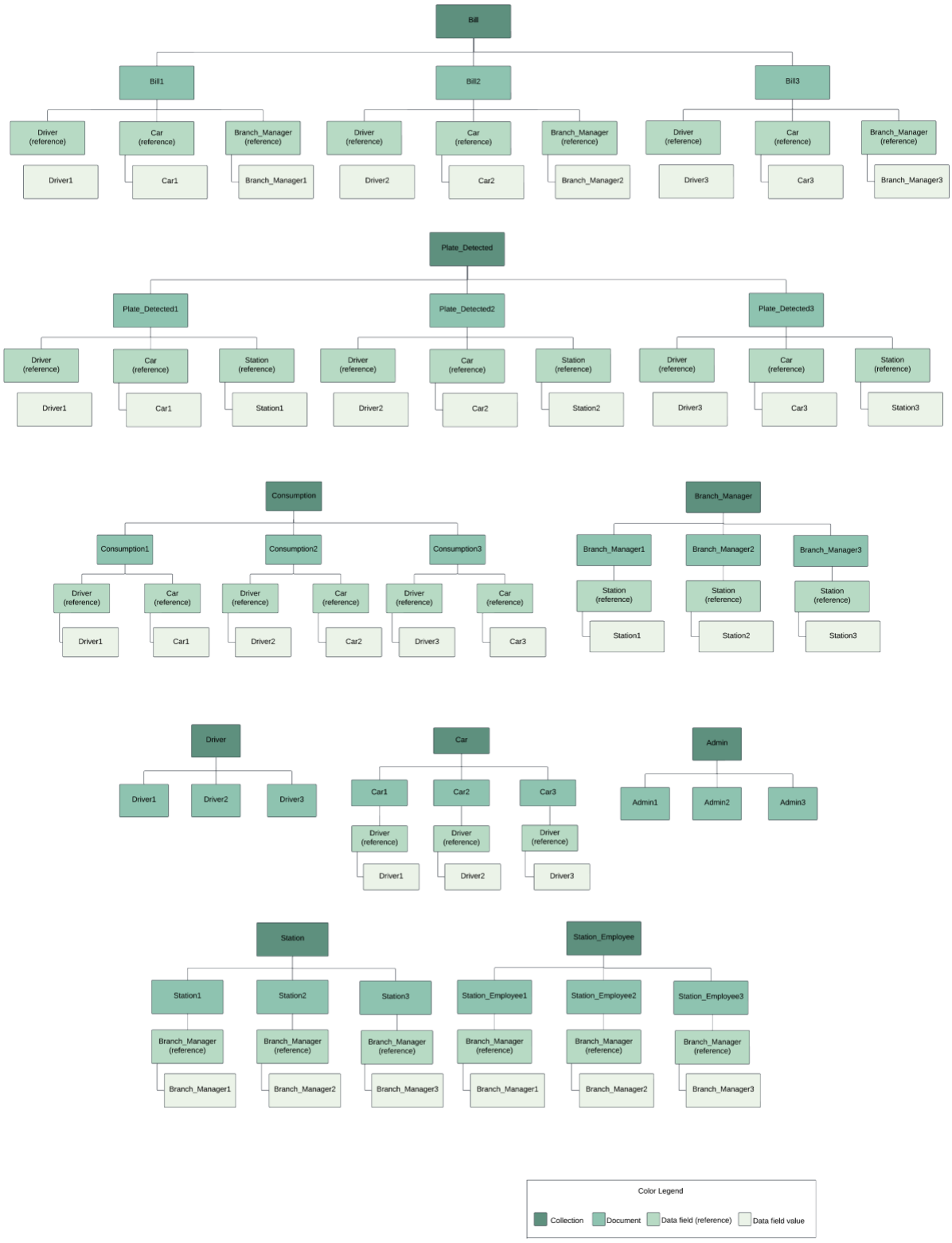

Figure 17- non-relational data model.

4.4.2 Data Collection and Preparation

- Car and Consumption Dataset by SASO

SASO (Saudi Arabian Standards, Metrology, and Quality Organization) [31] is a Saudi Arabian government agency responsible for developing and enforcing national standards, metrology, and quality systems across various industries. Its primary focus is to ensure the safety, quality, and conformity of products circulating within the Saudi market, as well as to promote consumer protection. SASO establishes technical regulations, sets standards, conducts product testing, and provides certifications to guarantee compliance with established requirements. Through its efforts, SASO aims to enhance the quality of products, safeguard public health, and facilitate fair trade practices in Saudi Arabia.

Derived from the Saudi Arabian Standards, Metrology, and Quality Organization (SASO), the Vehicle Fuel Economy Dataset encompasses various vehicle details, including model year, manufacturer, vehicle name, fuel economy, grade, and fuel type. Specifically centered around fuel economy ratings for different vehicles, this dataset offers comprehensive insights into automotive efficiency. Represented in tabular form Table 3, this dataset contains a snippet comprising 13,352 rows of information sourced from SASO. It offers a wide scope for analysis and exploration, serving as a robust resource for understanding and comparing fuel efficiency across diverse vehicles.

Below is an expanded description of each column in the data set:

Table 3- Description of each column in the SASO dataset

Column Name	Data Type	Description
ModelYear	Integer	The year of the car's model
Manufacturer	String	The company that produced the car
VehicleNameEn	String	The specific model of the vehicle
FuelEconomy	Float	Fuel efficiency of the car (e.g., kilometers per liter)
Grade	String	Rating or classification related to fuel economy
FuelTypeEn	String	The type of fuel used by the car

The table below presents a sample from the dataset:

Table 4- Sample from the SASO dataset.

ModelYear	Manufacturer	VehicleNameEn	FuelEconomy	Grade	FuelTypeEn
2015	Ford	F150	8.7	Very Poor	Gasoline
2016	CHTC MOTOR CO., LTD	C4E(HKL6480 A)	10.1	Poor	Gasoline
2016	Toyota	Land Cruiser Prado	10.5	Average	Gasoline
2016	Nissan	NP300	11.2	Good	Gasoline
2016	Ford	Ranger	12	Very Good	Diesel
2016	Subaru	Outback	12.1	Excellent	Gasoline
2019	Toyota	Hilux	14.6	Excellent+	Diesel

The dataset helps optimize data retrieval by allowing precise filtering and tailored presentation of specific car details based on user input. For instance, choosing a car make like BMW triggers a filtered display of BMW models, refining options for detailed information access, aligning closely with user preferences. Additionally, utilizing fuel type information enables the extraction of accurate liter prices. Moreover, the dataset's fuel economy values facilitate comparative analysis with real fuel consumption data. This comparison distinguishes between efficient and less efficient performance, providing valuable insights into a vehicle's fuel efficiency, and aiding users in evaluating performance in terms of fuel economy.

- License Plate Numbers Extraction Datasets

As part of the extract plate numbers model training process, a comprehensive dataset is essential for both training and testing the model's performance. In this context, The labeled dataset offers a collection of cropped images of KSA number plates as shown a sample in the figure 18, with annotations provided for the numbers and letters present on the plates [32].

The dataset comprises 593 images, each accompanied by a corresponding TXT file and XML file containing annotations. The classes are categorized into numbers from 0 to 9 and a subset of letters comprising only the following characters: A, B, D, E, G, H, J, K, L, N, R, S,

T, U, V, X, and Z. These characters are assigned class labels accordingly, with numbers spanning from 0 to 9 and letters assigned class labels from 10 to 26. It's important to note that this dataset reflects the specific character set commonly found on Saudi Arabian number plates, where only a subset of letters is utilized. Each annotation provides details such as class labels, bounding box coordinates, and image filenames, facilitating the localization and recognition of license plate characters. The TXT files present annotations in a structured format with class IDs and normalized bounding box coordinates, while the XML files follow the PASCAL VOC format, including additional metadata such as image size and segmentation information. These annotations serve as crucial ground truth data for training and evaluating object detection models like YOLO, ensuring accurate localization and identification of characters on KSA number plates.

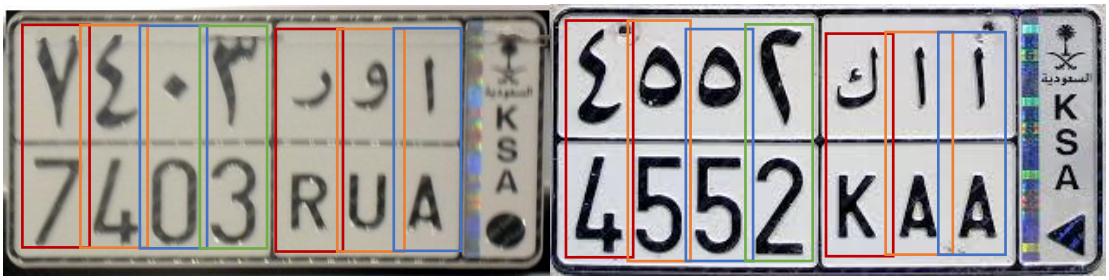

Figure 18- First dataset sample.

- License Plate Numbers Position Recognition Datasets

To complement the plate recognition model, another dataset has been found to train a model capable of recognizing the position of the license plate frame within a car. This dataset, sourced from Kaggle, includes images of KSA license plates as shown a sample in the figure 19, with annotations specifically outlining the plate frame's location [33].

The total training dataset consists of 339 images, each accompanied by a corresponding XML file containing detailed annotations. Unlike the previous dataset, this dataset focuses solely on annotating the plate frames, designated by a single class label (0). The sample annotation provided demonstrates the bounding box coordinates defining the plate frame's position within an image. As part of preprocessing, files without XML annotations were removed from the dataset. Additionally, to align with the requirements of the previous model, TXT files were generated for each image using a script to extract bounding box coordinates from the XML annotations. These preprocessing steps ensure the dataset's compatibility with

training and evaluate the model's ability to recognize license plate frame positions within car images.

Figure 19- Second dataset sample.

4.5 Interface Design

In this section, we will explore our web and app interfaces, each designed with user-friendliness in mind. Following UX guidelines we incorporated while designing the interfaces, we have crafted intuitive experiences for users as they navigate through both platforms. Let us delve into the thoughtful design choices that enhance usability, ensuring a seamless interaction for everyone.

4.5.1 Site maps

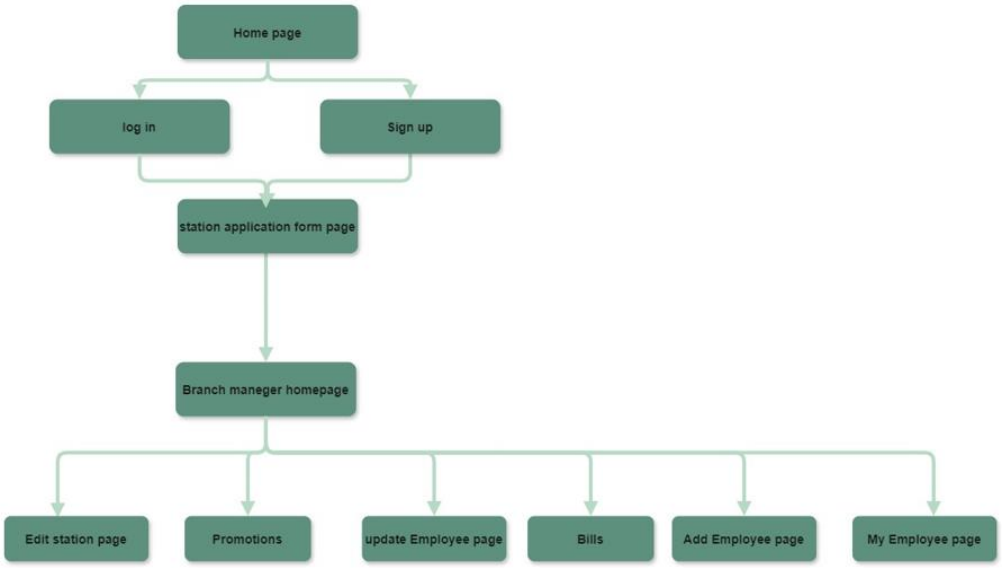

Figure 20- Branch manager website site map.

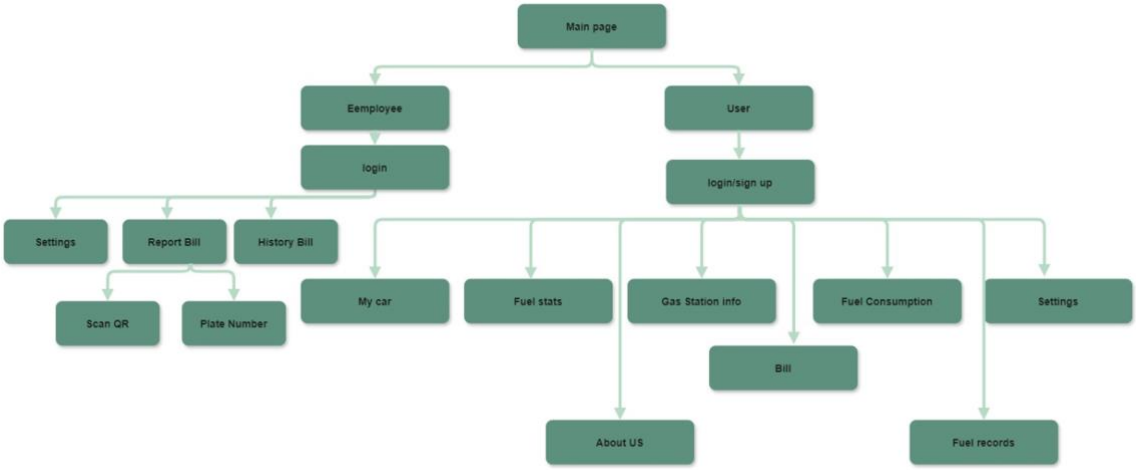

Figure 21- 91 Mobile application site map.

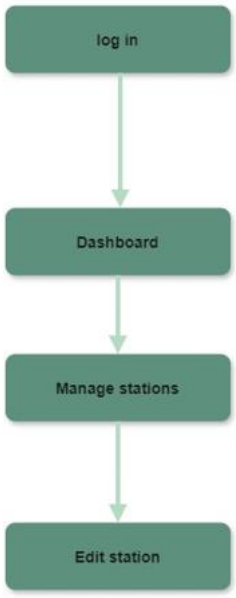

Figure 22- Admin website site map.

4.5.2 UX guidelines

1- Simplicity

In our application, we designed the interfaces to be as simple as possible, and we used simple and easy-to-understand language in the interface, instructions, and error messages. We avoided complicated terminology that could confuse users and avoided using too many colors or complex visual elements that could distract or overwhelm users.

2- Feedback

We place a strong emphasis on providing clear and intuitive feedback to enhance user experience. One of the key features we implement is the progress bar indicator. This visual tool appears whenever users engage in actions that require some processing time, such as login, signup, and calculation. This not only keeps users informed but also adds to their confidence in the application's responsiveness and reliability, the figures below show how progress indicators are used.

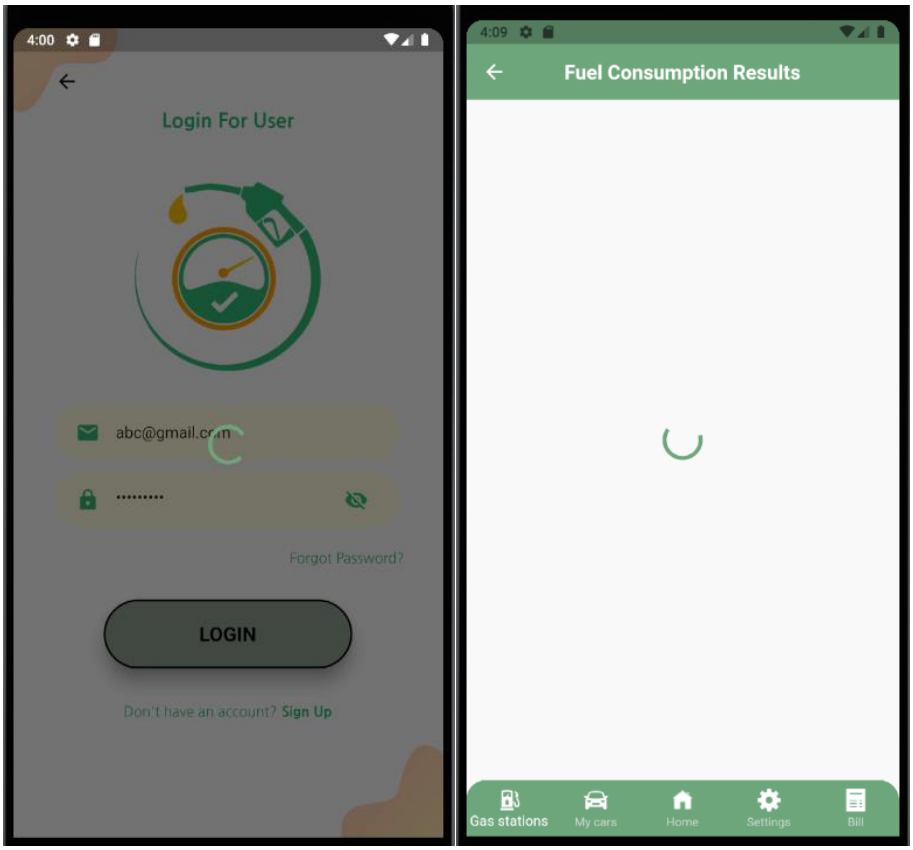

Figure 23- Feedback interface.

3- Error prevention

A major focus has been placed on error prevention. We've achieved this by implementing smart, user-friendly design elements. For example, the forms include validation that alerts users to errors, such as incorrect email formats or password strength issues. Additionally, helpful tooltips and contextual guidance are provided, assisting users in understanding what information is required and how it should be formatted. This proactive approach not only streamlines the user experience but also significantly reduces the likelihood of errors during data entry, ensuring smoother, more efficient interaction for our users.

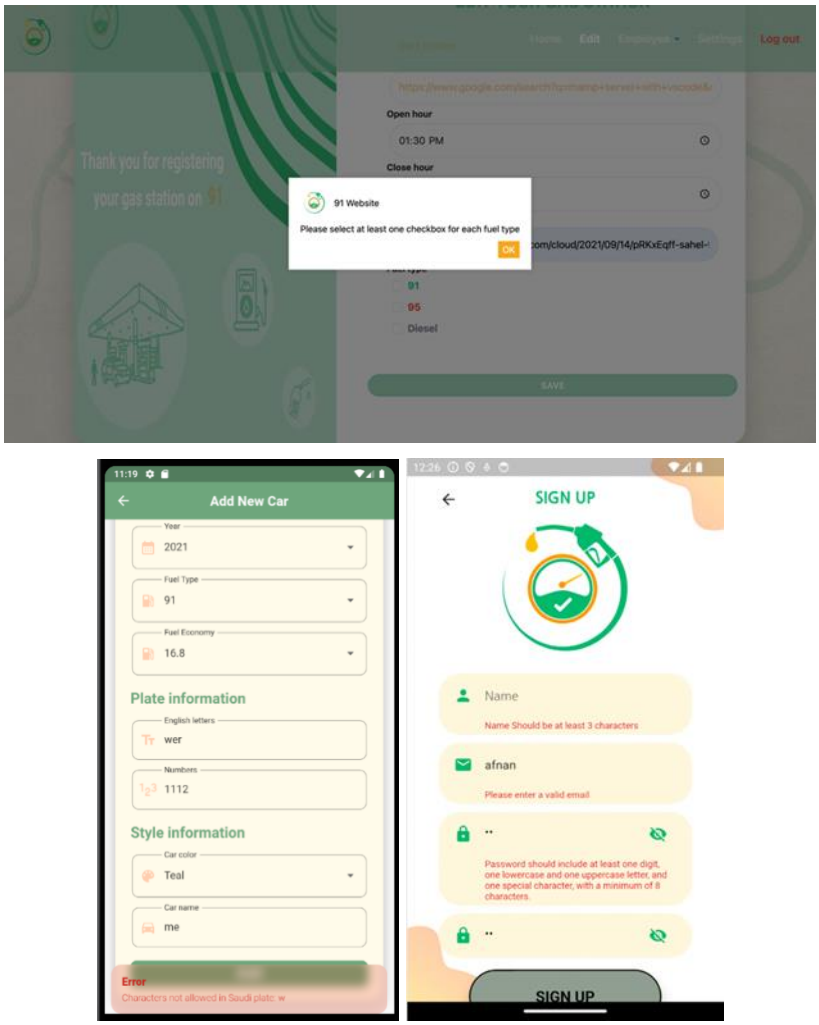

Figure 24- Error prevention interface.

4- Consistency

We prioritize consistency to create a seamless and intuitive user experience. This is evident in our design elements such as the app bar and bottom bar, which maintain a uniform style and functionality across all screens. By doing so, users enjoy a familiar navigation experience, regardless of where they are in the app. Additionally, we've carefully selected a consistent color palette that resonates throughout the application, reinforcing brand identity and aiding in the visual categorization of information. This cohesive use of colors not only enhances aesthetic appeal but also aids in intuitive understanding, as users quickly associate certain colors with specific types of actions or information.

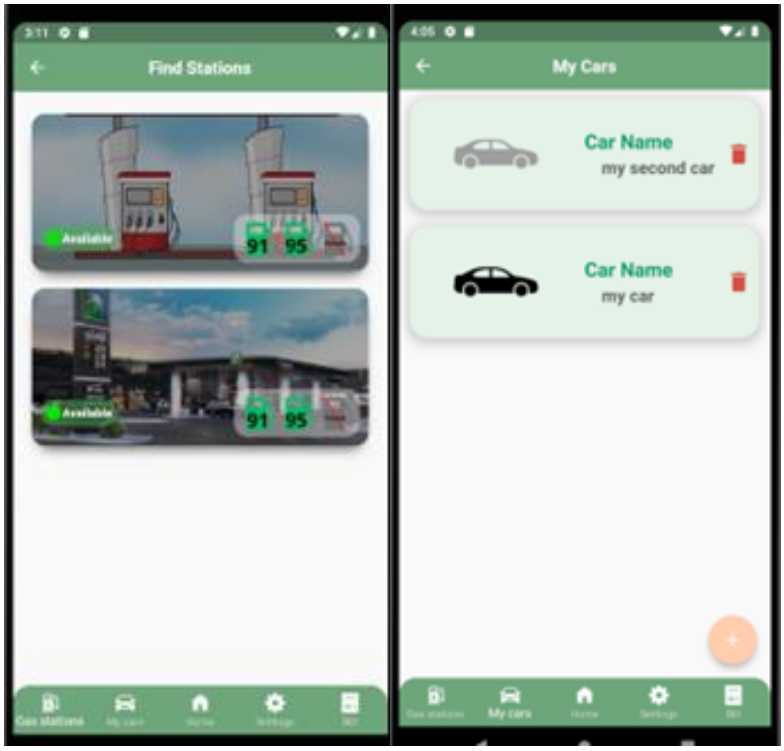

Figure 25- Consistency interface.

5- Familiarity

We understand the importance of familiarity in user experience. To this end, we have meticulously integrated familiar icons throughout the interface. These icons, recognized universally, a house for home, the bill icon for display bill or the gear for settings, help users navigate our app intuitively. This choice not only shortens the learning curve for new users but also provides a comfortable and efficient experience for returning users. By leveraging these widely understood symbols, we ensure that our users can focus on their tasks, rather than spending time deciphering unfamiliar icons.

Figure 26- Familiarity interface.

4.6 Implementation

4.6.1 91 Overview

91 is an Android application designed to help users locate gas stations, provide fuel availability information and real-time information on gas station occupancy. Additionally, the app tracks users' fuel consumption and costs. This system also contains a website for gas station branch managers to manage their station information, which is then displayed to users through the app. And an Admin website to manage applications and stations' information.

4.6.2 Development tools and technologies

For the mobile app development, we used the Dart language within the Flutter framework. And for the web development HTML, CSS, and JavaScript were used. YOLO was also used in the development of occupancy detection and car license plate recognition functions.

4.6.3 Challenges and solutions

In this subsection, we will explore the main challenges and solutions related to the implementation of 91.

1- Camera Integration with YOLO

During the development process, our team encountered several challenges. One of the initial challenges was choosing the right cameras that could be integrated with YOLO. To address this challenge, we conducted research and decided that any IP camera with RTSP would work [34]. We then searched for the easiest cameras to set up and the choice ended up being the eufy wireless cameras [35], which will be detailed further in this section. And even though we have reached out to the eufy development team to ensure the suitability of the camera we still encountered problems sitting up the RTSP. Because it needed some hardware device from a certain brand that does not have any points of sale in Saudi Arabia. We reached out again to eufy for alternatives, and consulted security camera experts with no luck. So, we took matters into our own hands and proceeded setting up without the hardware device and were able to configure the RTSP successfully.

2- Saudi Car License Plate Recognition

Another challenge involved using YOLO for Saudi car license plate recognition, and we addressed that by reviewing GitHub repositories (experiments and challenges) for different car license plate recognition and used a similar approach while dividing the process into multiple steps for easier development. One of these GitHub repositories was ksa_plate_numbers_yolov8_detection [30], it recognizes Saudi car plates but only in pictures where the car plate position is similar, so we had to develop a way where the model can detect car plates in various positions.

3- Fuel Economy Data Collection

Another challenge was collecting data of the average fuel economy for all the cars in Saudi Arabia, there was no such database available online. And to collect all this data manually we would have to check every manufacturer's website to access these data. So instead, we reached out to the Saudi standards metrology & quality organization (SASO) [31] and asked for their help. After holding a meeting with them, explaining our project and request we got their approval, and they provided a database of all the cars in Saudi Arabia and the fuel economy.

4- Database and Image Display

There were also challenges related to database selection, database integration and image display, which were addressed through thorough research, consultations, and troubleshooting.

4.6.4 Development environment

The development environment consisted of three Windows laptops and two MacBooks, which were used for coding and testing purposes. Visual Studio was the primary integrated development environment (IDE) used for code editing and building [36], while Android Studio was used for launching and utilizing phone emulators [37].

The code was managed using GitHub, and Firebase Firestore database was used in both the mobile application and the website.

4.6.5 Machine learning models

We developed a license plate recognition system composed of two models one for plate position detection, which we implemented, and another for character extraction from identified plate regions, available online [30].

Initially, we utilized YOLOv8, a state-of-the-art object detection model known for its exceptional performance in diverse detection tasks [29]. To expedite the training process, we leveraged Google Colab, which provides free access to powerful computational resources like GPUs and TPUs [38].

We employed YOLOv8 for detecting cars within the frame and then passed this frame to the first model. Trained using a combination of available datasets and additional data sources, the first model identifies cense plates regions within images.

Once the first model successfully localizes the license plate within a given image frame, we pass this region of interest (ROI) containing the license plate to the second model. Specializing in extracting alphanumeric characters from the license plate frame, this model recognizes and extracts the characters comprising the license plate number.

The workflow involves sending an image frame, typically containing a car with a visible license plate, to the first model. Upon detecting the license plate region, the ROI is extracted and forwarded to the second model for character extraction. By segmenting the task into two separate models, each focusing on a specific aspect of license plate recognition, we aim to achieve a more efficient and accurate overall system for automated license plate recognition (ALPR). This modular approach also allows for flexibility in model training, optimization, and deployment, facilitating easier maintenance and potential future improvements.

- Camera Specifications

We are using the Eufy Camera S330, an IP camera that supports RTSP as shown in figure 27 [35]. This system includes two cameras and a home base, all of which are linked to a corresponding mobile application.

Figure 27- Eufy S330 Camera

- Operational Deployment at Entry and Exit Points

We need to position two cameras at the station: one at the entrance and one at the exit. The primary goal of the entrance camera is to identify each car by its plate number as it enters the station and to count these entries to estimate the occupancy level. Similarly, the exit camera will count cars exiting the station to help estimate the occupancy level.

- Camera Setup

Due to security concerns, we could not access surveillance cameras at existing stations. Understanding these restrictions, we opted for a simulated setup instead. Our simulation took place at the front of Gate 2 in King Saud University, specifically at the entrance to the health colleges. This location features a single pathway where vehicles move from left to right. Accordingly, cars coming from the left are counted as entering the station, while those exiting to the right are counted as leaving. Figure 28 shows the camera preparations.

Since the station layout is a bit different, we simulated the setup with two cameras, though more cameras can be added if needed. In a real station, the layout will reflect the actual station configuration.

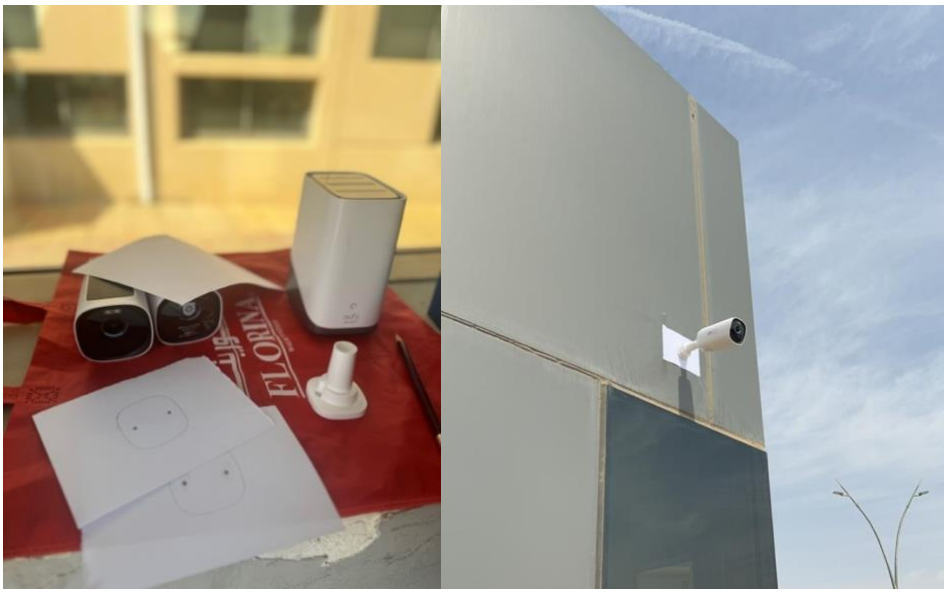

Figure 28- Camera Setup Preparation

The exit camera setup is shown in the figure 29, while the entrance camera held by hand, as shown in the figure 30, rather than mounted above, this approach was chosen because when the camera was positioned higher, the quality of the footage of the moving plates was not sufficient for accurate recognition of the plates by the AI model. Therefore, the optimal solution is to position the camera at the same level as the cars.

Figure 29 - Exit Setup

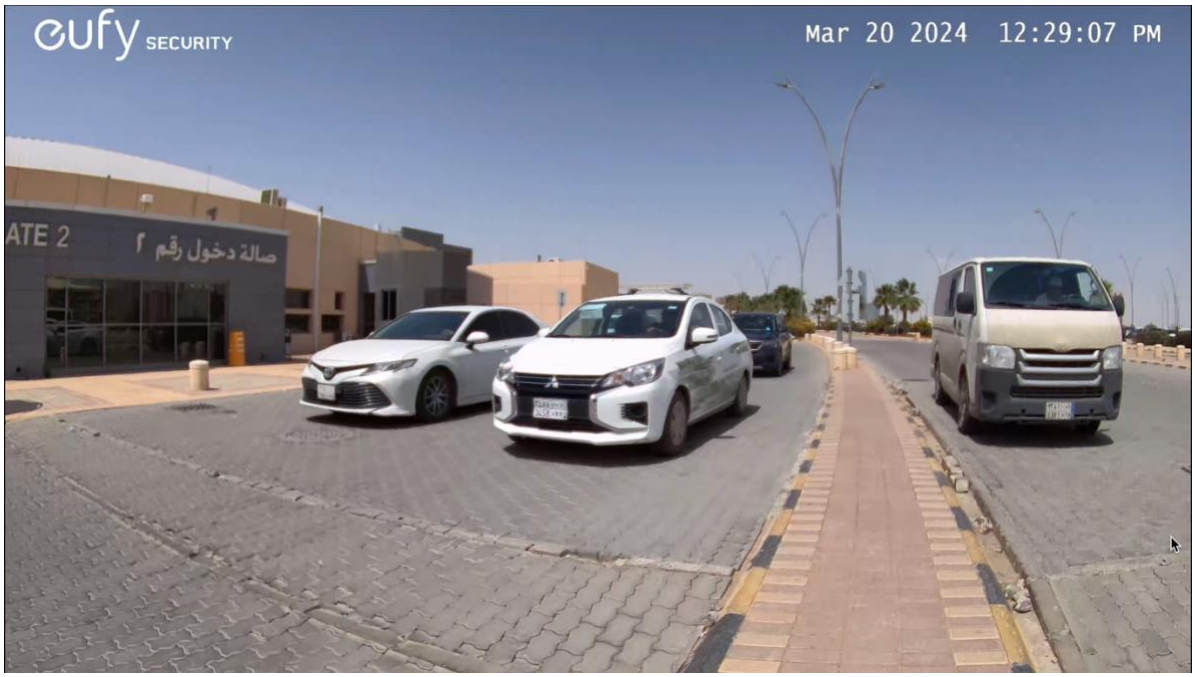

Figure 30- Entrance setup

4.6.6 Summary

The "91" app uses Dart and Flutter for mobile, HTML, CSS, and JavaScript for the web, and YOLO for occupancy detection and license plate recognition. Developed on Windows and MacBooks, we used Visual Studio, Android Studio, GitHub, and Firebase. A two-model system with YOLOv8 and Eufy Camera S330 was used in a simulated setup to estimate station occupancy.

4.6.7 Functions

Here are some of the main functions implemented, For more details, please refer to our GitHub repository (see Appendix C)

Table 5- Car detection and counting function.

Function name	Car detection and counting
Description	YOLO is a real-time object detection pre-trained model that can detect 20 different classes of objects, one of which is cars. In developing the car detection and counting functionalities 2 streams were processed (entrance and exit streams), both with certain interest areas. If a car is detected in one of the interest areas a counter for that area is incremented and then the occupancy will be updated accordingly.

Code snippet

```
    # Detect cars and update tracker for stream1
    detections1 = model(frame1)[0]
    if detections1:
        detections1_ = []
        for detection1 in detections1.boxes.data.tolist():
            x1, y1, x2, y2, score, class_id = detection1
            if int(class_id) in [2, 3, 5, 7]:  # Filtering vehicles
                detections1_.append([x1, y1, x2, y2, score])
        # print(detections1_)
        tracked_cars1 = tracker1.update(detections1_)
    else:
        tracked_cars1 = []

    # Detect cars and update tracker for stream2
    detections2 = model(frame2)[0]
    if detections2:
        detections2_ = []
        for detection2 in detections2.boxes.data.tolist():
            x1, y1, x2, y2, score, class_id = detection2
            if int(class_id) in [2, 3, 5, 7]:  # Filtering vehicles
                detections2_.append([x1, y1, x2, y2, score])

        tracked_cars2 = tracker2.update(detections2_)
    else:
        tracked_cars2 = []

    # Process entering and exiting cars for both streams
    for stream_index, (tracked_cars, area, car_counter, cars_dict) in
enumerate([(tracked_cars1, entering_area, entering_car_counter, entering_cars),
                                                                    (tracked_cars2,
exiting_area, exiting_car_counter, exiting_cars)], start=1):
        for bbox in tracked_cars:
            x1, y1, x2, y2, car_id = bbox
            cx = (x1 + x2) // 2
            cy = (y1 + y2) // 2

            # Check if the car is within the entering or exiting area
            if cv2.pointPolygonTest(np.array(area, np.int32), (cx, cy), False) >= 0:
                cars_dict[car_id] = (cx, cy)
                if car_id not in car_counter:
                    car_counter.append(car_id)

    current = len(entering_car_counter) - len(exiting_car_counter)
    doc_ref = db.collection('Station').document(stationId)
    doc_ref.update({'current': current})
```

Table 6- Car plate recognition function.

Function name	Car plate recognition
Description	To recognize Saudi car license plate we used YOLO to detect the car, localize the plate, then extract the characters. The code reads frames from the video stream, detects vehicles within a defined area, tracks them using SORT, and extracts license plates. It then processes the license plates by predicting characters, substituting certain characters if needed, and storing the characters and their confidence scores in a dictionary.
Code snippet	

```
import cv2
from sort.sort import *
from ultralytics import YOLO
import csv
import numpy as np
from database import CarSearch

# Initialize SORT tracker
mot_tracker = Sort()

# Load YOLO models
coco_model = YOLO('yolov8n.pt')
license_plate_detector = YOLO('python/locate_plate.pt')
read_plate = YOLO('python/extract_plate.pt')

area = [(300, 1040), (1175, 870), (1902, 994), (1590, 1575)]

# Load video
cap = cv2.VideoCapture('python/video9.mov')

def RGB1(event, x, y, flags, param):
    if event == cv2.EVENT_MOUSEMOVE:
        colorsBGR = [x, y]
        print(colorsBGR)

cv2.namedWindow('Stream 1')

cv2.setMouseCallback('Stream 1', RGB1)
# Container to store the predicted characters and their confidence scores for each
license plate
plate_characters = {}

# Read frames
frame_nmr = -1
ret = True
while ret:
    if frame_nmr > 30:
        break
    frame_nmr += 1
```

```
    ret, frame = cap.read()
    if not ret or frame.size == 0:
        print("Error: Empty frame or invalid dimensions")
        break
    if ret:
        print(frame.size)
        # Detect vehicles
        cv2.polylines(frame, [np.array(area, np.int32)], True, (0, 255, 0), 2)
        detections = coco_model(frame)[0]
        detections_ = []
        for detection in detections.boxes.data.tolist():
            x1, y1, x2, y2, score, class_id = detection
            if int(class_id) in [2, 3, 5, 7]:  # Filtering vehicles
                # Check if the center of the detected vehicle is within area1
                cx = (x1 + x2) / 2
                cy = (y1 + y2) / 2
                if cv2.pointPolygonTest(np.array(area, np.int32), (cx, cy), False) >=
0:
                    detections_.append([x1, y1, x2, y2, score])
                detections_.append([x1, y1, x2, y2, score])

        # Track vehicles
        if detections_:
            track_ids = mot_tracker.update(np.asarray(detections_))


        for detection in track_ids:
            x1, y1, x2, y2, track_id = detection  # Extract coordinates and track ID
            cx, cy = int((x1 + x2) / 2), int((y1 + y2) / 2)

            cv2.circle(frame, (cx, cy), 4, (0, 0, 255), -1)
            cv2.rectangle(frame, (int(x1), int(y1)), (int(x2), int(y2)), (255, 255,
255), 2)
            # Display track ID
            cv2.putText(frame, f'Track ID: {track_id}', (int(x1), int(y1) - 10),
                        cv2.FONT_HERSHEY_SIMPLEX, 0.5, (255, 255, 255), 2)

            # Cut out the car image
            car_image = frame[int(y1):int(y2), int(x1):int(x2)]

            # cv2.imshow("Car Image", car_image)



            # Detect license plates within the car image
            license_plates = license_plate_detector(car_image)[0]

            # Process license plates detected in the car image
```

```
            for plate_idx, license_plate in
enumerate(license_plates.boxes.data.tolist()):
                x1_lp, y1_lp, x2_lp, y2_lp, score_lp, _ = license_plate  # Unpack
license plate variables

                # Convert license plate coordinates to match the frame coordinates
                x1_lp += x1
                x2_lp += x1
                y1_lp += y1
                y2_lp += y1

                cv2.rectangle(frame, (int(x1_lp), int(y1_lp)), (int(x2_lp),
int(y2_lp)), (0, 0, 255), 2)

                # Crop license plate
                license_plate_crop = frame[int(y1_lp):int(y2_lp),
int(x1_lp):int(x2_lp), :]
                # cv2.imshow("license_plate_crop", license_plate_crop)

                # Process license plate
                license_plate_crop_gray = cv2.cvtColor(license_plate_crop,
cv2.COLOR_BGR2GRAY)
                _, license_plate_crop_thresh = cv2.threshold(license_plate_crop_gray,
64, 255, cv2.THRESH_BINARY_INV)

                # Predict characters in license plate crop using a model named
extract_plate.pt
                p2 = read_plate.predict(license_plate_crop)

                # Extract the predicted bounding boxes for characters
                res2 = p2[0].boxes.data.cpu().numpy().astype(np.float64)
                sorted_res2 = res2[res2[:, 0].argsort()]

                # Extract predicted characters and apply necessary substitutions
                predicted_characters = sorted_res2[:, -1]
                substituted_characters = [number_to_substitute.get(char,
str(int(char))) for char in predicted_characters]
                print(f"frame_nmr: {frame_nmr}, substituted_characters:
{substituted_characters}")

                # Extract confidence scores
                confidence_scores = sorted_res2[:, 4]

                # Group characters by license plate
                plate_key = (frame_nmr, track_id)
                if plate_key not in plate_characters:
                    plate_characters[plate_key] = {'characters':
substituted_characters, 'confidence_scores': confidence_scores}
                else:
```

```
                    # Retrieve the previously stored confidence scores
                    existing_confidence_scores =
plate_characters[plate_key]['confidence_scores']

                    # Determine the length of the existing confidence scores
                    existing_length = len(existing_confidence_scores)

                    # Ensure that the length of confidence_scores matches the length of
existing_confidence_scores
                    if len(confidence_scores) != existing_length:
                        if len(confidence_scores) < existing_length:
                            confidence_scores = np.pad(confidence_scores, (0,
existing_length - len(confidence_scores)), mode='constant', constant_values=-1)
                        else:
                            confidence_scores = confidence_scores[:existing_length]

                    # Update the confidence scores in plate_characters using
np.maximum()
                    plate_characters[plate_key]['confidence_scores'] =
np.maximum(existing_confidence_scores, confidence_scores)

    # Display frame
    cv2.imshow('Stream 1', frame)
    # Press 'q' to exit
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break
```

System Evaluation

91 application

5 System Evaluation

Testing the system is a critical and important process with the main goal of ensuring that the system meets its user requirements, identifying any confusing aspects for improvement, and checking for errors during system use, this section discuss the experimental results, the user accepting testing, and discussion results.

5.1 Experimental Results

5.1.1 Car License Plate Recognition Model Results

In the beginning, license plate recognition model was trained and tested first using the dataset from Kaggle [33]. where 276 images were used for training and 63 for testing. The performance of our license plate recognition system before and after the incorporation of an additional dataset is summarized in the following table:

Table 7 - Evaluation comparison.

Metric	**Before**	**After**
Precision	0.9016393442622951	0.9333333333333333
Recall	0.873015873015873	0.8888888888888888
Intersection Over Union (IOU)	0.8798108310218908	0.8888569115613515

Before incorporating the additional dataset, our system exhibited a precision of 0.9016, indicating that 90.16% of the identified license plates were correct. The recall was 0.8730, signifying that 87.30% of the actual license plates were successfully detected. The average IoU across all images stood at 0.8798, suggesting a high degree of overlap between the predicted and ground truth bounding boxes.

Following the integration of the additional dataset, notable improvements were observed across all performance metrics. The precision increased to 0.9333, indicating a higher accuracy rate of 93.33% in identifying correct license plates. Similarly, the recall improved to 0.8889, suggesting that 88.89% of the actual license plates were successfully detected. Moreover, the average IoU across all images rose to 0.8889, reflecting enhanced localization accuracy and a higher degree of overlap between the predicted and ground truth bounding boxes.

These results underscore the effectiveness of incorporating additional data in refining the performance and robustness of our license plate recognition system.

5.1.2 License Plate Number Extraction Model Results

License Plate Number Extraction Model was trained using the dataset [32]. 563 was used for training and 30 for testing. We calculated the accuracy of the predictions from the license plate recognition system based on the method outlined in [39]. The accuracy is determined by comparing the number of correctly predicted letters to the ground truth.

The process involves comparing each predicted letter with the corresponding ground truth letter for each license plate. The accuracy is calculated as the ratio of correctly predicted letters to the total number of ground truth letters. This approach ensures a detailed and precise measurement of the recognition system's performance.

The ground truth and predicted data are provided in tabular format. Each entry consists of a filename, and the corresponding label, which represents the license plate number. A mapping dictionary converts numeric class labels into alphabetic characters, ensuring the predicted and ground truth labels are comparable.

For predicted labels, each unpredicted label was replaced with hyphens (-). When the predicted label contains hyphens, these are included in the predicted letters string and considered during the comparison. The function iterates over each file, compares the translated ground truth and predicted letters, and counts the number of correctly predicted letters.

The accuracy for each file is calculated by dividing the number of correct predictions by the total number of ground truth letters and expressing this as a percentage. The table below shows a sample of the comparison between the ground truth and predicted license plate numbers, along with the calculated accuracy for each entry. The full results can be found in Appendix F.

Table 8- Sample results plate accuracy.

	File	Ground Truth Plate	Predicted Plate	Accuracy
19	ckj6u30bj0003246ad1yv8vtg	5732NXD	5732NXD	100%
20	ckj6uqogb000l246a11f6lmsy	3523AHA	3523AHA	100%

	File	Ground Truth Plate	Predicted Plate	Accuracy
21	ckj6z1rgf0017246a29d2uvj8	5732NXD	5732NXD	100%
22	ckn7azkx000vz30681dukt0g6	6927NJJ	-927-JJ	71.0%
23	ckn7b8dn700z830683o4wnr49	7997HGD	7997HGD	100%
24	ckn7cludx018d3068ezkbk89i	3775JED	3775J-D	86.0%

5.1.3 Final Results

Figure 31 and table 8 show a sample of the results after running the model on a video captured with the entrance camera that shows two car plates were accurately predicted, demonstrating the model's effectiveness.

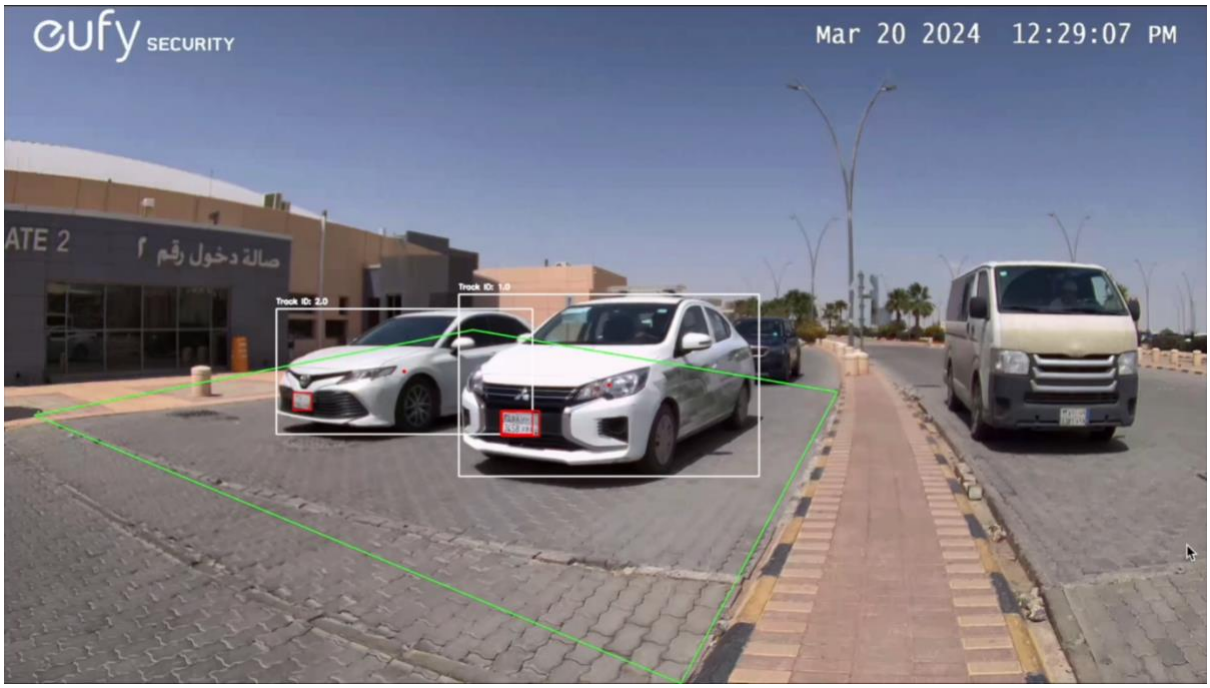

Figure 31 - Testing Models on Entrance

Sample results in the following table:

Table 9 - Plate extraction results sample.

Frame Number	Track ID	Top Predicted Characters	Top Confidence Score
29	1.0	3458XBR	0.91229647397995

155	5.0	5726ZND	0.8704591393470760

5.2 User Acceptance Testing

User Acceptance Testing (UAT) represents the final testing stage in software development before production, utilized to gather feedback from users who evaluate both the software and its user interface (UI) [40].

In this section, we conducted user acceptance testing with a total of 22 users: 12 drivers, 4 station employees, 4 branch managers, and 2 admins. We allowed drivers and station employees to use the application, while branch managers and admins were given access to the website. Information was collected via a questionnaire that asked a variety of questions about their experience using the application/website.

5.2.1 Demographics of Participants

In the questionnaire, we inquired about the demographics for each role. We asked participants about their age, gender, and role. In Table below I show the demographics for each role (See Appendix C).

This information helps us improve our approach. By understanding these details, we can communicate and provide information in a way that makes sense to them. It's like getting to know them better, so we can use our time and resources wisely, focusing on what matters most to each group. This makes our project more user-friendly, and everyone feels included and considered.

Table 10- Demographics of participants.

Role	Number	Gender	Age
Admin	2	One Mela Admin One Female Admin	One between 35 and 44 One between 25 and 34
Branch Manager	4	Three Female Manager One Mela Manager	Two between 18 and 24 One between 25 and 34 One between 35 and 44
Driver	12	Eight Female Driver Four Mela Driver	Ten between 18 and 24 One between 25 and 34 One between 45 and54
Station Employee	4	Three Female Employee One Male Employee	One between 18 and 24 Two between 25 and 34 One between 45 and 54

5.2.2 Questionnaire/Interview Results

The questionnaire (see Appendix C) was an integral part of the testing phase for a new system aimed at evaluating the user experience. It gathered responses from a diverse group of users, including drivers, branch managers, station employees, and admins. This comprehensive approach incorporated both quantitative (answers on a scale from 1 to 5) and qualitative (answers in comments) feedback, providing a robust evaluation of the system's effectiveness and usability, and identifying potential areas for improvement.

- Drivers' Feedback:

The drivers who use our system frequently are highly satisfied with it, especially regarding the ease of account registration and adding cars. They particularly appreciate the user-friendly

process and enjoy tracking bills for each car within our app. Moreover, they show a strong grasp and comfort with the fuel consumption analysis features, as evidenced by their positive feedback. In their detailed feedback, drivers praised the application's attractive design and intuitive interface. They found real-time information on fuel availability and consumption tracking to be especially helpful. The ability to review bills for each car within the app was also highlighted as a valuable feature for everyday use.

Below is a visualization of the drivers' responses to quantitative questions, with a scale ranging from 1 (strongly agree) to 5 (strongly disagree) and for questions (see Appendix D).

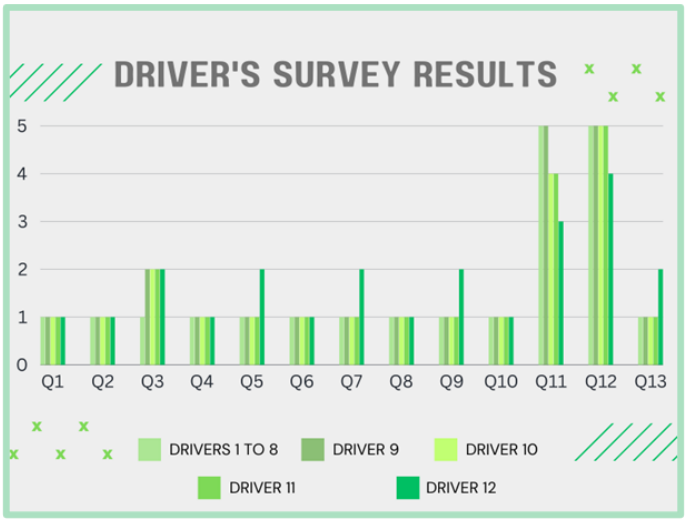

Figure 32- Drivers Responses Visualization

Additionally, we inquire about the overall satisfaction with the app and its features, aiming to ensure clarity and identify areas for improvement. And we saw positive feedback, but some users provided comments suggesting enhancements, such as a request to adjust the color scheme in the consumption results for better readability and a suggestion to clarify password requirements in the sign-up form. Here are their comments:

Figure 33- Drivers Comments

- Branch Managers' Feedback:

Branch managers, tasked with overseeing the operational facets of the stations, expressed high levels of efficiency and ease of use in managing station details and adding employees. They also found the system effective in updating station bills, as indicated by their quantitative responses. These managers felt in control of their interactions with the system and were comfortable with the amount of information presented to them.

Below is a visualization of the branch managers responses to quantitative questions, using a scale ranging from 1 (strongly agree) to 5 (strongly disagree) and for questions (see Appendix D).

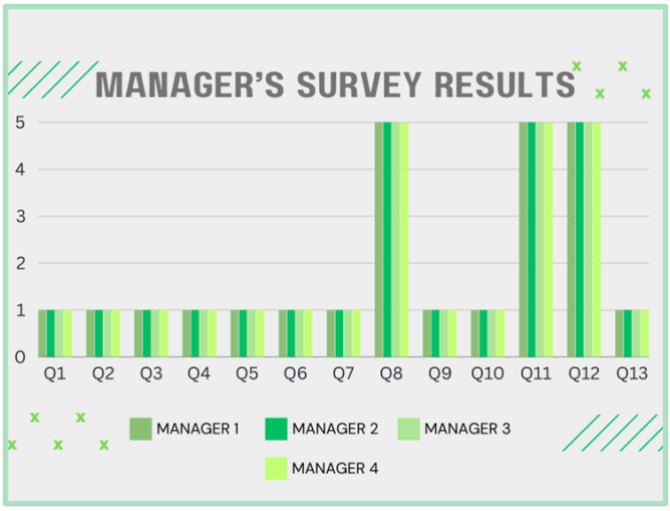

Figure 34- Branch Managers Responses Visualization

Also, we inquire about all the features of the website, and they commented that the system is comprehensive and efficient for station management. They particularly appreciated the ability to update fuel availability, manage staff, and efficiently handle station services and promotions. Overall, their feedback is positive, affirming that the website is user-friendly, easy to use, and understandable. The figure below visualizes the results of the branch managers comments.

Figure 35- Branch Managers Comments

- Station Employee's Feedback:

The feedback from station employees was pivotal in understanding the system's onboarding process. They outlined a clear and efficient method for logging into their accounts in the app using the email provided by their manager. Moreover, they expressed appreciation for the efficiency of reporting bills. They also found the process of scanning QR codes of cars and viewing the plate numbers of all cars in stations to be straightforward and helpful.

Below is a visualization of the Station Employee responses to quantitative questions, using a scale ranging from 1 (strongly agree) to 5 (strongly disagree) and for questions (see Appendix D).

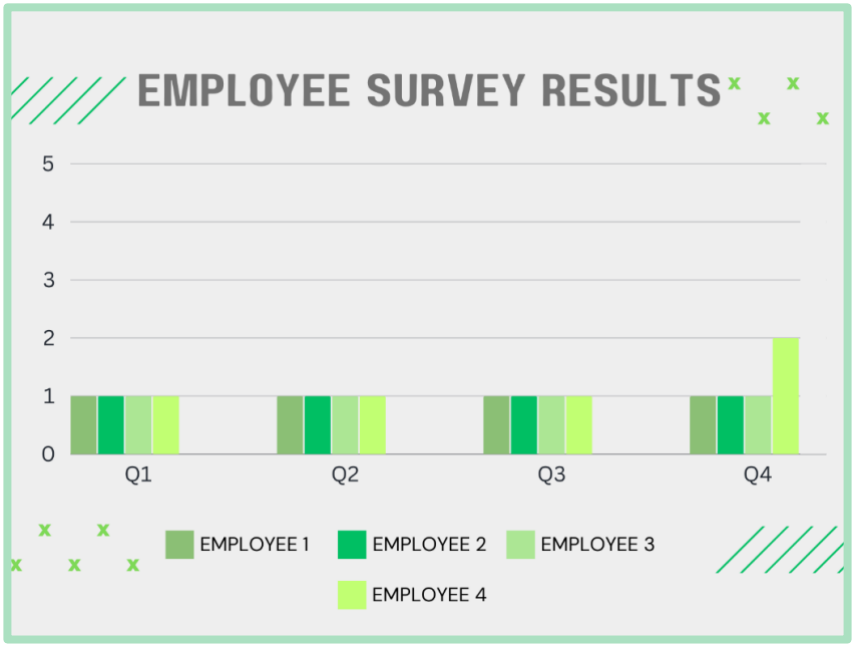

Figure 36- Employees Responses Visualization

Also, we inquired about all the features of the app, and they commented that the system is comprehensive and efficient for reporting bills. They particularly appreciated the ability to scan QR codes or select plate numbers of cars in the station for reporting bills. Overall, their feedback is positive, affirming that the app is user-friendly, easy to use, and understandable.

The figure below visualizes the results of the station employee comments:

Figure 37- Employees Comments

- Admin Feedback:

The feedback from the admin was crucial in understanding the system's onboarding process. They described the method for logging into their accounts on the website as clear and efficient. Additionally, they expressed appreciation for the efficiency of accepting or rejecting gas station requests. They also found the process of updating branch manager information to be straightforward and helpful.

Below is a visualization of the admin responses to quantitative questions, using a scale ranging from 1 (strongly agree) to 5 (strongly disagree) and for questions (see Appendix D).

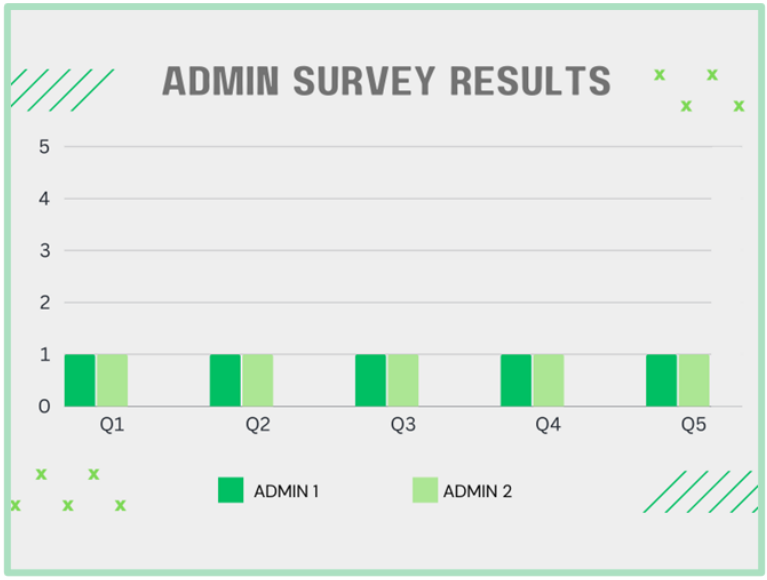

Figure 38- Admins Responses Visualization

Also, we inquired about all the features of the website, and they commented that the system is comprehensive and efficient for managing gas station requests, station information, and reviewing overall system information. They also liked the ease of changing branch manager information. Overall, their feedback is positive, affirming that the website is user-friendly, easy to use, and understandable.

The figure below visualizes the results of the admin comments.

Figure 39- Admins Comments

5.3 Quality Attributes (NFR testing)

We rigorously tested the non-functional requirements (NFR) for both the 91 application and website, covering Availability, Usability, and Error Handling. Our evaluation confirmed seamless availability, intuitive user experience, and effective error management on both platforms. The results, summarized in the table below, demonstrate successful implementation of all NFRs for the application.

Table 11- Quality Attributes

User story	Quality Attribute	Measure	Results
As a user, I want the application to be accessible around the clock so that I can access it at any time that suits me.	Availability: How likely the system is accessible to a user at a given point in time.	Compute the average response time of the application for user requests over different time periods.	•It takes 3 steps: 1. Define testing time periods. 2. Send user requests randomly during each period. 3. Confirm if the user accessed the application without any crashes. •12 users completed the test. •We found that 12 out of the 12 users

			successfully accessed the application without any crashes.
As a user, I want the application to show helpful error messages and handle unexpected errors smoothly so that I can easily understand and resolve issues.	Error Handling: How the system helps users understand and recover from errors and unexpected situations.	Assess how effectively the system aids users in understanding and resolving issues.	• It takes 4 steps: 1. Cause errors intentionally. 2. Read error messages carefully. 3. Try to fix the error using the instructions provided. 4. Confirm if the issue is resolved without extra assistance. • 12 users completed the test. • We found that all 12 out of 12 users successfully resolved the issue without

			additional help.
As a user, I want the interface to be user-friendly and accessible, so that I can use the application easily, no matter what my familiarity level or accessibility needs.	Usability: How the user can learn and operate through interactions with the system.	Users need to complete the three main functionalities without errors.	• The users tested three main features: login, adding a car, and adding a consumption report. • 12 users completed the test. • We found that all 12 out of 12 users successfully added the 3 main features without errors.

5.4 Discussion

After analyzing the results of the 12 drivers, 4 station employees, 4 branch managers, and 2 admins, we concluded that the overall results from the system evaluation were good based on the results of the user acceptance testing. The admins' reaction to the system was positive, with the majority acknowledging its value in streamlining administrative tasks proficiently. For the admin's system usability scale results, we calculated it to be an average of 89.5 which is an excellent rating based on table 12 obtained from this research Measuring and Interpreting System Usability Scale (SUS) [41].

Table 12- SUS Score Guide

SUS score	Grade	Adjective rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 - 68	D	Poor
< 51	F	Awful

Since the results range from 1 to 5 (1 being strongly disagree and 5 being strongly agree), we assign those points for each response received. The calculation procedure for the SUS process [41] was as follows:

• Add up the total score for all odd-numbered questions, then subtract 5 from the total to get (X).

• Add up the total score for all even-numbered questions, then subtract that total from 25 to get (Y).

• Add up the total score of the new values (X+Y) and multiply by 2.5.

• We repeat these steps for every user, then we divide it by the number of users to get the final SUS score.

Feedback from branch managers conveyed a predominantly positive sentiment regarding the system's ability to oversee multiple station operations and manage employee assignments efficiently. They lauded its comprehensive features, including services, promotions, and billing functionalities. For the branch managers' system usability scale results, we calculated it to be an average of 89.5, which is also an excellent rating based on Table 12. We calculated the SUS score using the steps mentioned above.

During the testing phase of the application, we collected feedback from both driver and Station employee. The drivers' response to the system was predominantly positive. They found the station page, occupancy level, billing features, car addition, fuel availability, consumption reports, and expense statistics to be particularly useful. However, a few drivers noted issues during the sign-up process, where the error message appeared prompting the inclusion of

special characters in the password without specifying which special characters options. Additionally, they suggested removing the back arrow from the home page and modifying the consumption page to display consumption exceeding the default value in red rather than green. Overall, the system received favorable feedback from most drivers, indicating its good usability and effectiveness in supporting their daily tasks. For the drivers' system usability scale results, we calculated it to be an average of 98.75, which is also an excellent rating based on Table 11 We calculated the SUS score using the steps mentioned above. All the suggestions were taken into consideration and the application was modified accordingly Figure 41. Station employees provided valuable insights into the system's functionality, highlighting its usefulness in facilitating the billing process and generating reports for bills. They expressed satisfaction with the system's efficiency in handling billing processes. For the station employees' system usability scale results, we calculated it to be an average of 83, which is also an excellent rating based on Table 11 We calculated the SUS score using the steps mentioned above. Also, all the three non-functional requirements (Availability, Usability, and Error Handling) were successfully implemented. As shown in Table 12, we have represented how we measured each one of them. For availability, we conducted three steps: 1. Defined testing time periods, 2. Sent user requests randomly during each period, 3. Confirmed if the user accessed the application without any crashes. All 12 users completed the test and successfully accessed the application without any crashes. For error handling, we tested if users were able to resolve issues successfully without additional help. Furthermore, we assessed usability by allowing users to test the first main functionality, which is logging in, and then testing the other two main functionalities in the application: 1. Adding a car, and 2. Adding a consumption report. We observed them while they tested these three main functionalities, and all 12 users completed the test successfully without any errors.

Figure 40- Interfaces after testing

Conclusions and Future Work

91 application

6 Conclusions and Future Work

In this section, we present the conclusion and future work of the "91" project. We discuss the global and local impact of the project, the problems and challenges encountered during software development, the limitations of the system, and the main contribution of the project. Additionally, we outline the planned future developments and enhancements that will further improve the user experience and functionality of the application. The aim is to continuously evolve the "91" project, align it with sustainability goals, address user concerns, and provide advanced features.

6.1 Global and Local Impact.

The “91” project has an immediate local impact as it addresses challenges faced by the drivers on their daily lives such as crowded station’s, fuel availability and fuel consumption and expenses tracking,

It also can impact globally as the world seeks sustainability due to climate change. The average carbon footprint for a person is four tons [41], and the world needs this number to go down. So, tracking fuel consumption might lead people to become more cautious and aware of the world we are living in.

6.2 Problems and Challenges Encountered During Development

We successfully addressed challenges during the development of 91. One challenge was incorporating an additional form for employee login while distinguishing between users and employees. We implemented a seamless solution that classifies individuals during login without compromising previous work. This enhancement improves functionality and user experience.

Another challenge involved implementing a filtering mechanism in the database based on the selected car company. Users could choose a car company and then refine their selection by model and manufacturing year. This iterative process tailored the database output to the user's preferences.

We also faced challenges in implementing the employee update page, including image loading, station setting, and validation accuracy issues. To enhance security, we withheld the return of passwords and required users to substitute the old password for modification. We

reviewed data fetching and display processes for an optimal user experience and robust authentication.

During the initial stages of our project, we encountered difficulties in finding a suitable location with access to camera footage that could be utilized for our project. Many external stations rejected our request due to concerns regarding ownership rights over their photos and car data. This posed a significant setback to our project's progress. In response to the challenges faced, we sought approval from the university administration to install our cameras at one of the university's gates. After presenting our case and outlining the system's benefits, our request was accepted, and installation commenced promptly. The installation of the cameras at the university gate proved to be successful. We captured the required footage and extracted plate numbers efficiently, thus fulfilling our project's objectives.

6.3 Limitations of The System.

The effectiveness of the "91" system depends on functioning camera systems and stable internet connection. Resistance to technology and privacy concerns regarding the collection and storage of personal data like car plate numbers may limit user adoption. Another limitation is user identification through QR codes as they may face scanning problems. Low digital knowledge rates can also pose challenges. Installation and maintenance costs are barriers for gas station owners. And adverse weather conditions can impact system performance.

6.4 The Main Contribution of The Project

The "91" project enhances the fueling experience by offering real-time occupancy detection, a user-friendly interface, and comprehensive information about gas stations. It optimizes resource allocation, promotes convenience, and aligns with sustainability goals. The project addresses privacy concerns and supports national development initiatives. Overall, it enhances the gas station industry by applying technology to improve efficiency and user experience.

6.5 Future Work

In the coming stages, the "91" application will offer new features to enhance the user experience and move forward towards beneficial development and improvement. Including allowing the addition of new features, it is a system that can be developed, including the possibility of setting this system for each station and not limited to one station, like our project. We developed it so that each station has its system, and it can also be developed so that it is

compatible with the Arabic language and not just the English language. We do not stand against useful improvements, but rather, on the contrary, we support and encourage them. The goal is to provide the technology that it needs and facilitate the experiences of users in their lives.

Acknowledgements

91 application

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Refernces

91 application

8 References

[1] “Saudi Arabia Oil Consumption,” Saudi Arabia Oil Consumption, 1965 – 2023 | CEIC Data, https://www.ceicdata.com/en/indicator/saudi-arabia/oil-consumption (accessed Aug. 31, 2023).

[2] “Fuel station companies in Saudi Arabia - gas station market,” Fuel Station Companies in Saudi Arabia - Gas Station Market, https://www.mordorintelligence.com/industry-reports/saudi-arabia-fuel-station-market (accessed Aug. 31, 2023).

[3] “PetroApp,” app.petroapp.com.sa. https://app.petroapp.com.sa/auth/login (accessed Aug. 27, 2023).

[4] Kanade, V.A. (2022) What Is Machine Learning? Definition, Types, Applications, and Trends for 2022, Spiceworks. Available at: https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/ (Accessed: 18 September 2023).

[5] Gupta, M. (2023) What is machine learning?, GeeksforGeeks. Available at: https://www.geeksforgeeks.org/ml-machine-learning/ (Accessed: 18 September 2023).

[6] What is deep learning?: How it works, techniques & applications (no date) How It Works, Techniques & Applications - MATLAB & Simulink. Available at: https://www.mathworks.com/discovery/deep-learning.html (Accessed: 18 September 2023).

[7] What are neural networks? (no date) IBM. Available at: https://www.ibm.com/topics/neural-networks (Accessed: 18 September 2023).

[8] Simplilearn (2023) What is Computer Vision: Applications, benefits and how to learn it, Simplilearn.com. Available at: https://www.simplilearn.com/computer-vision-article (Accessed: 18 September 2023).

[9] Mihajlovic, I. (2021) Everything you ever wanted to know about computer vision. here’s a look why it’s so awesome., Medium. Available at: https://towardsdatascience.com/everything-you-ever-wanted-to-know-about-computer-vision-heres-a-look-why-it-s-so-awesome-e8a58dfb641e (Accessed: 23 September 2023).

[10] What is object detection? (no date) What Is Object Detection? - MATLAB & Simulink. Available at: https://www.mathworks.com/discovery/object-detection.html#:~:text=Object%20detection%20is%20a%20computer,learning%20to%20produce%20meaningful%20results (Accessed: 18 September 2023).

[11] Kundu, R. (2023) Yolo algorithm for object detection explained [+examples], YOLO Algorithm for Object Detection Explained [+Examples]. Available at: https://www.v7labs.com/blog/yolo-object-detection (Accessed: 18 September 2023).
[12] kulhary, ramswarup (2022) OpenCV - Overview, GeeksforGeeks. Available at: https://www.geeksforgeeks.org/opencv-overview/ (Accessed: 19 September 2023).
[13] Solegaonkar, V.K. (2021) Introduction to Py Torch, Medium. Available at: https://towardsdatascience.com/introduction-to-py-torch-13189fb30cb3 (Accessed: 19 September 2023).
[14] The Pros & Cons of IP Cameras: Overview, Types, Features (no date) The Pros & Cons of IP Cameras | Overview, Types, Features. Available at: https://info.verkada.com/security-cameras/ip-camera/ (Accessed: 19 September 2023).
[15] Automatic Recognition and Localization of Saudi License Plates - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Saudi-license-plates_fig1_287234079 [accessed 21 Sep, 2023]

[16] Vedoveli, H. (2023) *Metrics matter: A deep dive into object detection evaluation*, *Medium*. Available at: https://medium.com/@henriquevedoveli/metrics-matter-a-deep-dive-into-object-detection-evaluation-ef01385ec62 (Accessed: 21 May 2024).

[17] Rosebrock, A. (2023) *Intersection over union (IOU) for object detection*, *PyImageSearch*. Available at: https://pyimagesearch.com/2016/11/07/intersection-over-union-iou-for-object-detection/ (Accessed: 21 May 2024).

[18] Lubna, Mufti, N. and Shah, S.A.A. (2021) Automatic Number Plate Recognition:A detailed survey of relevant algorithms, MDPI. Available at: https://www.mdpi.com/1424-8220/21/9/3028 (Accessed: 20 September 2023).
[19] Nguyen, L.A.T. and Ha, T.X. (2021) A novel approach of traffic density estimation using CNNS and computer vision, European Journal of Electrical Engineering and Computer Science. Available at: https://www.ejece.org/index.php/ejece/article/view/353 (Accessed: 20 September 2023).
[20] L. Fuelly, “Fuelly: MPG & Service tracker,” App Store, https://apps.apple.com/us/app/fuelly-mpg-service-tracker/id295905460 (accessed Sep. 22, 2023).

[21] A. Alsenan, “Petroapp,” App Store, https://apps.apple.com/us/app/petroapp/id1267297826 (accessed Sep. 22, 2023).
[22] Sasco, “Sasco,” App Store, https://apps.apple.com/us/app/sasco/id553790427 (accessed Sep. 22, 2023).
[23] N. Solutions, “Petrol Stations Singapore,” App Store, https://apps.apple.com/ca/app/petrol-stations-singapore/id1579351914 (accessed Sep. 22, 2023).

[24] Bydrec, I. (no date) *Agile methodology steps: A flexible and collaborative approach to software development, Bydrec Blog*. Available at: https://blog.bydrec.com/agile-methodology-steps (Accessed: 20 May 2024).

[25] *What is Scrum?* (no date) *Scrum.org*. Available at: https://www.scrum.org/resources/what-scrum-module (Accessed: 20 May 2024).

[26] *What is a product backlog?* (no date) *Scrum.org*. Available at: https://www.scrum.org/resources/what-is-a-product-backlog (Accessed: 20 May 2024).

[27] “Essential Scrum: A Practical Guide to the Most Popular Agile Process - PDF Free Download,” *epdf.pub*. https://epdf.tips/essential-scrum-a-practical-guide-to-the-most-popular-agile-process.html (accessed Apr. 20, 2024).
[28] “MVC Framework introduction,” GeeksforGeeks, https://www.geeksforgeeks.org/mvc-framework-introduction/ (accessed Sep. 22, 2023).

[29] Ultralytics (no date) *Ultralytics/ultralytics: New - yolov8 🚀 in PyTorch > ONNX > OpenVINO > CoreML > TFLite, GitHub*. Available at: https://github.com/ultralytics/ultralytics (Accessed: 20 May 2024).

[30] ch1cly (no date) *Ch1cly/ksa_plate_numbers_yolov8_detection: KSA plate numbers yolov8 detection, GitHub*. Available at: https://github.com/ch1cly/ksa_plate_numbers_yolov8_detection (Accessed: 20 May 2024).

[31] K. M. Department, “ المملكة العربية السعودية - الهيئة السعودية للمواصفات والمقاييس و الجودة,” *saso.gov.sa*. https://www.saso.gov.sa/en/pages/default.aspx/(Accessed: 28 November 2023)

[32] Bikbulatov, T. (2024) *KSA_NUMBER_PLATES*, *Kaggle*. Available at: https://www.kaggle.com/datasets/timurbikbulatov/ksa-number-plates1 (Accessed: 20 May 2024).

[33] Khan, A.H. (2022) *KSA license plates labled*, *Kaggle*. Available at: https://www.kaggle.com/datasets/aamirhasankhan/ksa-license-plates-labled (Accessed: 20 May 2024).

[34] Group, S.M. (2020) *Blurring the boundaries: IP and Machine Vision Cameras converge*, *Tech Briefs*. Available at: https://www.techbriefs.com/component/content/article/19947-blurring-the-boundaries-ip-and-machine-vision-cameras-converge (Accessed: 20 May 2024).

[35] eufy (no date) *eufy Security eufyCam 3, 4K Wireless Security Camera with Integrated Solar Panel, Face Recognition AI, expandable local storage, Forever Power, Spotlight and Color Night Vision, No Monthly Fee*, *amazon*. Available at: https://www.amazon.sa/dp/B0B7NLK2T1?starsLeft=1&ref_=cm_sw_r_cso_wa_apin_dp_GTQDTMMHHDSNSWMYHVRY (Accessed: 20 May 2024).

[36] Microsoft (2021) *Visual studio code - code editing. redefined*, *visualstudio*. Available at: https://code.visualstudio.com/ (Accessed: 20 May 2024).

[37] *Download Android Studio & App Tools* (no date) *Android Developers*. Available at: https://developer.android.com/studio (Accessed: 20 May 2024).

[38] *Colab.google* (no date) *colab.google*. Available at: https://colab.google/ (Accessed: 20 May 2024).

[39] GeeksforGeeks (2023) *License Plate recognition with opencv and TESSERACT OCR*, *GeeksforGeeks*. Available at: https://www.geeksforgeeks.org/license-plate-recognition-with-opencv-and-tesseract-ocr/ (Accessed: 20 May 2024).

[40] A. Carpenter, "What Is User Acceptance Testing (UAT)?," *Codecademy News*, Feb. 17, 2022. https://www.codecademy.com/resources/blog/what-is-user-acceptance-testing/ (accessed May. 10, 2024).

[41] W. T, “Measuring and Interpreting System Usability Scale (SUS) - UIUX Trend,” *UIUX Trend*, May 31, 2017. https://uiuxtrend.com/measuring-system-usability-scale-sus/ (accessed May. 11, 2024).

[42] U. C. for S. Education, “Center for Science Education,” What’s Your Carbon Footprint? | Center for Science Education, https://scied.ucar.edu/learning-zone/climate-solutions/carbon-footprint#:~:text=Worldwide%2C%20the%20average%20person%20produces,causes%20our%20climate%20to%20warm. (accessed Dec. 3, 2023).

Appendix

91 application

1 Appendix A: Interviews

a. First Interview:

Interviewer: Shahad Alqahtani

Interviewee: Nasser naif (car driver)

1. Did you face the problem of running out of gas station fuel at the moment you arrived at the station? Do you support the idea of determining the types and availability of fuel at each station?

Yes, permanently. Yes, I strongly want to.

2. What is the most difficult thing for you to do when you come to a gas station?

Waiting to refuel, especially if it is crowded.

3. How do you avoid crowded stations?

There is no way except when you reach the site and see it with the naked eye.

4. How do you manage your fuel consumption? What are the problems with fuel consumption?

Reducing unimportant trips, the problem of the engine shutting off while driving on the highway.

5. How do you manage your fuel expenses?

There is no method or application to manage expenses.

6. Do you prefer the cost report or the fuel consumption report?

Both.

7. What features do you think motivate you to use the application and invite others to use it?

Is it available or do you suggest adding it? It is easy to reach the station location quickly Find out if the station is crowded or not available.

8. How do you envision incorporating an app like 91 into your daily routine as a driver? And how likely are you to switch to a different gas station based on the information provided by the app?

I imagine that it will be one of the highly used applications because I need it to know the crowding or type of gasoline available at the station, at a high rate.

b. Second Interview:

Interviewer: Rahaf Alnassrallah

Interviewee: Reem Alnassrallah (car driver)

1. Did you face the problem of running out of gas station fuel at the moment you arrived at the station? Do you support the idea of determining the types and availability of fuel at each station?

Yes, I face this problem and it takes me time especially when I'm going to my work. So, it will be a great idea to provide this feature in application.

2. What is the most difficult thing for you to do when you come to a gas station?

I face problem's when I refuel my car and the station is busy, like some cars close the exits to go to shop and I'm waiting for them to go, it takes me time and effort

3. How do you avoid crowded stations?

I see in google maps if it is busy or not but sometimes the accuracy in google Maps is not very good.

4. How do you manage your fuel consumption? What are the problems with fuel consumption?

I don't have a plan how to manage it but if I observe that I spend money for refueling more than I spend it usually I check in my car if there has any problem in it, but sometimes I can't notice easily it takes time.

5. How do you manage your fuel expenses?

I specify the amount of money per month.

6. Do you prefer the cost report or the fuel consumption report?

I think consumptions report is more useful

7. What features do you think motivate you to use the application and invite others to use it? Is it available or do you suggest adding it?

It is very useful to know the services in gas station also fuel consumption report. It is a new idea, and I don't see it before in other application

8. How do you envision incorporating an app like 91 into your daily routine as a driver? And how likely are you to switch to a different gas station based on the information provided by the app?

It will help me to save my time, and yes depending on the app information i will switch to another station.

c. Third Interview:

Interviewer: Rahaf Alnassrallah

Interviewee: Raneem Al-habib (car driver)

1. Did you face the problem of running out of gas station fuel at the moment you arrived at the station? Do you support the idea of determining the types and availability of fuel at each station?

This often happens three times every six months, whether there is no specific type of gasoline in it, or at all the station shuts down because the gasoline has run out.

2. What is the most difficult thing for you to do when you come to a gas station?

I can worry about the delay and that it becomes crowded, especially if I have an appointment

3. How do you avoid crowded stations?

There are about three stations next to our house, so I go first to the closest one. If there is crowded, I pass by the rest so as not to waste time waiting, and I prefer to refuel in night time more than morning.

4. How do you manage your fuel consumption? What are the problems with fuel consumption?

There are times when gasoline consumption is faster than before, and the difference is noticeable. So, I try to reduce my trips or combine them together and only once in order to save - Also, if the weather is nice, I don't turn on the air conditioner because it helps conserve gasoline.

5. How do you manage your fuel expenses?

I allocate a monthly amount for gasoline in case I exceed it. I know that my trips this month have increased

6. Do you prefer the cost report or the fuel consumption report?

I feel that a liter would be more accurate in determining gasoline consumption each month. But if it contains a spending rate that helps me with financial management + it will be a motivation. If I consume a lot of fuel this month, I will not notice or feel the difference unless I see the price increases.

7. What features do you think motivate you to use the application and invite others to use it? Is it available or do you suggest adding it?

The first thing that attracted me was the uniqueness Real-time occupancy Sometimes it is useful, especially if I am going to a new area or place and I do not know where the gas stations are. What if I can know where they are and the level of crowding there Frankly, it is very exciting.

8. How do you envision incorporating an app like 91 into your daily routine as a driver? And how likely are you to switch to a different gas station based on the information provided by the app?

I will use the application every time I fill up with gas, especially when I'm in a hurry and worried about being late. At a convenient moment, I'll open the app and find the nearest and least crowded gas station, relying on the information it provides.

d. Fourth interview:

Interviewer: Futoon Alsalami

Interviewee: Raed Alsalami(car driver)

1. Did you face the problem of running out of gas station fuel at the moment you arrived at the station? Do you support the idea of determining the types and availability of fuel at each station?

Yes, it is a big problem that I faced, especially on the way to travel when I stopped at the gas station and found that 95 fuel was not available, which hindered me a lot of time.

2. What is the most difficult thing for you to do when you come to a gas station?

Traffic is what worries me the most, as it takes a long time to refill.

3. How do you avoid crowded stations?

I started at a closed gas station at my place to refill my car but when I found it crowded, I moved to another gas station, and so on until I found an available gas station.

4. How do you manage your fuel consumption? What are the problems with fuel consumption?

Every car is different from another car. It's easy for me to know if I've exceeded my car's normal level of fuel consumption, often by making more trips than usual.

5. How do you manage your fuel expenses?

I made a budget for 4 weeks.

6. Do you prefer the cost report or the fuel consumption report?

Cost report is more important to me

7. What features do you think motivate you to use the application and invite others to use it? Is it available or do you suggest adding it?

Real-time occupancy is what motivates me the most to use the app, I have a real problem when I go looking for a gas station and it is very crowded.

8. How do you envision incorporating an app like 91 into your daily routine as a driver? And how likely are you to switch to a different gas station based on the information provided by the app?

I need to use the app every day when I fill my car with fuel, it is necessary to know the availability of the fuel type because it is a critical issue for me. Based on the nearest and least crowded gas station.

e. Fifth interview:

Interviewer: Afnan Alotaibi

Interviewee: Alnassar Station Manager (Branch Manager)

1. How do you communicate any changes that happen in the gas station (running out of gas, promos, new shops etc..) to your customers?

There is no way to communicate these changes with customers, they must visit the gas station to find out about anything.

2. Would you support and use an application that allows you to communicate such information with your customers?

Yes of course, I think it would be great. If my gas station was not going to close in two months due to aldreah project I would definitely use it.

3. How do you manage gas runouts and refills? Do you know in advance? Do you have schedules?

There is a plan that predicts when we will need to refill, and it depends on knowing the size of the tanks we use and the number of customers we serve daily. But this plan doesn't prevent the station from running out of gas before the refill because many factors can be

involved in the refill process like the companies and trucks that provide the refills, the roads etc... so, any problem can cause delay of the refill, so we run out of gas before the refill.

4. How do you deal with customers when gas runs out? does it negatively impact you?

We must apologize and not serve them, which has a negative impact on the revenue.

5. How often does the gas station get crowded and how do you manage the crowd?

Crowds are managed with tracks and lines of gas type, an employee will ask the customer if they need 91 or 95 then will direct the customer to the appropriate line.

6. If there was an app that gives real time data of occupancy in gas stations, would you sign up for it?

It's a very good idea, I think I would sign up for it if my gas station was not going to close in about 2 months.

7. What are the features that would benefit you as gas station owner and you would like to add to the application?

I would like to know how many customers visited my gas station and how much sales have I made, I would also like to know how much gas is in my tanks because sometimes we would request an amount for a refill but we would get less due to evaporation.

8. For such an application to work there would be cameras to detect occupancy, are you okay with that?

I don't think this would cause any problems.

9. Would prefer this application to be for desktops or mobile phones?

The manager of each gas station would probably use a desktop.

f. Sixth interview:

Interviewer: Sarah Alqahtani

Interviewee: Al-Omrani Station Manager (Branch Manager)

1 How do you communicate any changes that happen in the gas station (running out of gas, promos, new shops etc..) to your customers?

There is no way to communicate changes to the customers. Except for the mandatory sign that shows the gas prices at the entrance of the station.

2 Would you support and use an application that allows you to communicate such information with your customers?

Yes, I would use it.

3 How do you manage gas runouts and refills? Do you know in advance? Do you have schedules?

Refills are scheduled periodically with the providers, but we can not know for sure when we are going to need a refill, we just estimate it based on the sizes of our tanks.

4 How do you deal with customers when gas runs out? does it negatively impact you?

We unfortunately just turn them down.

5 How often does the gas station get crowded and how do you manage the crowd?

The rush hour is mostly in the morning when people are going to work. As for managing the crowd, sometimes the line can extend to the outside of the station, and we can not do anything about it but we try to serve the customers as fast as possible.

6 If there was an app that gives real time data of occupancy in gas stations, would you sign up for it?

Most likely yes.

7 What are the features that would benefit you as gas station owner and you would like to add to the application?

I would like to know the number of visitors.

8 For such an application to work there would be cameras to detect occupancy, are you okay with that?

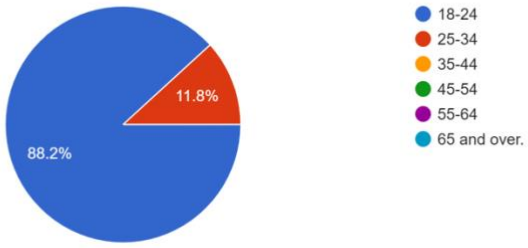
I don’t think this would be a problem.

9 Would prefer this application to be for desktops or mobile phones?

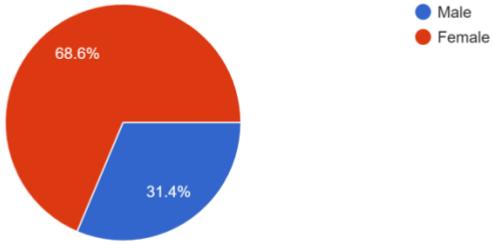
A desktop is better when running a business.

2 Appendix B: Questionnaires

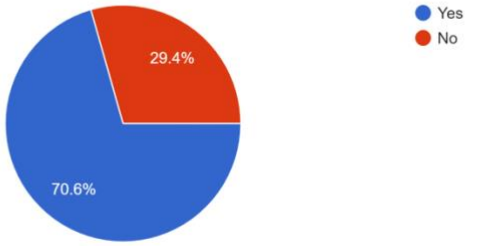
Age?
51 responses



Gender?
51 responses



Do you drive a car?
51 responses

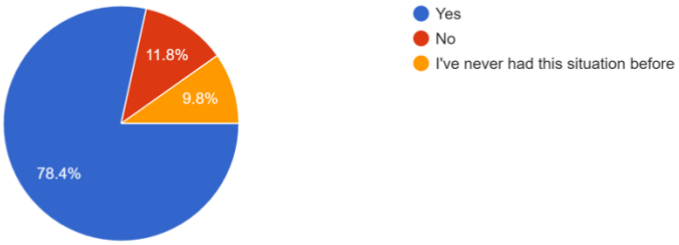


How often have you arrived at a gas station only to find it crowded?

51 responses

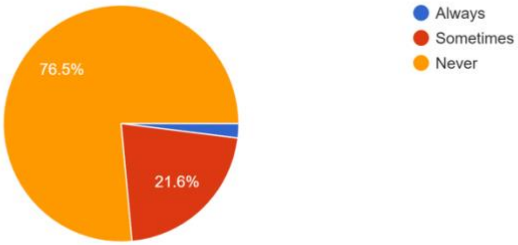
When you went through such a situation, did it cause delays that made you late for your planned activities or trips?

51 responses



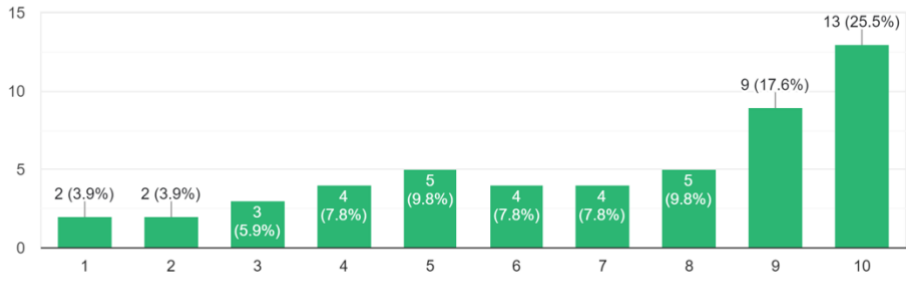
How often do you check the gas station crowd status on Google Maps?

51 responses



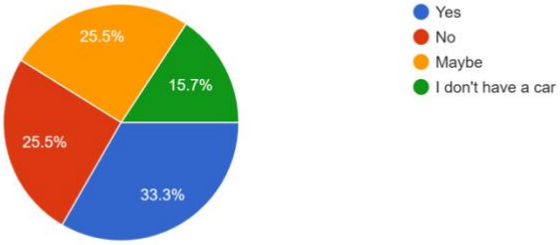
On a scale of 1 to 10, how important is it for you to know a gas station's occupancy before arrival at peak periods? (1 being not important and 10 being very important)

51 responses



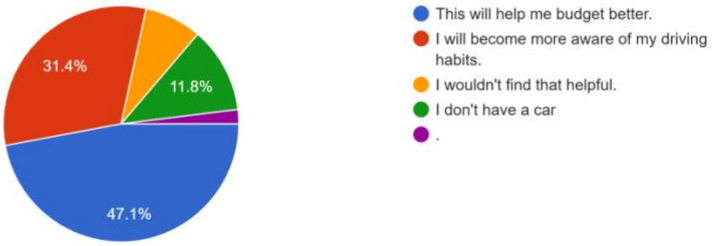
Do you constantly keep track of your car's fuel expenses?

51 responses



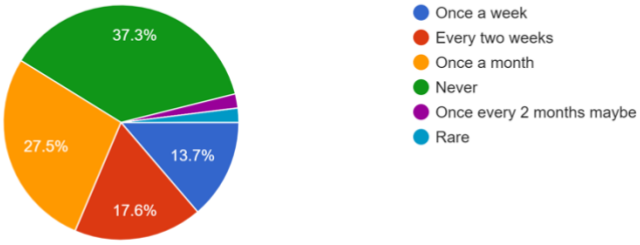
How can you benefit from our application that provides monthly statistics on your fuel expenses?

51 responses



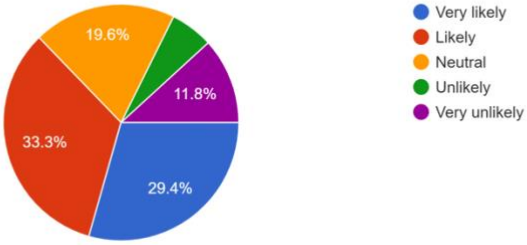
How often have you arrived at a gas station to find that your preferred fuel type has run out at that moment?

51 responses



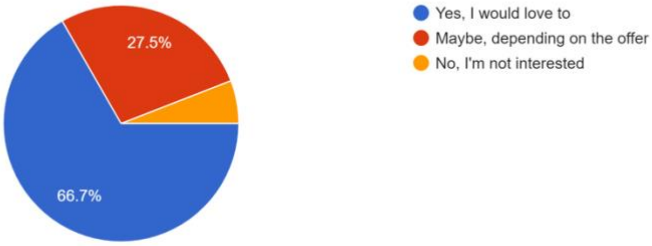
How likely are you to use an app that provides real-time occupancy levels at gas stations?

51 responses



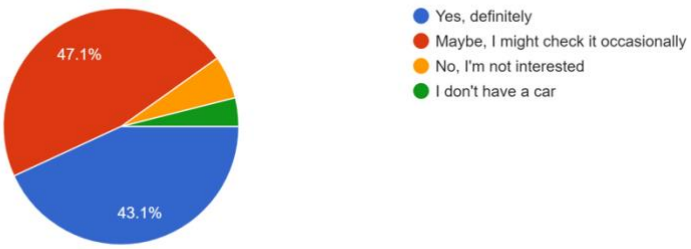
Would you be interested in receiving promotions or discounts through the app?

51 responses



Would a feature providing monthly fuel expense statistics be of value to you?

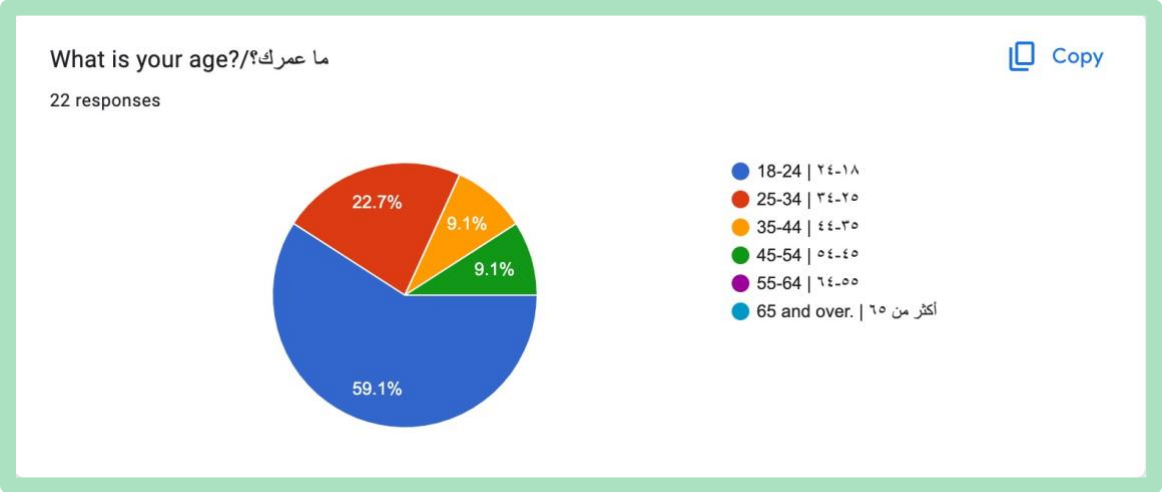
51 responses

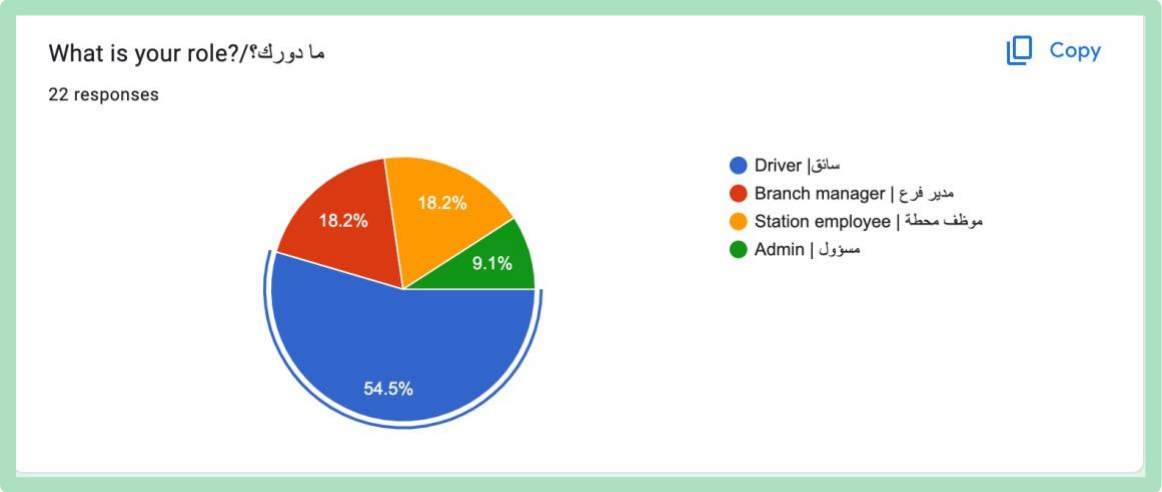


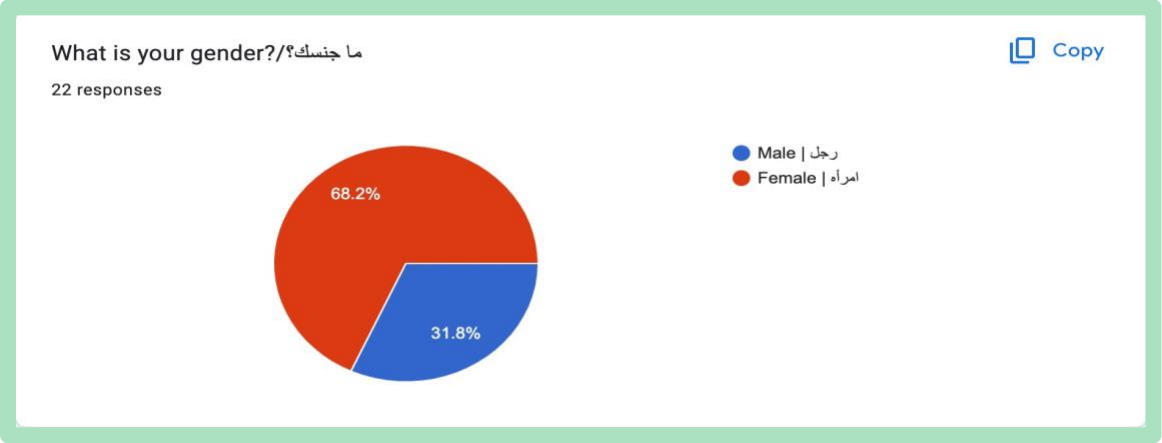
3 Appendix C: Testing Questionaries Results

The link to questionnaires for all roles https://forms.gle/6ULgMuQFg2Bgks7J6

Demographics for all roles:





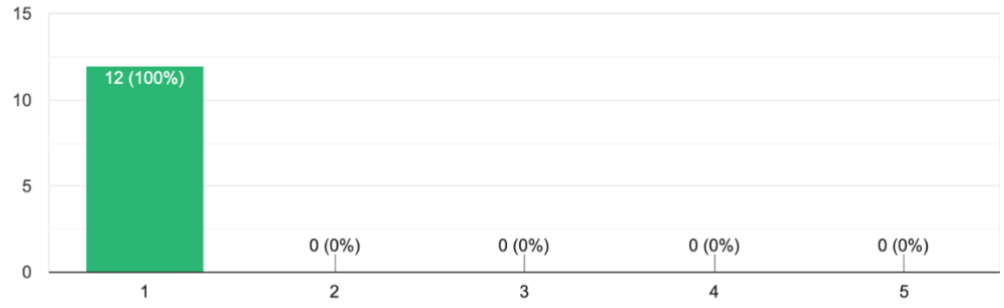


Drivers' Answers:

I found the process of registering a new account on the app to be straightforward and user-friendly. وجدت عملية تسجيل حساب جديد عملية واضحة وسهلة الاستخدام.

Copy

12 responses



I can add my car to the system easily.
يمكنني إضافة سيارتي إلى النظام بسهولة.

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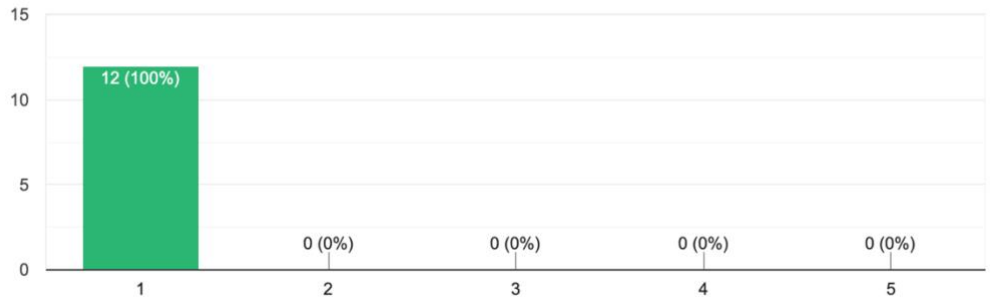
12 responses



The system made it easy for me to understand and track my fuel consumption.
لقد سهّل النظام عليّ فهم استهلاك الوقود وتتبعه.

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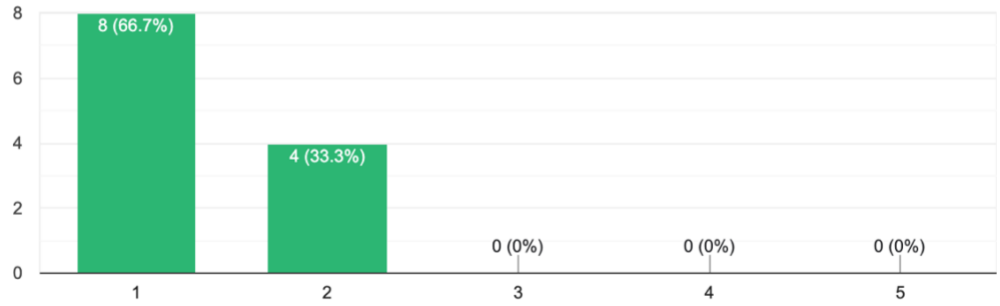
12 responses



the bill page adequately presents all necessary billing details and information?
أن صفحة الفاتورة تعرض كافة تفاصيل ومعلومات الفواتير الضرورية بشكل مناسب؟

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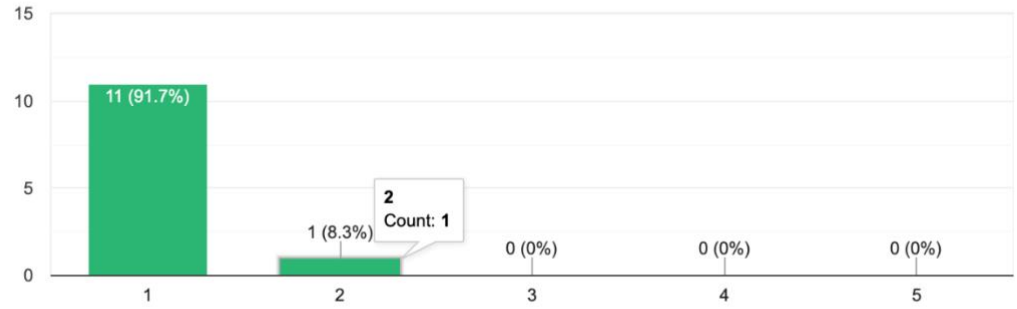
12 responses

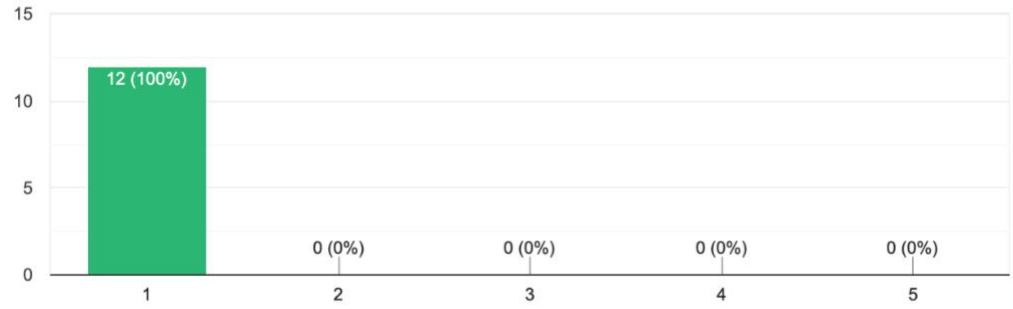


How likely are you to recommend our platform to others based on the promotions and special offers available at gas stations?

Copy

ما مدى احتمال أن توصي الآخرين بمنصتنا بناءً على العروض الترويجية والعروض الخاصة المتوفرة في محطات الوقود؟

12 responses



I can know whether the station contains some type of gasoline or not in real time easy way.

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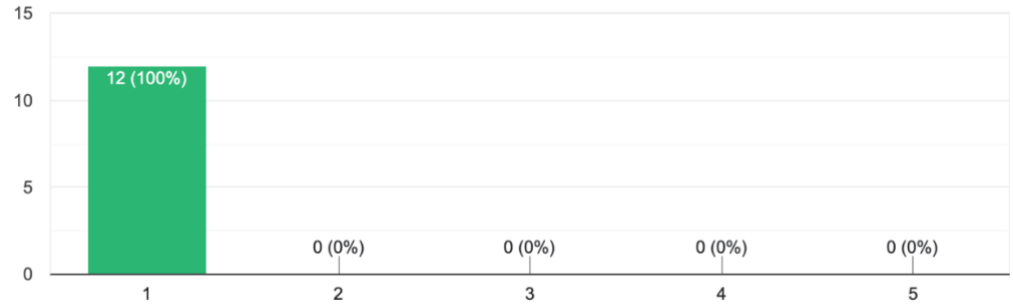
يمكنني معرفة ما إذا كانت المحطة تحتوي على نوع ما من البنزين أم لا في الوقت الفعلي بكل سهولة؟

12 responses



How would you rate the availability and variety of amenities and services offered at gas stations?

كيف تقيم مدى توفر وتنوع وسائل الراحة والخدمات المقدمة في محطات الوقود؟

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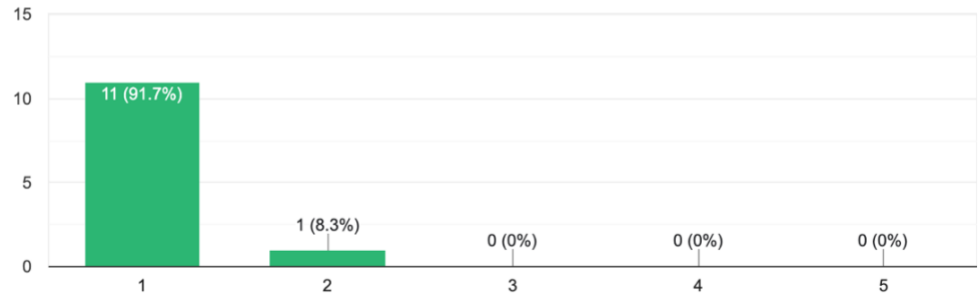
12 responses



Do you think that knowing the level of crowding at gas stations before arriving is important to you and useful in the application?

هل ترى أن معرفة مستوى الإزدحام في محطات الوقود قبل الوصول مهمه لديك ومفيدة في التطبيق؟

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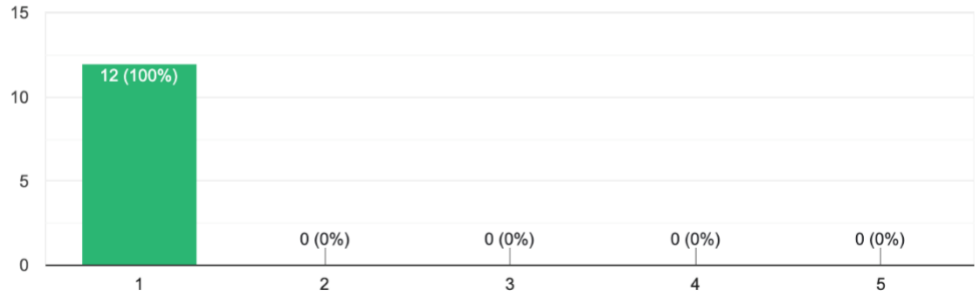
12 responses



I found the fuel expenses chart straightforward.

لقد وجدت مخطط نفقات الوقود واضحًا ومباشرًا.

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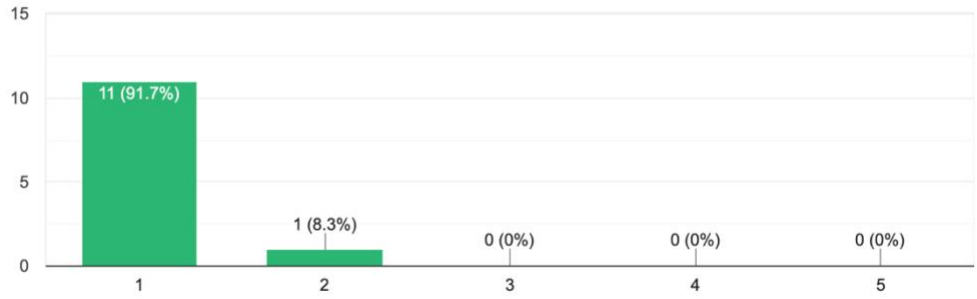
12 responses



I felt in control of the interactions I had with the system.
شعرت بالسيطرة على التفاعلات التي أجريتها مع النظام.

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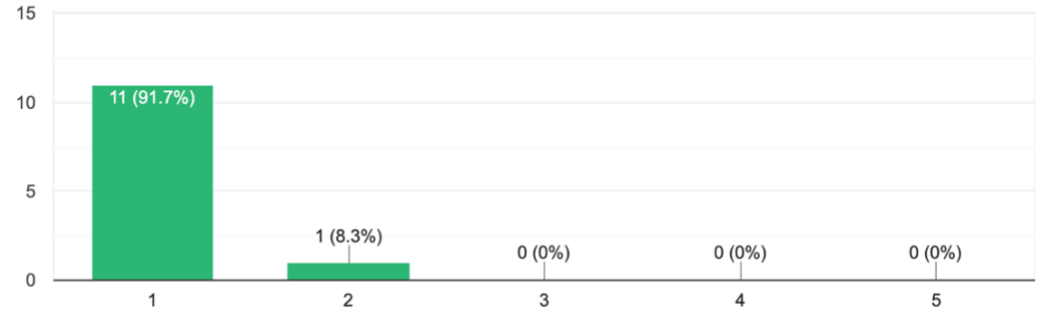
12 responses



I felt overwhelmed by the amount of information presented by the system.
لقد شعرت بالإرهاق من كمية المعلومات التي يقدمها النظام.

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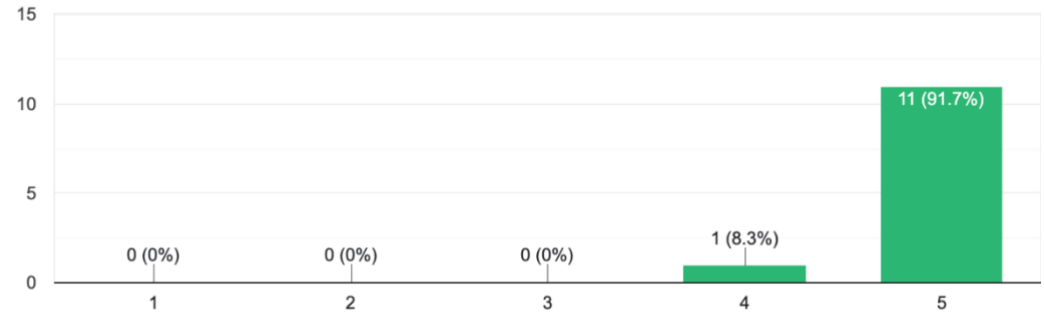
12 responses



I think that I would like to use this system frequently.

أعتقد أنني أرغب في استخدام هذا النظام بشكل متكرر.

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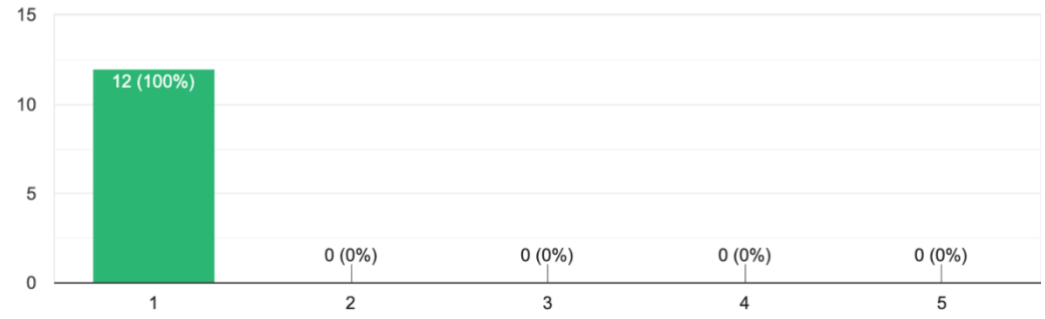
12 responses



Which features of the system do you find most useful and why? ما هي ميزات النظام التي تجدها أكثر فائدة ولماذا؟

12 responses

I think the idea of stations appearing is the best because I can comfortably choose the station that suits me and offers all the services I need.

هل ما اذا كانت محطات البنزين متاحه او مزحومه، وهذا لتوفير الوقت وسد الحاجه في اسرع وقت.

قائمة المحطات المتوفره حاليا - ومخطط نفقات البنزين

توفر محطات و تجميع الفواتير

View the bill so I can see it when I need it

The occupancy level was the most useful feature that will help me with the problem of waiting

The feature that I see as most beneficial is the occupancy level

اضافة سيارتي للتطبيق والمميزات التابعه لها

The occupancy level solves the problem of wasted time

Can you describe your overall experience of the system? هل يمكنك وصف تجربتك الشاملة للنظام؟

12 responses

It is very comfortable, and I benefited from it. I think it is an excellent idea.

تجربة رائعة جدًا، خصوصًا في ظل زحمة الرياض اعتقد ان مثل هذا التطبيق سيسهل عملية اعادة تعبئة السياره بسهوله ويسر.

برنامج جدا رهيب ومميز، اتمنى لو يتم تطبيقه على ارض الواقع حتى نقدر ننظم إدارتنا باستهلاك البنزين

التجربه سلسة جدا وواضحه والمعلومات جدا مفيده

Easy for beginners

اعجبني التطبيق جدًا كانت تجربة رائعة

Easy to use and effectively solves the driver's problem

كانت تجربة رائعة اعجبني تدرج الوان التطبيق كان مريح للعين

تحربة جمييله اتمنى اشوفه بالواقع واستخدمه في حياتي اليومية

How satisfied are you with the system's features, and what improvements or additional features would you suggest? ما مدى رضاك عن ميزات النظام، وما هي التحسينات أو الميزات الإضافية التي تقترحها؟

12 responses

اقترح توضيح اكثر للسبشل كاركتر المتاحه في الساين اب

Very satisfied, none

لا يوجد تطبيق رائع

The occupancy level, the most attractive feature to me, makes the app very good

اضافة محطات اكثر

تطبيق متكامل

جدا راضي عن خدمات النظام المميزه، في صفحة عرض الاستهلاك عندما يكون الاستهلاك اكثر من الديفولت يكون اللون مختلف عن اللون الاخضر كاللون الاصفر او الاحمر ، لاداعي لوجود اسهم في اعلى جميع الصفحات حتى في صفحة الهوم

no improvement need, it was a complete app to me

لا يوجد، تطبيق جميل ومفيد للغاية

I found the process of registering a new account on the website to be straightforward and user-friendly. وجدت عملية دخولي للموقع عملية واضحة وسهلة الاستخدام.

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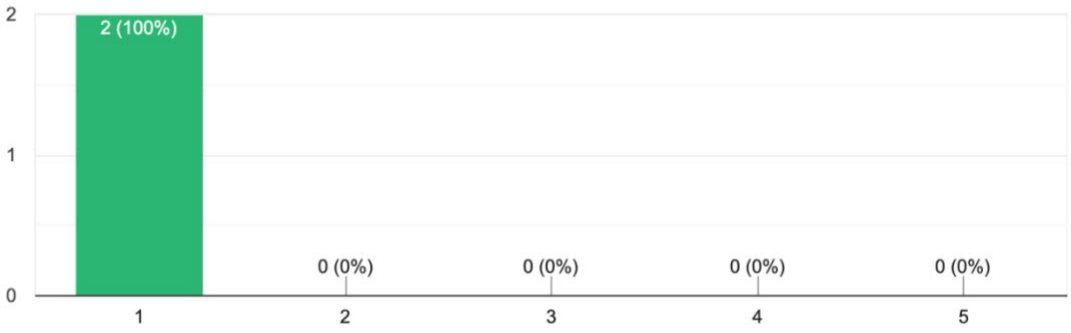
2 responses

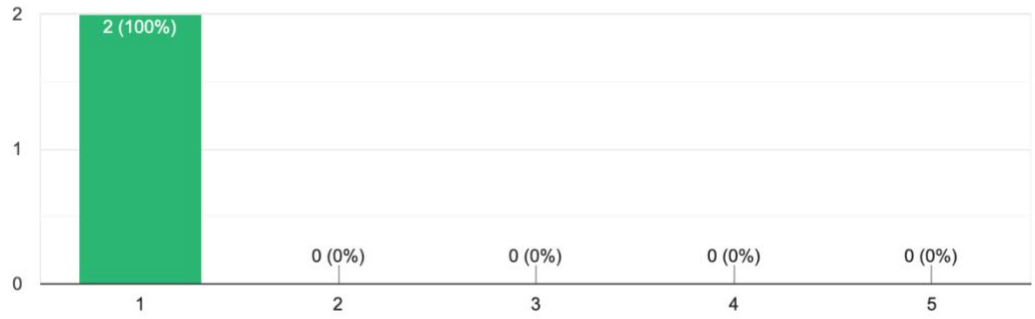


- Admins' Answers:

The dashboard was useful and comprehensive with important information for managing gas stations?
لوحة البيانات كانت مفيدة وشاملة بالمعلومات المهمه لإدارة محطات الوقود ؟

Copy

2 responses



Gas station information is suitable and completed when requested to be available in the application ?
معلومات محطات الوقود عند طلبها لتتواجد بالتطبيق مناسبة ومكتملة؟

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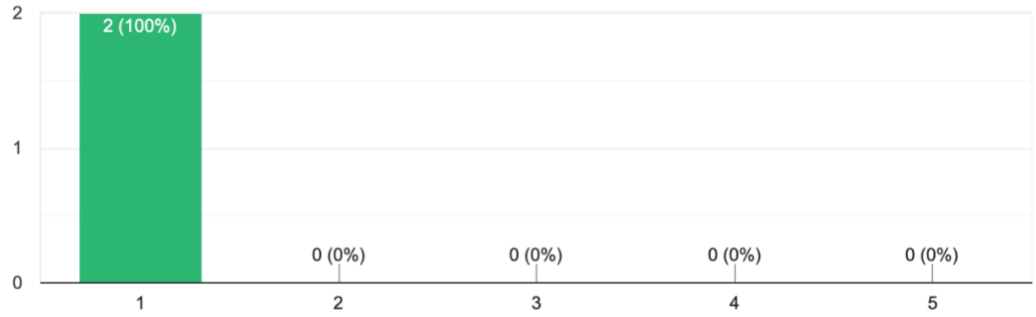
2 responses



Was the process of accepting or rejecting a gas station easy and clear?عملية قبول او رفض محطة وقود ما كانت سهله وواضحة؟

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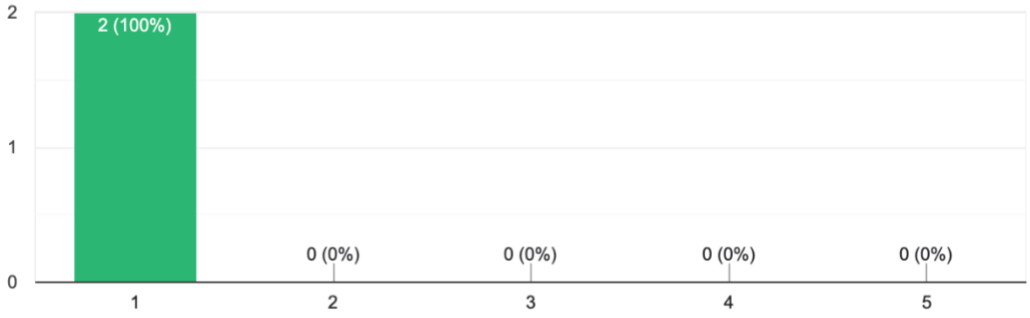
2 responses



How satisfied are you with the system's features, and what improvements or additional features would you suggest? ما مدى رضاك عن ميزات النظام، وما هي التحسينات أو الميزات الإضافية التي تقترحها؟

2 responses

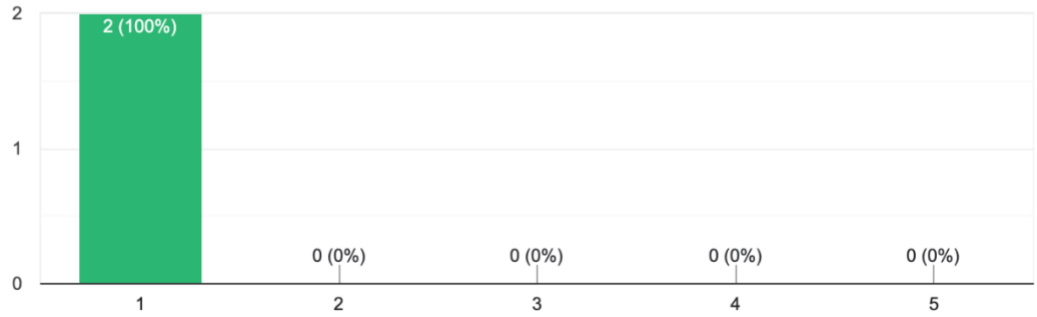
موقع مفيد لادارة المحطات، لوحة المعلومات كانت مفيده وموجزة لاهم المعلومات

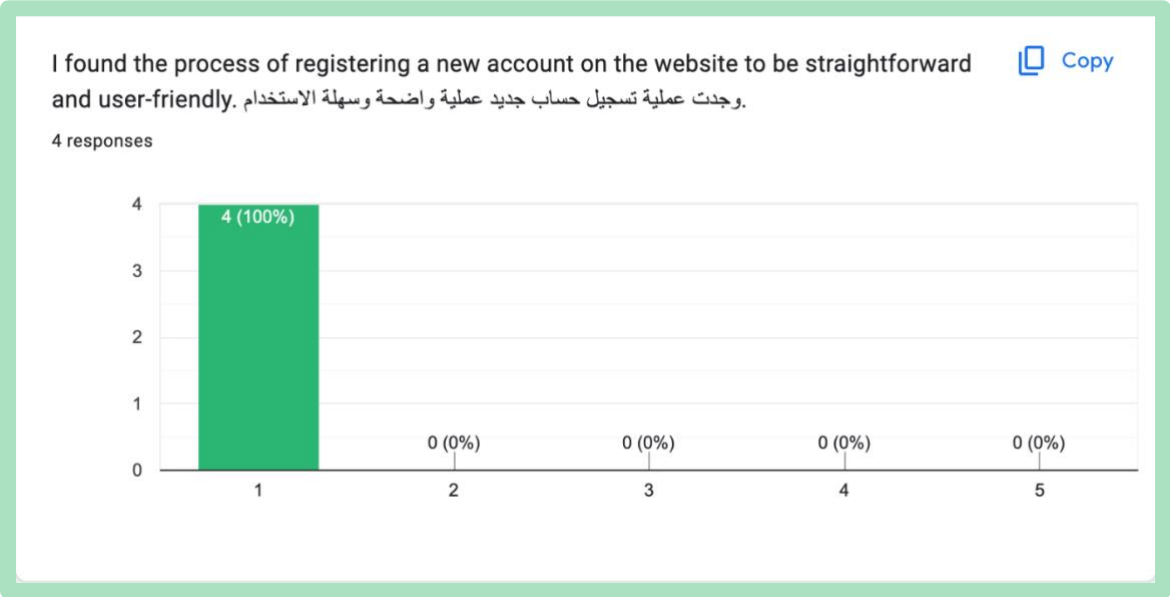
الموقع كان واضح والبيانات سهلة الفهم، عملية قبول او رفض المحطات كانت واضحه وسهلة

Was the process of modifying the station manager's data and his email easy and understandable?
عملية تعديل بيانات مدير المحطة والبريد الخاص فيه كانت سهله ومفهومه؟

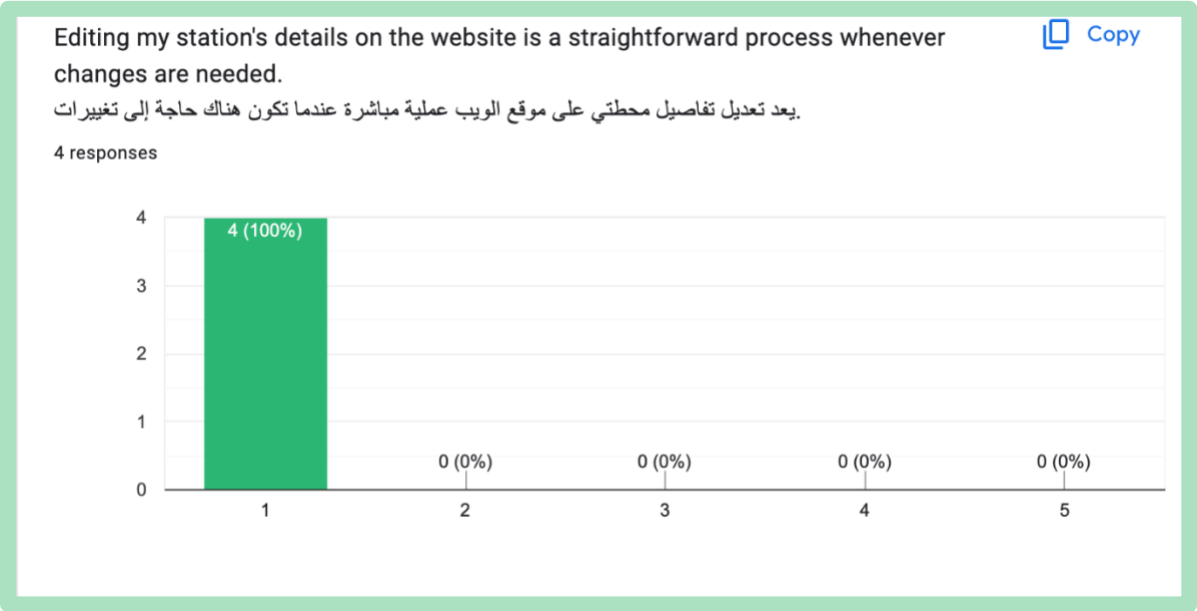
Copy

2 responses





- Branch Managers' Answers:

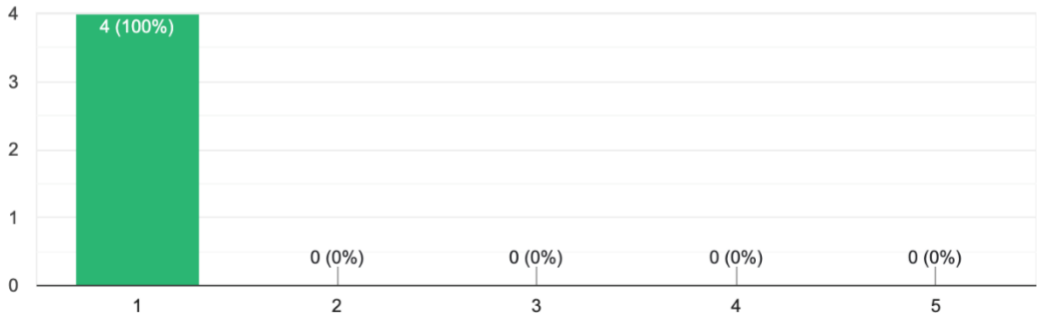


I can easily add my station details like the station's image and available fuel types to the system.

يمكنني بسهولة إضافة تفاصيل محطتي مثل صورة المحطة وأنواع الوقود المتوفرة إلى النظام.

Copy

4 responses

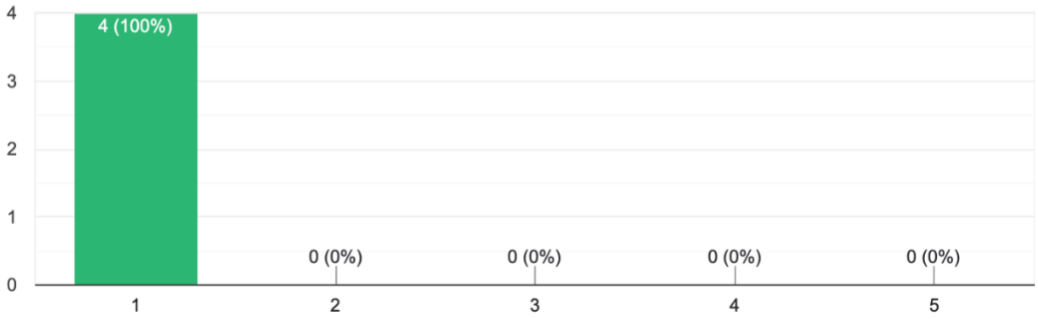


Submitting my station's information (name and location) for admin approval was a clear and efficient process.

كان تقديم معلومات محطتي (الاسم والموقع) للحصول على موافقة المشرف عملية واضحة وفعالة.

Copy

4 responses

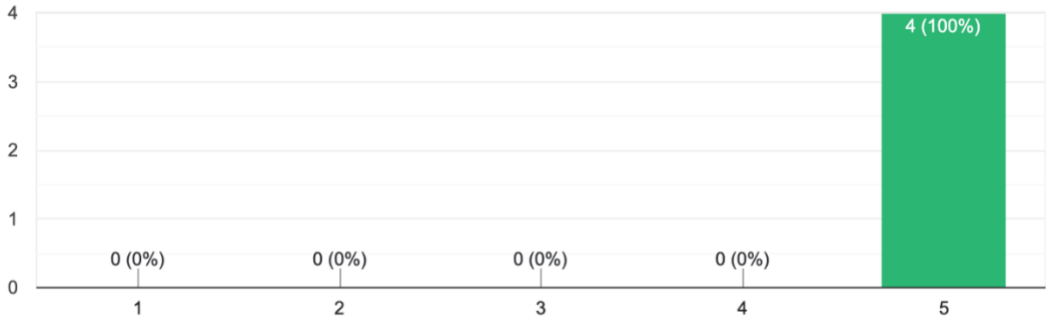


Have there been any challenges or obstacles encountered during the process of adding your promotion to our platform?

هل كانت هناك أي تحديات أو عقبات تمت مواجهتها أثناء عملية إضافة عرضك الترويجي إلى منصتنا؟

Copy

4 responses

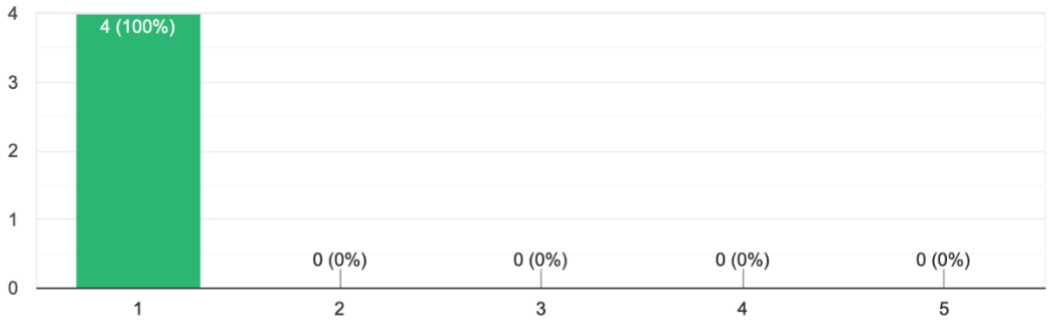


These new services enhance the overall customer experience at the gas station on our platform?

هذه الخدمات الجديدة تعزز تجربة العملاء بشكل جيد في محطة الوقود على منصتنا؟

Copy

4 responses



I am able to promptly reflect changes in fuel availability to customers through the system easy way.

أنا قادر على توضيح التغييرات في توافر الوقود للعملاء من خلال النظام بكل سهولة.

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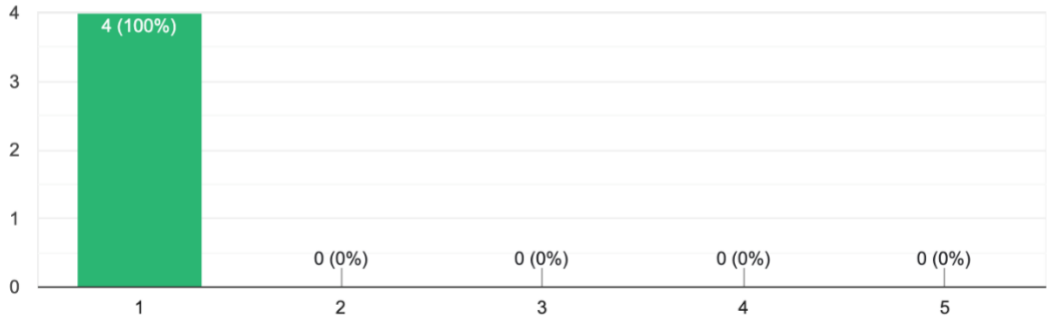
4 responses

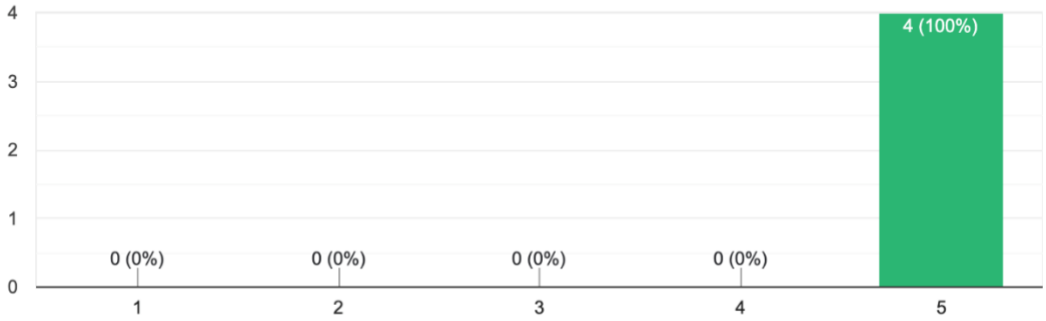


I think that I would need the support of a technical person to be able to use this system.

أعتقد أنني سأحتاج إلى دعم أحد الأشخاص التقنيين حتى أتمكن من استخدام هذا النظام.

Copy

4 responses

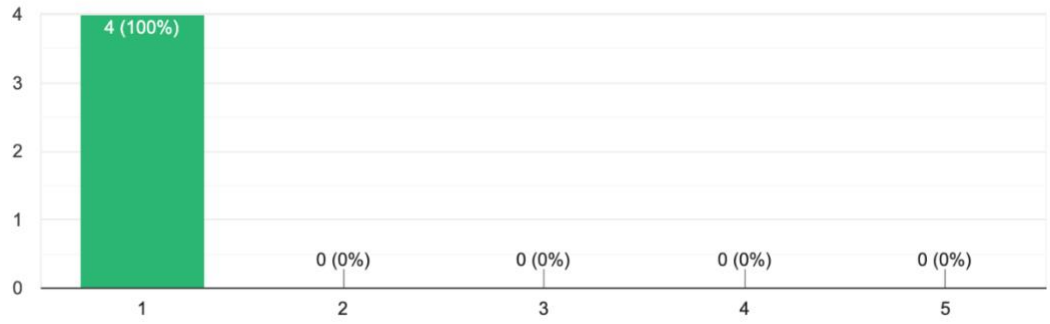


Have the bill viewing, updating, and deleting features contributed to enhancing your overall experience with our system more best?

ساهمت ميزات عرض الفاتورة وتحديثها وحذفها في تعزيز تجربتك بشكل أفضل مع نظامنا؟

Copy

4 responses

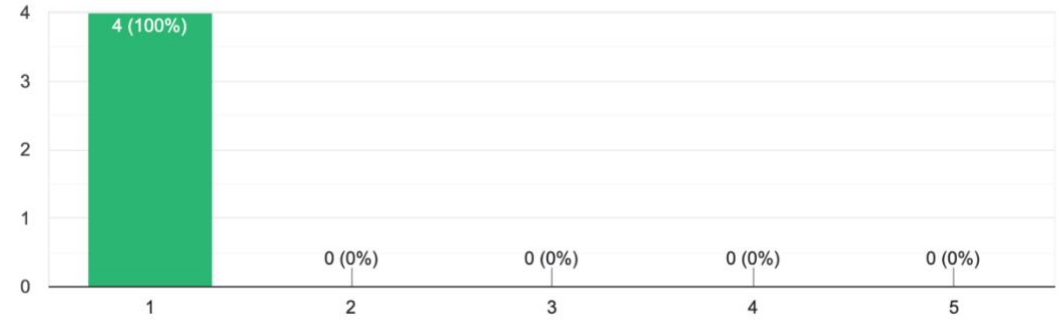


I think that I would like to use this system frequently.

أعتقد أنني أرغب في استخدام هذا النظام بشكل متكرر.

Copy

4 responses

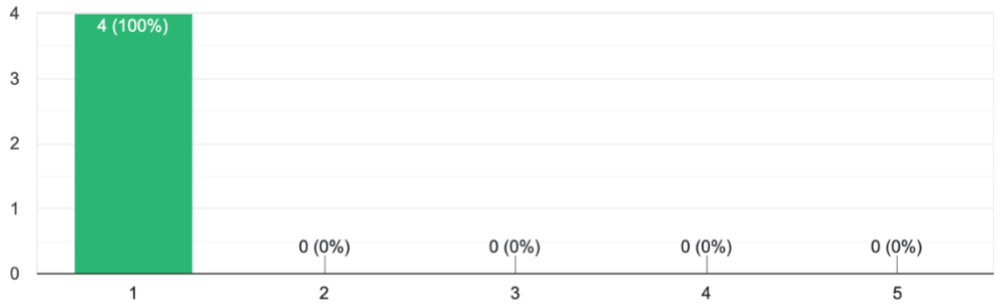


Adding employees to the system for using app later is an intuitive and hassle-free process.

إن إضافة الموظفين إلى النظام لاستعمالهم التطبيق لاحقًا هي عملية بديهية وخالية من المتاعب.

Copy

4 responses

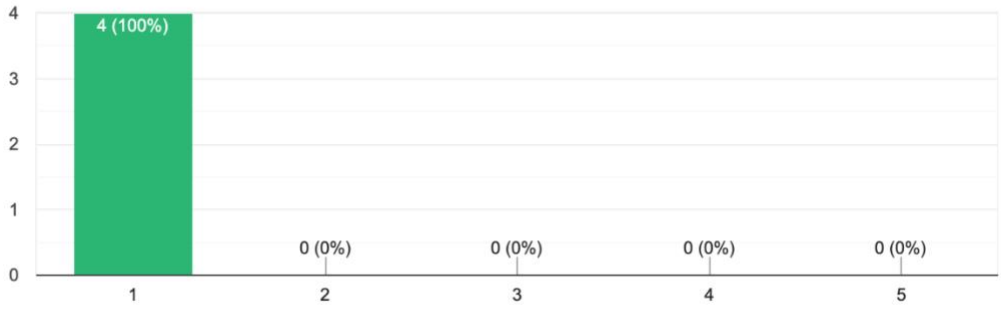


I felt in control of the interactions I had with the system.

شعرت بالسيطرة على التفاعلات التي أجريتها مع النظام.

Copy

4 responses



I felt overwhelmed by the amount of information presented by the system.
لقد شعرت بالإرهاق من كمية المعلومات التي يقدمها النظام.

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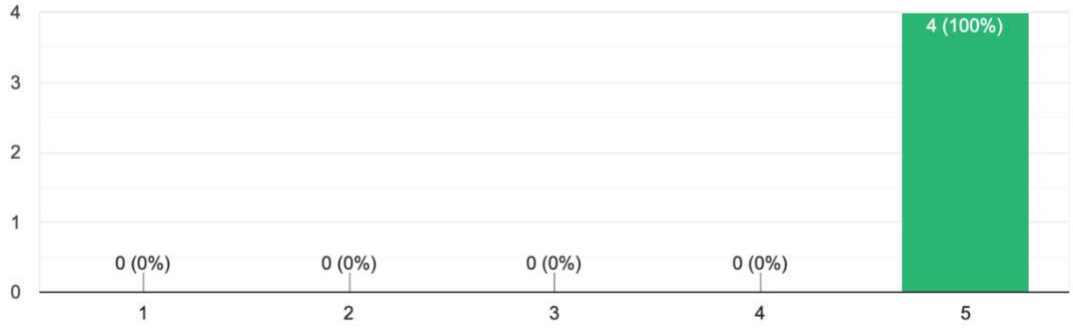
4 responses



Can you describe your overall experience of the system? هل يمكنك وصف تجربتك الشاملة للنظام؟

4 responses

تجربة جميلة استفدت منها كثيرا

تجربة جميله وموقف جميل

The website is great!

تجربة جميله وموقع جيد

Which features of the system do you find most useful and why? ما هي ميزات النظام التي تجدها أكثر فائدة ولماذا؟

4 responses

العروض كانت جذابه ولفتت انتباهي

اضافة الموظفين إلى النظام ومعرفة الفواتير وتفاصيلها

how can add the promotion, services and my employee in website it was the most useful features. also it is easy of use!

اضافة معلومات محطتي، الخدمات والعروض الترويجيه

How satisfied are you with the system's features, and what improvements or additional features would you suggest? ما مدى رضاك عن ميزات النظام، وما هي التحسينات أو الميزات الإضافية التي تقترحها؟

4 responses

رائعه ولا يوجد تحسينات

لا يوجد. موقع متكامل متحمس لرؤيته في السوق

nothing, great website!

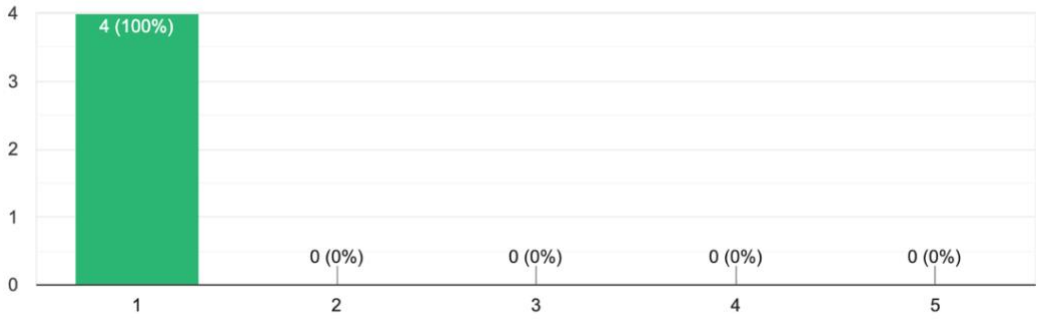
موقع متكامل ومرضي

The process of preparing bills for customers is easy and understandable

عملية إعداد الفواتير للعملاء سهله ومفهومه؟

Copy

4 responses



The ease of use of the QR code scanning feature for billing?

سهولة استخدام ميزة مسح رمز الاستجابة السريعة لإعداد الفواتير؟

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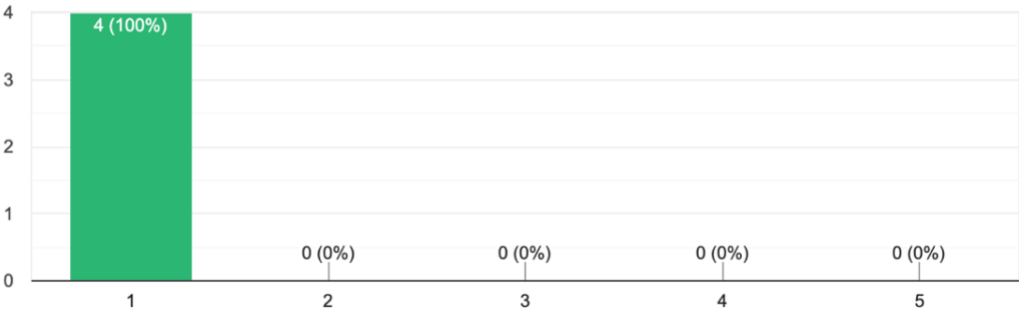
4 responses



As an employee, I found the process of being assigned by a branch manager, login using email, and OTP to access the system's features to be clear, secure, and user-friendly.

كموظف، وجدت أن عملية تعييني من قبل مدير الفرع، ودخولي باستخدام ايميل وكلمة المرور لمرة واحدة للوصول إلى ميزات النظام واضحة وآمنة وسهلة الاستخدام.

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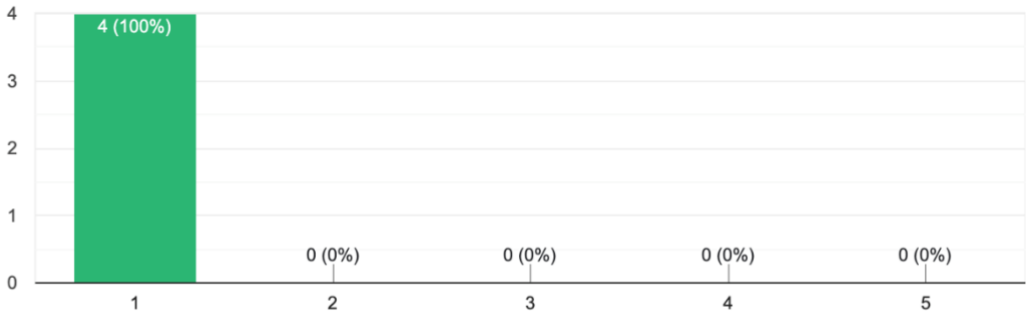
4 responses



- Station Employees' Answers:

What improvements or enhancements would you suggest to make the process of making bills more efficient or user-friendly?

ما هي التحسينات التي تقترحها لجعل عملية طباعة الفواتير أكثر كفاءة أو سهولة في الاستخدام؟

4 responses

كانت تجربة جيدة، ويفضل اضافة شريط بحث للوصول الاسرع للمستخدمين واضافة الفواتير لهم.

كانت واضحه وما واجهت مشكله أبدا

النظام رائع و متكامل لايحتاج إلى تعديل

العملية جداً سهله وسريعة ولا توجد لدي اقتراحات

Can you share your experience with the process of registering your email from a branch manager for using app?

هل يمكنك مشاركة تجربتك مع عملية تسجيل بريد الوصول الإلكتروني الخاص بك من قبل مدير الفرع لاستخدام التطبيق؟

4 responses

سهله وسلسه وتزيد من عملية الامان وضمان دخول فقط المسموح لهم هذه احد الميزات الرائعه.

سهل وواضح جدا

سريعه وسهله

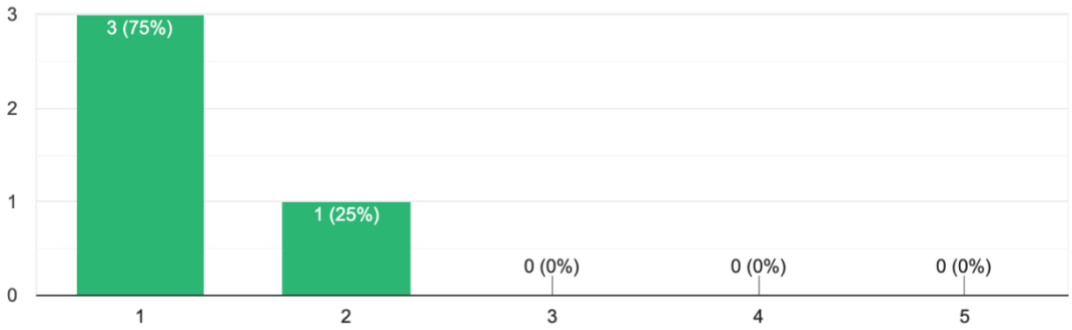
عملية جدا سهله وامنة

Finding plate numbers of customers for reporting bills it was easy and useful to me ?

العثور على أرقام لوحات العملاء لإعداد الفواتير كانت ومفيدة وسهله علي؟

Copy

4 responses



4 Appendix D: Testing Questions

- Drivers' Questions:

Q1: I found the process of registering a new account on the app to be straightforward and user-friendly. وجدت عملية تسجيل حساب جديد عملية واضحة وسهلة الاستخدام.

A1: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q2: I can add my car to the system easily.

يمكنني إضافة سيارتي إلى النظام بسهولة.

A2: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q3: The system made it easy for me to understand and track my fuel consumption.

لقد سهّل النظام عليّ فهم استهلاك الوقود وتتبعه.

A3: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q4: I can know whether the station contains some type of gasoline or not in real time easy way.

يمكنني معرفة ما إذا كانت المحطة تحتوي على نوع ما من البنزين أم لا في الوقت الفعلي بكل سهولة؟

A4: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q5: the bill page adequately presents all necessary billing details and information?

أن صفحة الفاتورة تعرض كافة تفاصيل ومعلومات الفواتير الضرورية بشكل مناسب؟

A5: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q6: How likely are you to recommend our platform to others based on the promotions and special offers available at gas stations?

ما مدى احتمال أن توصي الآخرين بمنصتنا بناءً على العروض الترويجية والعروض الخاصة المتوفرة في محطات الوقود؟

A6: 1 (محتمل جدًا | Very likely) to 5 (مستحيل | Never)

Q7: How would you rate the availability and variety of amenities and services offered at gas stations?

كيف تقيم مدى توفر وتنوع وسائل الراحة والخدمات المقدمة في محطات الوقود؟

A7: 1 (وسائل متنوعه للغاية | Very Variety) to 5 (لا يوجد تنوع | No Variety)

Q8: Do you think that knowing the level of crowding at gas stations before arriving is important to you and useful in the application?

هل ترى أن معرفة مستوى الازدحام في محطات الوقود قبل الوصول مهمه لديك ومفيدة في التطبيق؟

A8: 1 (مهمه للغاية| Very important) to 5 (غير مهمه | Not important)

Q9: I found the fuel expenses chart straightforward.

لقد وجدت مخطط نفقات الوقود واضحًا ومباشرًا.

A9: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q10: I think that I would like to use this system frequently.

أعتقد أنني أرغب في استخدام هذا النظام بشكل متكرر.

A10: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q11: I think that I would need the support of a technical person to be able to use this system.

أعتقد أنني سأحتاج إلى دعم أحد الأشخاص التقنيين حتى أتمكن من استخدام هذا النظام.

A11: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q12: I felt overwhelmed by the amount of information presented by the system.

لقد شعرت بالإرهاق من كمية المعلومات التي يقدمها النظام.

A12: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q13: I felt in control of the interactions I had with the system.

شعرت بالسيطرة على التفاعلات التي أجريتها مع النظام.

A13: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

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Q1: I found the process of registering a new account on the website to be straightforward and user-friendly. وجدت عملية تسجيل حساب جديد عملية واضحة وسهلة الاستخدام.

A1: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q2: Submitting my station's information (name and location) for admin approval was a clear and efficient process.

كان تقديم معلومات محطتي (الاسم والموقع) للحصول على موافقة المشرف عملية واضحة وفعالة.

A2: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q3: I can easily add my station details like the station's image and available fuel types to the system.

يمكنني بسهولة إضافة تفاصيل محطتي مثل صورة المحطة وأنواع الوقود المتوفرة إلى النظام.

A3: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q4: Editing my station's details on the website is a straightforward process whenever changes are needed.

يعد تعديل تفاصيل محطتي على موقع الويب عملية مباشرة عندما تكون هناك حاجة إلى تغييرات.

A4: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

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أنا قادر على توضيح التغييرات في توافر الوقود للعملاء من خلال النظام بكل سهولة.

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Q6: Adding employees to the system for using app later is an intuitive and hassle-free process.

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هذه الخدمات الجديدة تعزز تجربة العملاء بشكل جيد في محطة الوقود على منصتنا؟

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A1: 1 (Strong Agree | موافق بشدة) to 5 (Strong Disagree | غير موافق بشدة)

Q2: The ease of use of the QR code scanning feature for billing?

سهولة استخدام ميزة مسح رمز الاستجابة السريعة لإعداد الفواتير؟

A2: 1 (Strong Agree | موافق بشدة) to 5 (Strong Disagree | غير موافق بشدة)

Q3: The process of preparing bills for customers is easy and understandable

عملية إعداد الفواتير للعملاء سهله ومفهومه؟

A3: 1 (Strong Agree | موافق بشدة) to 5 (Strong Disagree | غير موافق بشدة)

Q4: Finding plate numbers of customers for reporting bills it was easy and useful to me ?

العثور على أرقام لوحات العملاء لإعداد الفواتير كانت ومفيدة وسهله علي؟

A4: 1 (Strong Agree | موافق بشدة) to 5 (Strong Disagree | غير موافق بشدة)

Admin Questions

Q1: I found the process of registering a new account on the website to be straightforward and user-friendly. وجدت عملية دخولي للموقع عملية واضحة وسهلة الاستخدام.

A1: 1 (Strong Agree | موافق بشدة) to 5 (Strong Disagree | غير موافق بشدة)

Q2: Gas station information is suitable and completed when requested to be available in the application ?

معلومات محطات الوقود عند طلبها لتتواجد بالتطبيق مناسبة ومكتملة؟

A2: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q3: Was the process of accepting or rejecting a gas station easy and clear? عملية قبول او رفض محطة وقود ما كانت سهله وواضحة؟

A3: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q4: The dashboard was useful and comprehensive with important information for managing gas stations?

لوحة البيانات كانت مفيدة وشاملة بالمعلومات المهمة لإدارة محطات الوقود ؟

A4: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

Q5: Was the process of modifying the station manager's data and his email easy and understandable?

عملية تعديل بيانات مدير المحطة والبريد الخاص فيه كانت سهله ومفهومه؟

A5: 1 (موافق بشدة | Strong Agree) to 5 (غير موافق بشدة | Strong Disagree)

5 Appendix E: Jira, GitHub, and dataset

Jira: https://jira.external-share.com/issue/8c821d35-a852-4554-b846-66f0f99e7464

GitHub: https://github.com/afnmo/2023-GP1-04.git

- Screen shot of a sample of the dataset

	F	E	D	C	B	A
1	FuelTypeEn	Grade	FuelEconomy	VehicleNameEn	Manufcaturer	ModelYear
2	Gasoline	Very Poor	8.7	F150	Ford	2015
3	Gasoline	Very Good	14.2	Ssangyong Tivoli	KG Mobility Corp	2024
4	Gasoline	Very Poor	9.5	Taurus	Ford	2015
5	Gasoline	Very Poor	9.5	Taurus SHO	Ford	2015
6	Gasoline	Very Poor	9.5	MKS	Lincoln	2015
7	Gasoline	Good	13.8	NQ5E SPORTAGE	Kia	2023
8	Diesel	Excellent+	14.7	Ranger XLS	Ford	2022
9	Diesel	Excellent+	14.7	Fortuner	Toyota	2022
10	Diesel	Excellent+	14.7	HILUX	Toyota	2022
11	Gasoline	Very Poor	9.7	MKT	Lincoln	2015
12	Gasoline	Very Poor	10.3	QX50	Infiniti	2015
13	Gasoline	Poor	12.7	650i A (6H51)	BMW	2017
14	Gasoline	Average	13.5	Outlander	Mitsubishi	2018
15	Gasoline	Average	13.5	MX-5	Mazda	2018
16	Gasoline	Excellent	15.4	Jeep Renegade Longit	FCA Italy S.p.A.	2020
17	Gasoline	Excellent	15.4	AMG A 35 4MATIC	Mercedes-Benz	2020
18	Gasoline	Very Poor	12	Avalon	Toyota	2015
19	Gasoline	Very Good	12	Dodge Durango	FCA US LLC	2020
20	Gasoline	Very Good	12	CX-9	Mazda	2020
21	Gasoline	Very Good	12	F-150 Regular Cab	Ford	2020
22	Gasoline	Very Good	12	Acadia	GMC	2020
23	Gasoline	Very Poor	7.4	Aventador	Lamborghini	2016

FE Vehicle Details

6 Appendix F: Experiments Results

	File	Ground Truth Plate	Predicted Plate	Accuracy
0	ckicup6z1000g246a7fphj2ry	6046JAA	6046JAA	100%
1	ckicv7bge000i246amogy2uak	5578KGA	5578KGA	100%
2	ckicz5mvn001m246adc3vvpi8	5854UDJ	5854UDJ	100%
3	ckid0aey1002d246a4yttijxq	4698LZJ	4698LZJ	100%
4	ckie431xs003u246amh9uo6cv	6924HEA	6924HEA	100%
5	ckie4cimr003x246aoznobsso	5349LVJ	5349LVJ	100%
6	ckie5frk9004n246afbzcg2bv	5542BVJ	5542BVJ	100%
7	ckie5gyti004o246apj0w8xa5	4754ZBB	4754ZBB	100%
8	ckie7hpqn0060246ajpom24hc	5542BVJ	5542BVJ	100%
9	ckie9t257007f246azz6y65h1	2948URD	2948URD	100%
10	ckifja6dj0080246ah2pbu5c7	6389BVJ	6389BVJ	100%
11	ckifob8ae00ac246aspnnzb4s	9454BKJ	9454BKJ	100%
12	ckifoesk900ae246adon2oi36	3757JED	3757JED	100%
13	ckj2qkszj0000246a97ibd89g	5732NXD	5732NXD	100%
14	ckj2qofgm0002246aka7idva2	4544NDJ	4544NDJ	100%
15	ckj2rbzak000i246a29ubfv5x	2039SZA	2039SZA	100%
16	ckj2rfvrd000l246axyi8kp5x	5074BNJ	5074BNJ	100%
17	ckj6p7y6j001g246aah9sd8u9	7980ESJ	7-80-SJ	71.0%
18	ckj6u1kxg0002246a2l9x47kt	6507EGB	6507EGB	100%
19	ckj6u30bj0003246ad1yv8vtg	5732NXD	5732NXD	100%

	File	Ground Truth Plate	Predicted Plate	Accuracy
20	ckj6uqogb000l246a11f6lmsy	3523AHA	3523AHA	100%